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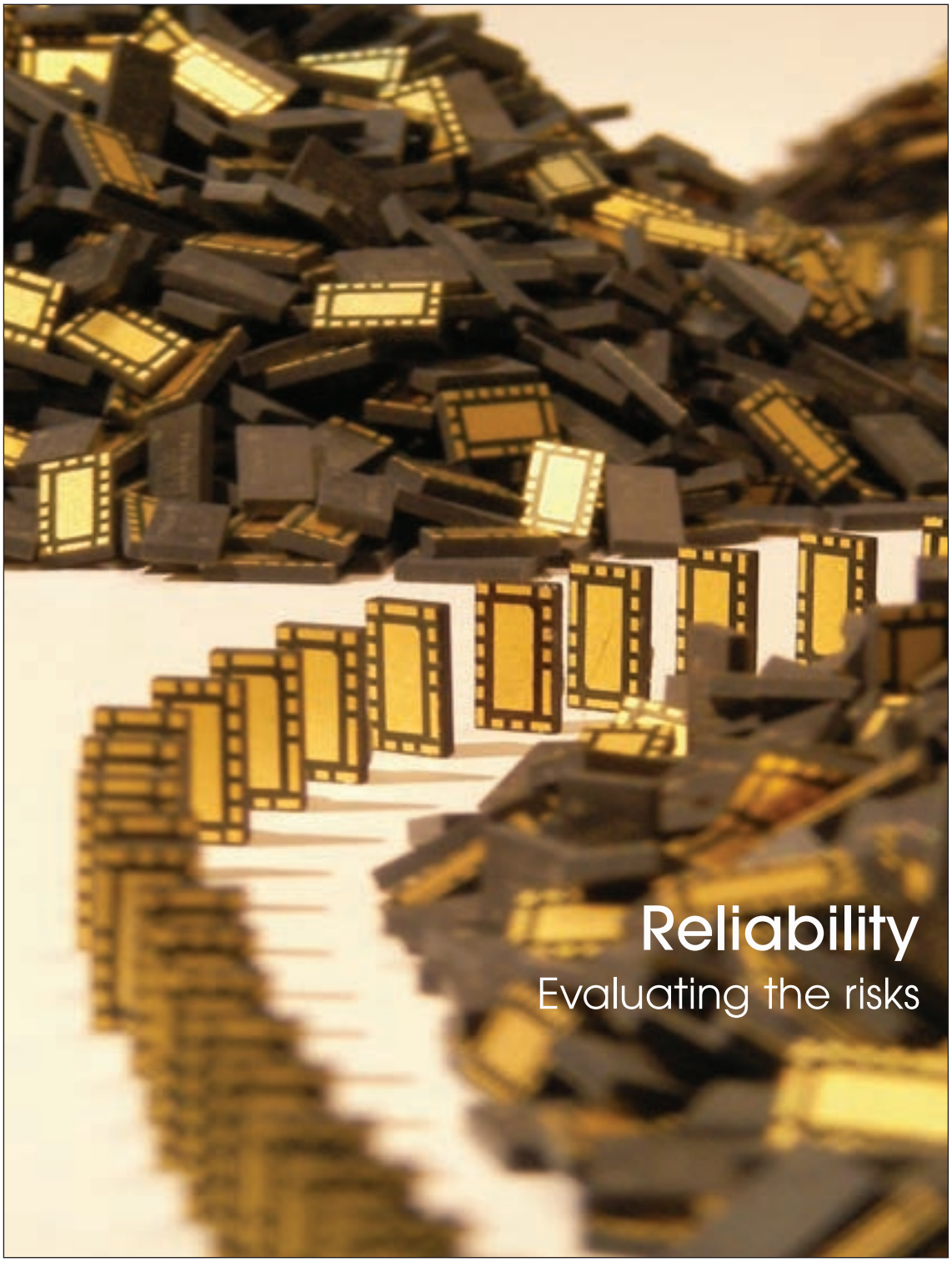
GaN-on-silicon LEDs
Historic UK site prepares to ramp production

CPV
Printing approach nets orders

Power amplifiers
CMOS threats

Sapphire
Opportunities in handsets



Reliability
Evaluating the risks

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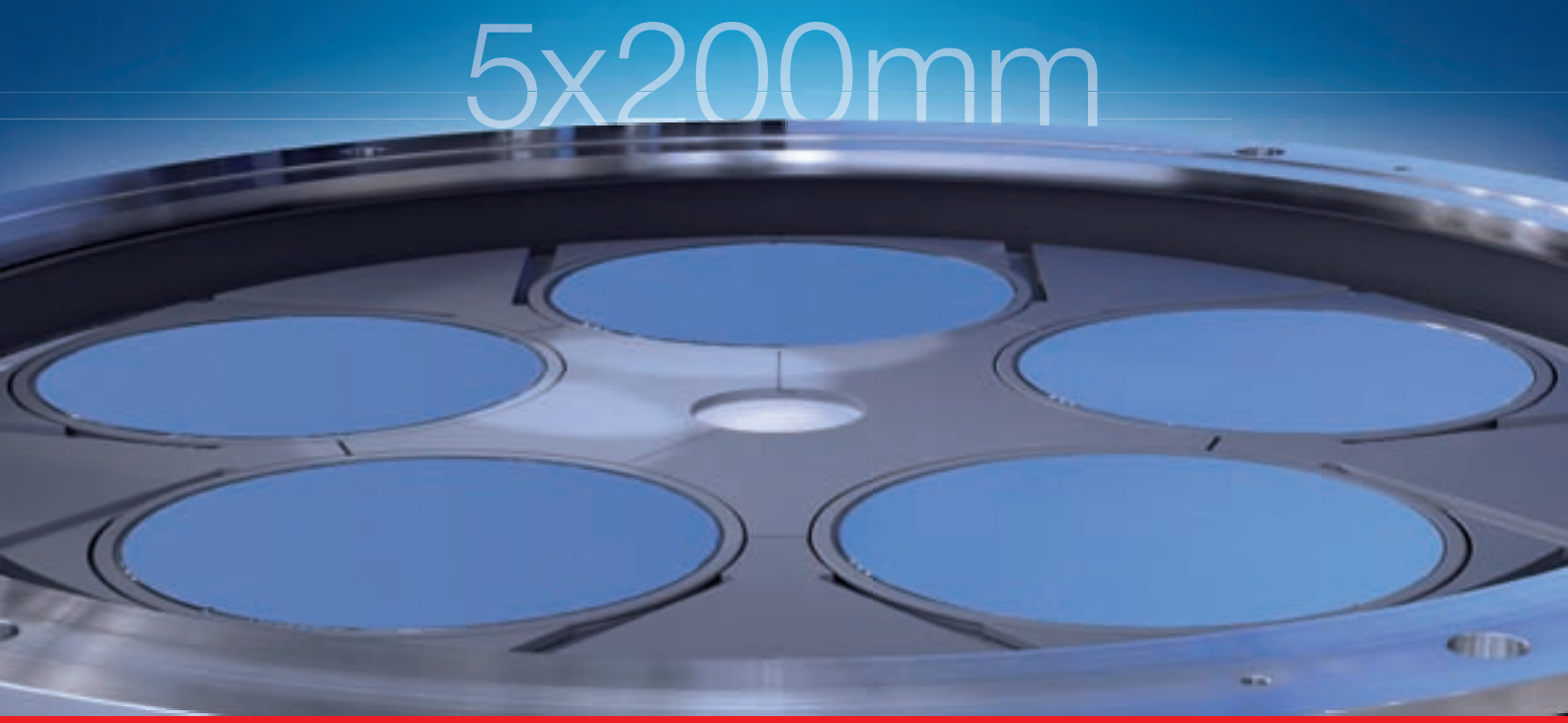
January / February 2013 Volume 19 Number 1

AIXTRON

200mm GaN-on-Si Batch Reactor



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AIX G5+ for GaN-on-Si

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Volume 19 Number 1

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The blurring of boundaries

NOT THAT LONG AGO, there was minimal overlap between the silicon and compound semiconductor industries. The silicon foundries churned out chips for microprocessors and power electronics, while the compounds were used to make RF amplifiers and a wide variety of optoelectronic devices.

Now the boundaries are blurring, and this trend is going to continue.

Take, for example, the smartphone. Traditionally, our industry has supplied LEDs for lighting keypads and backlights, plus GaAs components for switching and power amplification. Meanwhile, the use of silicon has been restricted to signal processing and memory. But this is changing. A form of silicon technology known as silicon-on-sapphire, which has been pioneered by Peregrine Semiconductor, is displacing GaAs in the switch in mobile phones (see feature on p. 55). And the use of III-Vs in the power amplifier is now facing competition from CMOS, with Javelin Semiconductor of Austin, Texas, building an amplifier that is is appearing in the Samsung Galaxy smartphones (see p. 20).

As silicon chipmakers move into new markets, their core business will start to need support from III-V materials. The superior electron mobilities associated with InGaAs makes it a very promising candidate for producing nMOSFETs at nodes of 11 nm or less, because this transistor can then operate at low voltages, trimming power consumption. Introducing this material into silicon foundries will not be easy, but researchers are starting to tackle many of the challenges. Read my report of the International Electron Devices Meeting on p. 34 of this issue to keep track of recent progress.

Another area where silicon and the III-Vs are coming together to create better products is LED production. 2013 will mark the birth of high-volume GaN-on-silicon manufacture, and it will be interesting to see which company grabs the lion's share of this market.

Many will expect the partnership between Bridgelux and Toshiba to lead the way, given the strong track record of impressive lab results by the US partner in this collaboration. But this team is up against some stiff competition from Plessey Semiconductors of Plymouth UK. When I visited this site late last year, Barry Dennington, the company's chief operating officer, told me that he believed that his firm had the best technology for manufacturing flat wafers with thin buffer structures (see p.28). He expects Plessey's LED products to make a big splash this year.

It's hard to predict the winner of that battle. But it's a lot easy to see that as we go through 2013 and beyond, devices combining silicon and the III-Vs are going to become more and more common.

Dr Richard Stevenson
Editor

LED

Solutions for High Brightness LED manufacturing

- Optical lithography and resist processing solutions
- Nano Imprint Lithography for patterned sapphire substrates PSS
- Wafer bonding for layer transfer
- Handling and processing of thin and bowed wafers

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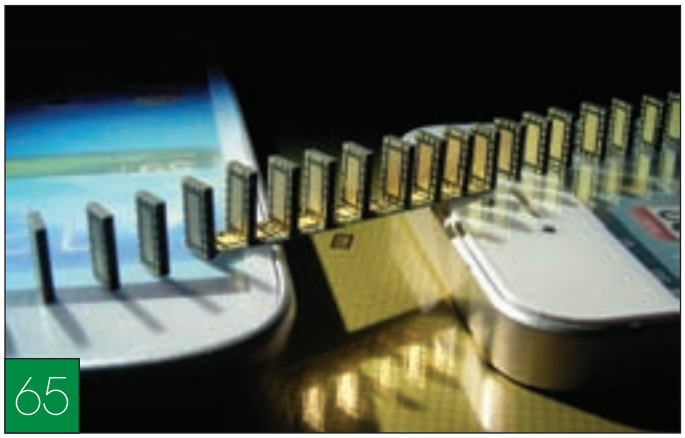
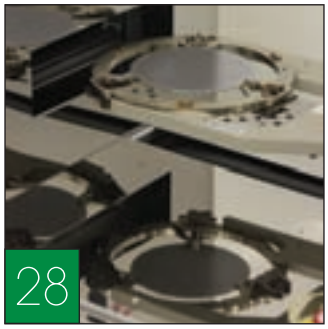
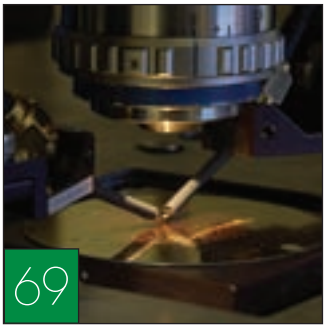






news + analysis

NRL unveils III-V solar cell for beating the 50% barrier

US NAVAL RESEARCH LABORATORY scientists in the Electronics Technology and Science Division, in collaboration with the Imperial College London and MicroLink Devices, Inc., Niles, IL, have proposed a novel triple-junction solar cell.

They say the cell has the potential to break the 50 percent conversion efficiency barrier, which is the current goal in multi-junction photovoltaic development.

"This research has produced a novel, realistically achievable, lattice-matched, multi-junction solar cell design with the potential to break the 50 percent power conversion efficiency mark under concentrated illumination," says NRL research physicist Robert Walters.

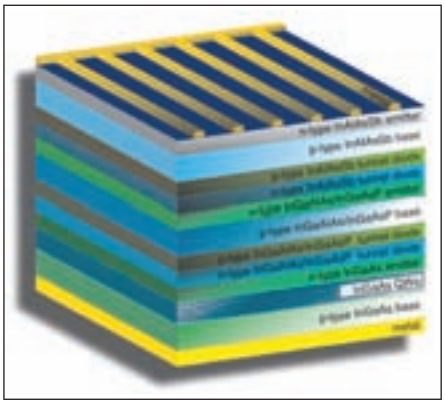
"At present, the world record triple-junction solar cell efficiency is 44 percent under concentration and it is generally accepted that a major technology breakthrough will be required for the efficiency of these cells to increase much further."

In multi-junction solar cells, each junction is 'tuned' to different wavelength bands in the solar spectrum to increase efficiency. High bandgap semiconductor material is used to absorb the short wavelength radiation with longer wavelength parts transmitted to subsequent semiconductors.

In theory, an infinite-junction cell could obtain a maximum power conversion percentage of nearly 87 percent. The challenge is to develop a semiconductor material system that can attain a wide range of bandgaps and be grown with high crystalline quality.

By exploring novel semiconductor materials and applying band structure engineering, via strain-balanced quantum wells, the NRL research team has produced a design for a MJ solar cell that can achieve direct band gaps from 0.7 to 1.8 electron volts (eV) with materials that are all lattice-matched to an InP substrate.

"Having all lattice-matched materials with this wide range of band gaps is the key to breaking the current world record," adds Walters. "It is well known that materials lattice-matched to InP can achieve band gaps of about 1.4 eV and below, but no ternary alloy semiconductors exist with a higher direct band-gap."



Schematic diagram of a multi-junction solar cell formed from materials lattice-matched to InP and achieving the bandgaps for maximum efficiency

The primary innovation enabling this new path to high efficiency is the identification of InAlAsSb quaternary alloys as a high band gap material layer that can be grown lattice-matched to InP.

Drawing from their experience with Sb-based compounds for detector and laser applications, NRL scientists modelled the band structure of InAlAsSb and showed that this material could potentially achieve a direct band-gap as high as 1.8eV.

With this result, and using a model that includes both radiative and non-radiative recombination, the NRL scientists created a solar cell design that is a potential route to over 50 percent power conversion efficiency under concentrated solar illumination.

Recently awarded a U.S. Department of Energy, Advanced Research Projects Agency-Energy (ARPA-E) project, NRL scientists, working with MicroLink and Rochester Institute of Technology, Rochester, New York, will execute a three year materials and device development program to realise this new solar cell technology.

Focus Lightings to double LED production with Aixtron reactors

CHINA'S Focus Lightings Tech Inc. has ordered a number of Aixtron CRIUS II-L systems for mass production of GaN LED epitaxial wafers. The systems will be configured to handle up to 69 x 2-inch wafers per run.

The purchase was made in the fourth quarter of 2012. Shipment of the systems started in December 2012. Huarong Pan, Chairman of Focus Lightings Tech, comments, "We eagerly await delivery of Aixtron's latest CRIUS Close Coupled Showerhead (CCS) generation for our future mass production of white-light LEDs. With the system's low cost of ownership and high productivity as well as Aixtron's strong customer service in China, the CRIUS II-L systems will increase our competitiveness in the LED market."

Tim Wang, General Manager at Aixtron China, adds "This new order from Focus Lightings Tech validates the production worthiness of the CRIUS II-L. I am convinced that Focus Lightings will soon benefit from the large production capacity and high throughput on a proven platform, along with the low cost of ownership, presently leading in the industry." Focus Lightings Tech Inc., located in Suzhou High-tech Industry Park (SIP), Jiangsu province of China specialises in developing and manufacturing high quality LED semiconductor chips, LD laser chips, as well as in semiconductor Lightings and IC products.

At its new plant the company houses chip production lines for red, yellow, blue, green, and white LED lights, as well as an R&D centre that aims to realise 150 LM/W with proprietary technologies for mass production and to successfully step up chip production from 2- to 4-inch substrates.

Yole: LED packaging cost reduction is key

III-NITRIDE LED packaging will drive new technology and design adoption. Depending on the device type, packaging can represent 40 to 60 percent of total LED cost. As such, packaging represents the single-largest opportunity for cost reduction, which is required in order for the industry to access the "Holy Grail" that is General Lighting.

However, if you're expecting this cost reduction to come from standardisation, you can abandon all hope. The creativity of LED engineers and specificities of each application have led to an infinite number of package type and formats.

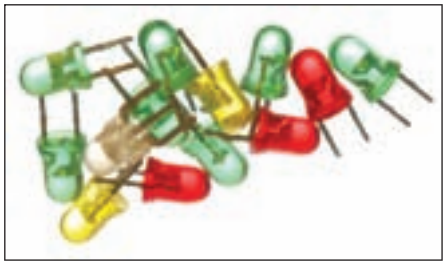
These include single or multiple chips, low and middle-power plastic leaded chip carrier, ceramic-based high-power LEDs, small and large arrays and chip on board devices. This profusion of styles is inhibiting LED manufacturing cost reduction by multiplying the stock keeping unit and preventing standardisation of the manufacturing process and the associated economies of scale.

In this context, LED manufacturers are reacting by developing new manufacturing concepts such as:

- "Design for manufacturing", which consists of trying to simplify and standardise elements whenever possible, and push differentiation as far downstream as possible in the manufacturing process.
- "Design for cost", which consists of favouring cost of ownership or cost per lumen over end performance.

"Technological developments are also impacted by the quest for cost reduction, and LED manufacturers are now searching for equipment and/or materials with the right mix between cost and performance", explains Pars Mukish, Technology & Market Analyst, LED at Yole Développement.

Also, equipment and materials suppliers are proposing more and more equipment and materials that fit these requirements, such as a laser-based dicer and a low-cost ceramic package substrate among other things. In the end, LEDs are going mainstream but are still not a mature commodity. This is good news for the entire industry, since design and materials innovation still provides opportunity for differentiation. All of this benefits the



consumer, who receives budget-friendly, environmentally friendly and increasingly credible LED-based alternatives for replacing traditional light sources.

The LED packaging materials market will enjoy a 20 percent CAGR during the period 2012 - 2017, driven primarily by package substrate and phosphors. The package substrate market will attain a CAGR of 20 percent over the aforementioned period, growing to nearly $900 million by 2017. Concerning LED phosphors, despite strong price pressure, the associated market will also enjoy double-digit growth, with a CAGR of 20 percent during the period 2012 - 2017.

In the face of intensifying competition, players are trying to differentiate themselves by proposing an increasing variety of technology options for LED packaging. Substrate material options as well as assembly and interconnection techniques abound as many companies work around the limiting patents of the established players. New players from the general semiconductor markets are proposing new solutions based on their respective capabilities. Similar to IC packaging, new technologies for LED packaging mimic the existing ones, without completely phasing them out - and there is still a lot of room for innovation, which could lead to more added-value. For such products, however, it remains paramount that the solution offers LED manufacturers an overall reduction in cost of ownership ($/lumen).

At the LED packaging equipment level, growth will return for the next three years "The LED packaging equipment market, which stagnated in 2012 due to industry oversupply, is growing again and will peak at nearly $650 million by 2016", says Pars Mukish. He adds LED packagers are still using mostly retrofitted equipment from the IC industry and relying on existing technology solutions and materials to improve LED cost of ownership and performance.

While this has allowed LED manufacturers to benefit from decades of R&D, and investments in the IC industry, it also limits the industry to a space defined by existing technology platforms which are not optimised to the specific needs of LEDs. However, the industry has gained enough momentum in 2011/2012 to entice equipment and material providers into developing dedicated solutions for LED manufacturing. Many dedicated solutions emerging from both existing and new players will allow significant reduction in LED manufacturing cost through improved yields, throughputs and material efficiency.

Korean Institute purchases Veeco MBE reactor

KOPTI's Laser-IT Research Centre and Photonics System Lab in Gwangju, South Korea, has ordered an MBE tool for high-powered GaAs-based laser diode research. Swook Hann, head of KOPTI's Laser-IT Research Centre and Photonics Systems Lab, says, "We have selected the MBE GEN20 system for our work in development of high-powered GaAs laser diodes because of its process flexibility and Veeco's impressive track record in supplying tools to the III-V laser diode market. These are critical elements for KOPTI since we are developing technologies that can be taken from lab to fab."

Jim Northup, Vice President, General Manager of Veeco's MBE Operations, adds, "KOPTI is known worldwide for developing pioneering breakthroughs which bridge the gap between pure research and industrial production. We are pleased to partner with such an important technology centre in Korea supporting the further commercialisation of high power laser diodes with our GEN20 MBE system."

IQE acquires Kopin Wireless for $75 million

UK-BASED epiwafer supplier IQE has increased it wireless market share substantially with the acquisition of Kopin Wireless, which had major customers that included Skyworks, AWSC, RFMD and TriQuint.

Kopin Wireless is a global manufacturer of heterojunction bipolar transistors (HBTs) which are used in power amplifiers, a key wireless component in mobile devices. These devices are produced using MOCVD epitaxial wafer technology. The initial consideration stipulates that $60 million will be payable in cash to Kopin on completion of the acquisition and $15 million will be payable in cash to Kopin on the third anniversary of completion.

IQE says this significantly extends the firm's market share and leadership in wireless industry supply and delivers a market leading position in MOCVD grown HBTs. Adding Skyworks Solutions, Inc., which has a long standing supply agreement with Kopin Wireless to its customer base will increase IQE's wireless market share. Skyworks' current contract with Kopin Wireless runs until the end of 2013 and guarantees a significant proportion of Skyworks' business.

Kopin Wireless also supplies HBT wafers to Advanced Wireless Semiconductor Company (AWSC), which provides foundry services to Skyworks. Other significant customers of the company include RFMD and TriQuint.

Another plus point is that Kopin Wireless' Taiwan manufacturing facility in Hsinchu, will add to IQE's global manufacturing footprint and provide the group with a strong position to in access the growing Asian semiconductor market. The company also has US based III-V operations in Taunton, Massachusetts. Significant cost synergies of at least £7 million per annum are expected from 2014. It is expected that the group will incur one-off exceptional costs of approximately £3 million in 2013 and £2 million in 2014 as part of the plan to achieve these synergies. IQE will finance the initial consideration through a new banking facility with HSBC for $40 million and $20 million from the proceeds of the placing. The deferred consideration will be paid from the enlarged group's organic cash flow.

IQE intends to raise approximately £16.5 million through a placing by the Joint Bookrunners, Espirito Santo Investment Bank and Canaccord Genuity Limited, of 56,900,961 new ordinary shares at a price of 29 pence per placing share (8.82 percent. of the group's enlarged share capital following admission).

The Directors believe that the acquisition will be earnings enhancing from the 2013 financial year onwards.

Microsemi adds to its SiC power product family

MICROSEMI CORPORATION has announced the availability of a new generation of industrial temperature, SiC standard power modules. The devices are ideally suited for use in high power switch mode power supplies, motor drives, uninterruptible power supplies, solar inverters, oil exploration and other high power, high voltage industrial applications requiring high performance and reliability. The power module family is also offered with extended temperature ranges to meet next-generation power conversion system requirements for higher power densities, operating frequencies and efficiencies.

SiC technology delivers higher breakdown field strength and improved thermal conductivity compared to silicon material. This enables improved performance characteristics in parameters including zero reverse recovery, temperature independent behaviour, higher voltage capability and higher temperature operation to achieve new levels of performance, efficiency and reliability. "We applied our extensive expertise in power semiconductor integration and packaging to deliver a next-generation family of silicon carbide power modules that deliver outstanding levels of performance, reliability and overall quality," says Philippe Dupin , general manager of Microsemi's Power Module Products group. "Our new modules also allow designers to shrink system size and weight, while reducing total systems costs."

Microsemi's new industrial temperature SiC power modules feature multiple circuit topologies and are integrated into low profile packages. The majority of the new module product family uses AIN substrates to enable isolation from the heat sink, which improves heat transfer to the cooling system.

Zephyr launch fabrication & foundry services

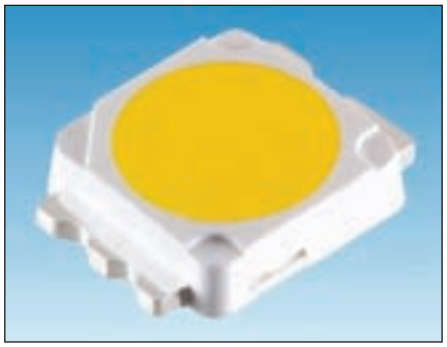
ZEPHYR hopes to meet the growing demands of III-V semiconductor companies by offering its growth, fabrication, testing and production facilities. The company uses proprietary wide-temperature III-V VCSEL-based, optical technology, to bring rugged, high-performance optical interconnect solutions to demanding mission-critical applications. The firm is now also providing foundry services to the compound semiconductor industry. These include III-V MBE growth, compound semiconductor characterisation including photoluminescence, X-Ray diffraction, Hall-Effect, multispectral reflectivity, multispectral ellipsometry, and Surfscan. Zephyr is also offering optoelectronic component testing.

Zephyr Photonics CEO Tom Steding, states, "Our Semiconductor Fabrication and Foundry Services business unit was formed to match the growing demands of fabless semiconductor companies and semiconductor companies with our growth, fabrication, testing and production capabilities. Zephyr Photonics currently provides time-critical device development, testing and production services for a number of key industry customers." Among Zephyrs' unique resources is its 10,000 square foot cleanroom in its Zephyr Cove facility, which includes a wide variety of growth, processing, testing, and production equipment. The facility is accredited by DMEA as the only U.S. Trusted optoelectronic foundry and IC supplier; and is ITAR compliant and ISO 9001:2008 certified. Zephyr Photonics' team combines more than 100 years of relevant experience and works seamlessly with its customers.

"Zephyr Photonics is excited about this opportunity to play a key fabrication role in the semiconductor industry, enabling our customers' innovation, and improving their time to market by leveraging our experience, in-depth knowledge, process libraries, IP and extensive facilities. Our customers couldn't have been clearer, voicing their enthusiasm with our flexibility, responsiveness, time to market, and breadth of experience, which helps them to improve their own execution and downstream customer satisfaction. We believe our new business unit will grow to be a very important part of our overall corporate mission, to be a high-performance, specialised and trusted foundry partner," concludes Tim McAllister, VP of Business Development.

Toshiba launch GaN-on-silicon LED packages

TOSHIBA CORPORATION has started sales of white LED packages that are claimed to offer makers of general purpose and industrial LED lighting solutions a cost-competitive alternative to current LED packages. According to Toshiba, LED chips are typically produced on expensive 2- to 4-inch sapphire substrates. Toshiba and Bridgelux have developed a process for manufacturing GaN LEDs on 200mm silicon wafers, which Toshiba has brought to a new production line at Kaga Toshiba Electronics Corporation. This is a discrete products manufacturing facility in northern Japan. Deployment of Toshiba and Bridgelux's new GaN-on-silicon technology to produce LED chips has



allowed Toshiba to replace sapphire substrates and to produce the chips on a much more cost-competitive silicon substrate. Going forward, Toshiba will promote product development and global sales toward securing a 10 percent share of the world market in 2016.

The LEDs, known as the TL1F1 series, operate at 1W and measure 6.4 mm x 5.0 mm x 1.35 mm. The light flux is 112 lm at 350mA.Planned production capability is 10,000,000 units per month.

Compound semiconductor market slow

DESPITE some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market. With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance. This is according to Strategy Analytics' GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review July - September 2012: Microelectronics."

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth. The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents. "The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs).

"However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry". Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

Trinity to guide ARC'S sapphire furnaces into a new era

AFTER qualifying sapphire substrates at many LED chip companies, Jiangsu Trinity Material Co., Ltd. continues to further improve the efficiency of ARC Energy's CHES furnaces.

ARC Energy is currently working on the upgrades to lower costs and increase equipment productivity.

"After our success in qualifying material at LED chipmakers, we are seeking further improvements in our efficiency," says Jamin Sheng, chief executive officer for Trinity Material. "Our partnership with ARC Energy will result in lower costs and increased equipment productivity."

CHES furnaces allow seamless upgrades without investment in entirely new furnaces. ARC Energy is currently working to further improve sapphire production costs by lowering consumable costs, reducing power consumption, and increasing equipment productivity. The company's CHES upgrades are targeted to further reduce costs in mid-2013. Trinity Material is poised to take advantage of these upgrades as they become available.

"In this challenging LED market, it is important for us to keep innovating, including supplying the latest technology

upgrades to our partners such as Trinity Materials," adds Rick Schwerdtfeger, co-founder and chief technology officer for ARC Energy. "We look forward to offering additional productivity and cost of ownership enhancements to CHES products in 2013."

Trinity Material Co., Ltd. specialises in research, production and sales of LED grade sapphire substrate material. It has two 100% owned factories: Jiangxi Trinity Material Co., Ltd. and Jiangsu Trinity Material Co., Ltd. Trinity Material produces 2 inch to 8 inch sapphire ingots for LED chip manufacturing. Headquartered in Nashua, N.H., the Advanced Renewable Energy Company, LLC (ARC Energy), was founded in 2007 to commercialise cutting-edge technologies for LED and other clean energy markets.

GaN power pioneer Eric Lidow passes away

INTERNATIONAL RECTIFIER has announced that Eric Lidow passed away on January 18th, 2013. Lidow co-founded International Rectifier (IR) in 1947 and served as chairman of the company's board of directors until his retirement in May 2008.

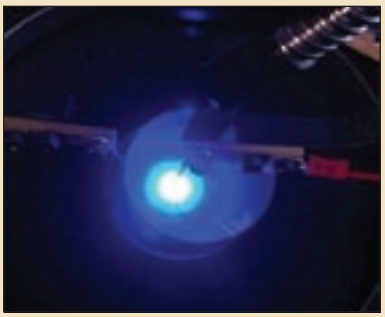
Over more than six decades, Lidow transformed IR from a start-up company that developed selenium photoelectric cells and selenium rectifiers into a major firm in power management technology. He was an innovator in GaN power device research. IR now produces thousands of analogue, digital, and mixed signal integrated circuits and other advanced power management technologies and products. Eric Lidow served as the Company's Chairman and CEO Officer until 1995, after which time he assumed the position of Executive Chairman.

"Eric was a highly respected pioneer in the power semiconductor industry," says President and Chief Executive Officer, Oleg Khaykin. "The development and growth of International Rectifier was a great source of pride to him and as we continue to grow as a company, the legacy of his leadership during his 60 years at IR will remain. Everyone at International Rectifier wishes to send their heartfelt condolences to Eric's family at this time of great sorrow."

BluGlass demonstrates low-temperature p-GaN

BLUGLASS has successfully grown p-type GaN, an essential material that make up the top layers of a nitride LED using its low temperature RPCVD process.

Preliminary testing has been carried out on the sample using a 0.5mm diameter size p-type indium contact. The light output was measured with a UV-detector positioned under the wafer calibrated at the wavelength of the light emission. At 20 mA and 4.7 V, the light output was 270 μW (light emission at 458 nm with a full width half maximum of 19 nm).

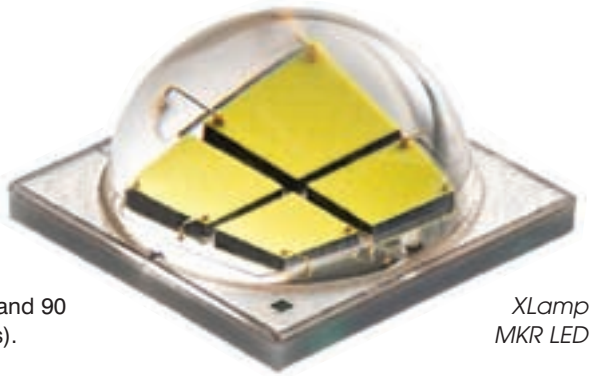


At 50 mA and 5.5 V, the light output was 1.23 mW (light emission at 456 nm with a full width half maximum of 18nm) - the current was applied continuously for over an hour without the loss of function of the device.

Demonstration of light emission from an RPCVD p-GaN layer grown on a MOCVD grown multi-quantum well structure.

Recently, at the company's AGM, BluGlass outlined that it was looking to demonstrate p-GaN and identified a number of steps in order to demonstrate improved LED efficiency with a low temperature process. BluGlass CEO, Giles Bourne commented, "While these results are preliminary, they represent highly encouraging progress, ahead of our expectations towards our next major milestone to prove that a low temperature technology can improve the efficiency of an LED."

Cree raises the bar with 200 lumen LED



XLamp MKR LED

TWO YEARS after breaking the 200 lumens-per-watt (LPW) R&D efficacy barrier, Cree says it has delivered another industry first with the introduction of the Cree XLamp MK-R LEDs.

The new MK-R LEDs leverage the SC^3 Technology next generation LED platform to deliver up to 200 lumen-per-watt (at 1W, 25°C) LEDs.

The new MK-R LEDs make the next generation of 100+ lumens-per-watt system possible for high lumen applications, including outdoor and indoor directional applications, such as halogen replacement lamps. MK-R LEDs are available in EasyWhite colour temperatures, providing one of the LED industry's best colour consistencies for designs that use only one LED.

For systems that use multiple LEDs, MK-R enables manufacturers to use fewer LEDs while still maintaining light output and quality, which translates to lower system cost.

"It's amazing that Cree is able to achieve a 200 lumens-per-watt LED so quickly," says Nicola Vendrame, CEO, Linea Light group. "The high efficacy of the MK-R LED means that we can drive the LED harder for more light output without creating heat issues. In addition, the MK-R LED has the right combination of size, colour consistency and optical control to enable the next generation of performance in our indoor directional luminaires."

"Cree's relentless innovation continues to push the boundaries of what is possible with LED lighting," adds John Edmond, Cree co-founder and director of advanced optoelectronics. "The MK-R LED is another game changer for the industry. An LED with this level of performance can accelerate the development of high output lighting applications and could enable applications we haven't even thought of yet."

The MK-R LED has a 7mm x 7mm footprint with a 6mm optical source and delivers up to 1600 lumens at 15W, 85°C. Characterised at 85°C, the MK-R component is available in 2700K to 7000K colour temperatures and offers minimum CRI options of 70, 80 and 90 (at selected colour temperatures).

All change for epiwafers

Despite a major re-shuffle in the epiwafer market, analysts predict a stable year for the compound semiconductor industry. Compound Semiconductor talks to Strategic Analytics directors, Eric Higham and Asif Anwar, to find out more.

ON JANUARY 10th this year, Wales-based IQE, struck a US$75 million deal to buy the III-V epiwafer manufacturing business, Kopin Wireless, of US-based Kopin. The move boosts the epiwafer heavyweight's market share to some 50% and secures custom from Skyworks, AWSC, RF Micro Devices and TriQuint.

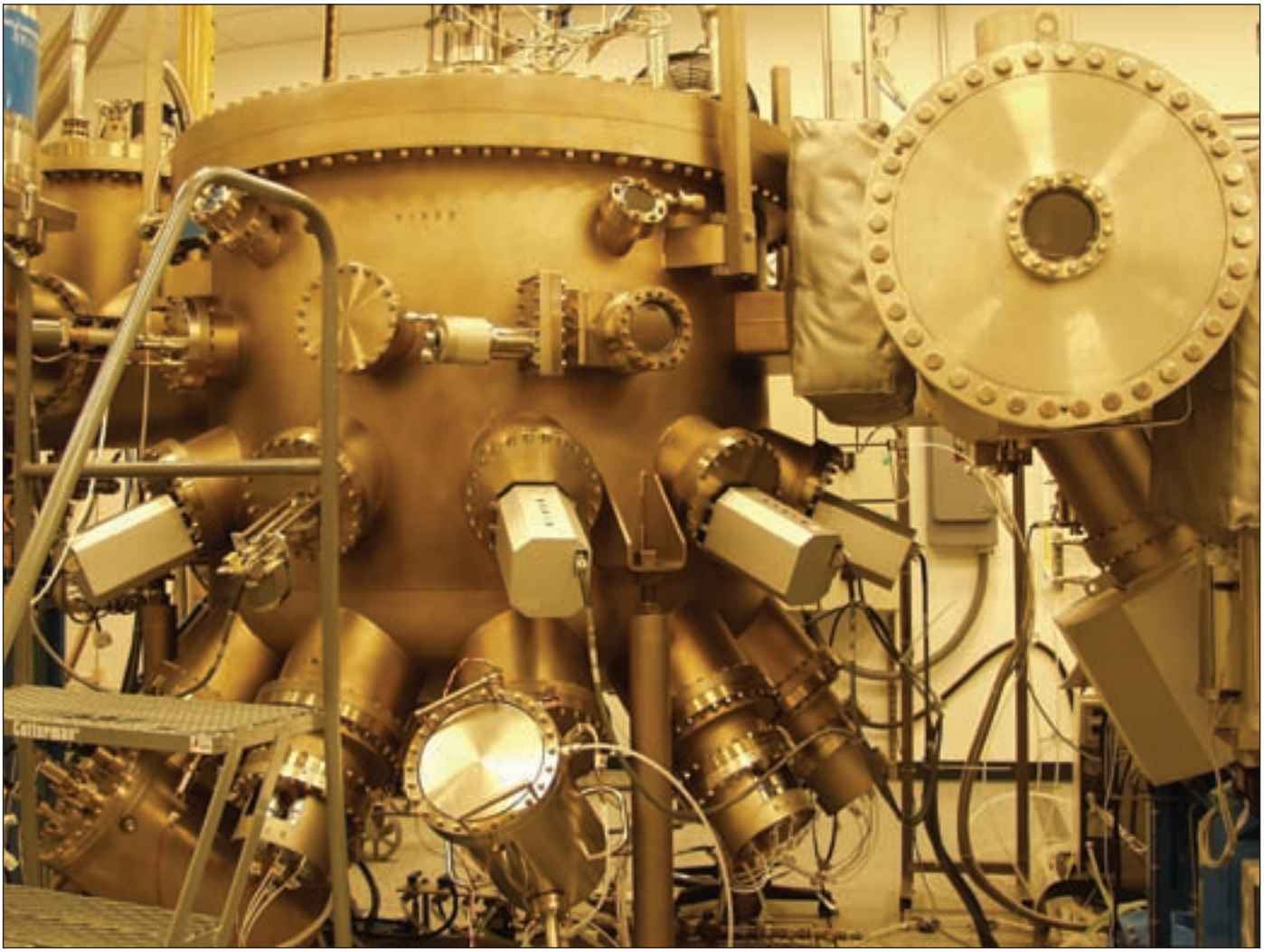
In recent reports, IQE chief executive, Drew Nelson, has said: "Our strategy is to supply as much as possible to as many as possible. That way, if Apple changes supplier, it doesn't impact us too much."

And indeed, its latest deal follows a long history of acquisitions aimed at achieving market dominance. While the business started life as an MOCVD outfit, it merged with US-based epitaxy business QED in 1999 to gain a firm MBE presence.

Subsequent acquisitions including Emcore's MOCVD arm, MBE Technology, Wafer Technology, Galaxy Compound Semiconductor and finally RFMD's MBE business built the company's market share in both epiwafer segments, but only delivered market dominance in the MBE sector. Not any more.

"I think this now arguably puts them as number one in MOCVD as well as the clear and dominant leader in MBE," says Strategic Analytics analyst and director, Eric Higham. "If market share percentages remain the same as 2011, IQE holds around twice the share of the second place supplier in the epitaxy world, so yes, they have just become very dominant."

Higham's colleague, Asif Anwar, agrees adding: "This acquisition definitely cements IQE's and solidifies its position in the MOCVD



MBE tool: IQE's key strength no longer lies in just MBE-made wafers, the Wales-based wafer maker now leads the III-V market in MOCVD fabrication too. (Credit: IQE)

market segment. The only competitor left now is VPEC."
So what impact will IQE's muscle have on the compound semiconductor industry? The company can now just as easily perform MOCVD processes as it can MBE, supplying the necessary wafer for whatever device.

As Higham points out: "Being so strong in both epitaxial deposition techniques could give the business the necessary critical mass to capture even more market share. They'll be seen as the proverbial one-stop shop, this is not something I would have predicted."

But Anwar does not expect businesses will see the epiwafer market as an IQE monopoly. "IQE's strategy has always been to acquire a company but then run that business as it was," he says. "For example, MBE Technology retained the good relationships it had with its suppliers and customers, I am assuming that the same will take place with Kopin."

But will IQE's successes in grabbing MBE epiwafer market, largely to fabricate pHEMT switches, prove short-lived as the likes of SkyWorks and RFMD trade the technology in for SOI. Ultimately, RFMD's MBE sale signalled the firm's preference for the SOI handset switch. Not so. As Higham emphasises, some companies, such as TriQuint, are sticking with pHEMT for switches.

"Our studies show that the biggest decline in pHEMT has taken place already," he says. "Yes, we're anticipating slower growth than we will see for the MOCVD segment, but still some growth. Lots of equipment is installed and it wouldn't make sense to abandon this."

Indeed, Anwar believes components makers will continue to use both SOI and pHEMT switches for the foreseeable future, selecting which technology is best for a specific application and market. Still, MOCVD-made HBT devices is where the action will be.

Multi-mode, multi-band wireless handsets now require broadband performance, a demand that will only fuel the growth of compound semiconductor technologies, rather than silicon-based devices.

"RFMD recently bought Amalfi to hedge its bets and meet a demand for silicon-based power amplifiers," says Anwar. "But as you go to higher and higher frequencies and more linearity, that plays to the advantage of compound semiconductor technologies."

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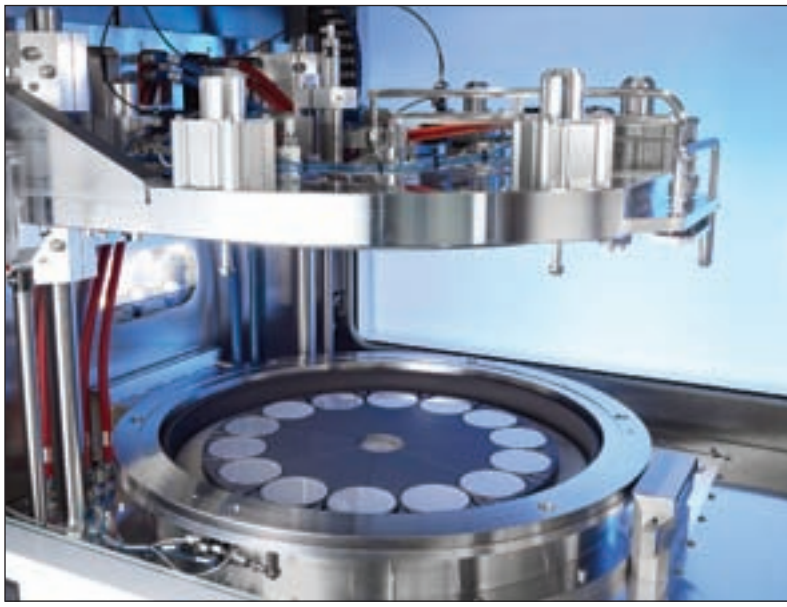
MOCVD tool makers flounder as LED lighting stalls

A heady mix of Chinese subsidies, disappointing LED lighting sales and near-saturation in back-lighting markets has tipped makers of MOCVD reactors off-kilter. Where next for the equipment manufacturers? asks Compound Semiconductor.



When will sales of MOCVD equipment, such as Aixtron's Planetary Reactor, gather pace?

WITHOUT A DOUBT, 2012 was a turbulent year for manufacturers of MOCVD reactors for LEDs. Buoyant demand in LED back-lighting for LCD displays, expected increases in general LED lighting sales and hefty Chinese government subsidies fuelled equipment sales from 2010 to 2011. But then came the crunch. As Alice Tao, IMS Research analyst puts it: "The back-lighting market is almost saturated, the lighting market has not taken off as most people thought and according to a government announcement I heard, subsidies stopped in the second half of 2011."

The triple whammy saw MOCVD sales plummet from late 2011, and come June 2012 industry analysts were warning of rocky times ahead. By October 2012 Germany-based Aixtron and Veeco, US, posted falling profits, blaming LED markets. Given this course of events, equipment makers are now sitting tight, waiting for excess capacity to clear and the general LED lighting market to finally take-off.

"The adoption of global LED lighting is gaining traction, but we are not yet at a point where LED manufacturers have started to significantly invest in new capacities," explains Rainer Beccard, vice-president of marketing at Aixtron. "Chinese subsidies created an unnatural equipment demand and excess [capacity] is being absorbed, but the story behind global LED lighting hasn't changed. For us it's a question of when, not if, LED lighting demand will translate into demand for equipment."

But this is where the future looks very uncertain. When exactly will China's excess equipment capacity be absorbed so MOCVD sales can pick-up? "China has started issuing initial subsidies to make the price of LED lighting products more attractive, so manufacturing and sales of LED lamps are subsidised rather than the purchase of equipment," highlights Beccard.

Such a move from local or central Chinese government could boost the adoption rate of LED lighting, and even help to clear an inventory backlog. As Beccard adds: "We've already seen something similar in Japan, post-Fukushima, where public grants and subsidies were put in place for LED lighting."

New subsidies or not, recent improvements in LED outputs twinned with falling lamp and bulb prices, could kick-start a recovery sooner rather than later. Beccard is banking on improvements this year, while IMS analyst Tao, believes capacity will be cleared a little later. "We think that LED lighting applications will really take off in 2014 and there will be good opportunities for equipment suppliers from 2014 to 2016," she says.

However, Tao believes some companies will fare better than others. "Veeco's global market share has now exceeded Aixtron's, mostly due to the China market," she points out. "We've asked LED makers why they choose a certain tool, and according to them, Veeco's tools are easier to run. China-based businesses tend to have less experienced technical staff, so most new entries here go for Veeco."

But developing the preferred tool or not, the future looks healthy for all makers of MOCVD equipment. Come 2014, Tao asserts LED lamps will make up a hefty 66 pecent of the lighting market as incandescent and fluorescent lights fade away. Surely this bodes well for reactor sales over the coming years?

As Beccard says: "We are not completely relaxed about the downturn but we know it's not a disaster. This is all about managing it. Its intensity and length is a bit different from what we have seen before but we know the prospects are there for things to get better."

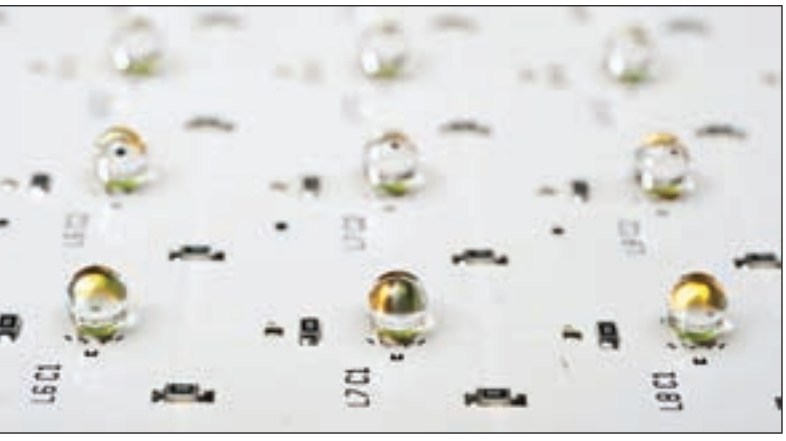
Novel solar cells weather industry doldrums

GaAs photovoltaic developer, Semprius, looks set to shine in a solar market where so many are fading, reports Compound Semiconductor.

AFTER YEARS OF DEVELOPMENT, the concentrated solar power sector finally looks set to take off. Middle East governments recently pledged to spend tens of billions of dollars on large-scale plant at the United Nations Climate Change conference, validating analysts' forecasts of healthy growth.

But just as the market looks promising, the CPV companies are floundering. California-based market leader Amonix recently closed its Nevada manufacturing site, swiftly followed by the demise of Greenvolts, also based in California. And then a few weeks later, San Jose-based SolFocus announced plans to sell, dismissing half of its staff, some 35 employees.

North Carolina-based CPV manufacturer, Semprius, has bucked this trend. In September 2012, the firm opened its first manufacturing plant in North Carolina, employing 50 staff poised to produce some 6 MW of panel a year. And then in November, the company revealed that US-based Pratt & Whitney Rocketdyne is to install a 200 kW system comprising 2400 of its modules at the US Department of Defense Edwards Air Force Base, in the California south-west desert.



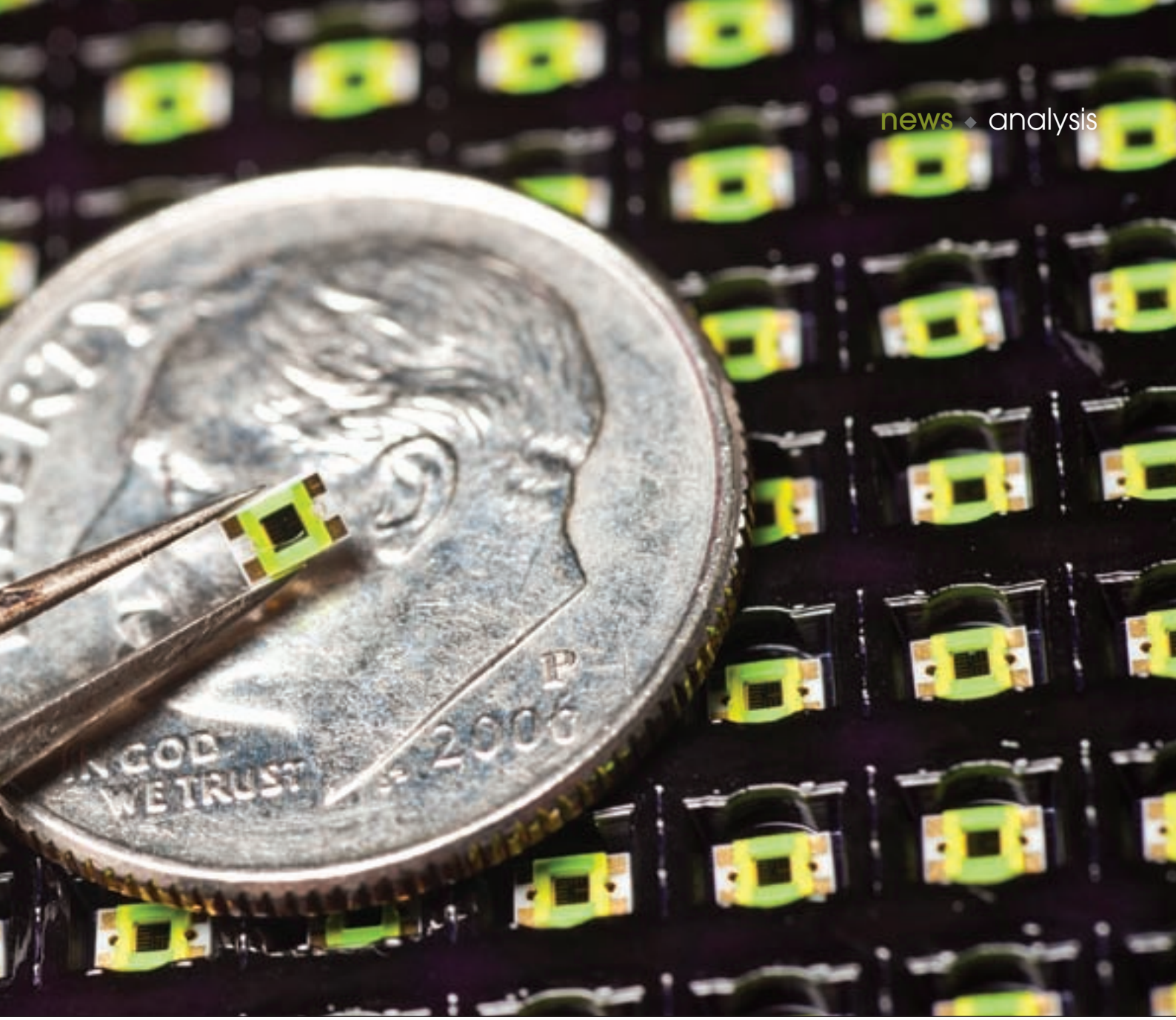
Semprius modules use hundreds of GaAs solar cells with lenses to concentrate light, boosting the efficiency and making the exotic photovoltaic affordable

As Russ Kanjorski, Semprius's vice president for business development, tells *Compound Semiconductor*: "This is the perfect location to test our technology for future applications... and is just one commercial-scale project we expect to do in 2013."

So what's its secret? On its website, the company claims to have combined very high module efficiencies – up to a dazzling 33.9 percent – with industry-standard, low-cost microelectronics manufacturing techniques. The company's modules comprise hundreds of triple-junction GaAs solar cells mounted on an industry-standard backplane.

Measuring only 600 μm by 600 μm by 10 μm, each cell is minuscule compared to your standard centimetre-sized cell and is designed to convert a relatively wide part of the solar spectrum into electricity, compared to silicon.

Kanjorski believes the company's success is also down to the cell fabrication process, which allows repeated use of the GaAs wafer. Semprius co-founder John Rogers has pioneered a 'micro-transfer printing' technique in which a sacrificial layer is first grown on a GaAs wafer, followed by epitaxial growth of thousands of triple-junction cells. Then, in a massive parallel process, a rubber stamp selectively picks up and transfers an array of cells to an alumina



The GaAs is the black square on each cell; Semprius's micro-transfer printing process is poised to make these exotic solar modules cost effective

receiver substrate. The stamp is then re-positioned over the GaAs wafer, before picking up and transfering more cells to another receiver substrate.

"We receive GaAs wafers from companies like Spectral Lab and Solar Junction and process these into cells," he explains. "We don't cut up the entire wafer as other [CPV manufacturers] do, we just take the top layers and then re-use the substrate."

Kanjorski won't reveal how many times an actual wafer can be used, only commenting 'multiple times', but he does add that a single 6-inch GaAs wafer can be used to fabricate enough cells for up to 50 modules. "We re-use the majority of the wafer, this is an important cost-saving when creating very small cells," he adds. A thin film metallization process follows to form the cathode and anode interconnection, with receiver substrates then surface mounted onto printed-circuit boards using industry standard solder re-flow. These are then placed beneath primary and secondary lenses that concentrate sunlight 1100 times.

"Our optics are different," adds Kanjorski. "We have a primary lens that concentrates the light and a novel secondary optic – a simple glass bead - that can keep the light on the cell if you are slightly off-axis from the sun."

Then factor in that Semprius' modules do not require cooling systems – the small cells generate less heat – and the cost-savings really adding up. So, perhaps this explains how, in just seven years, the North Carolina start-up has bagged some $40 million in funds, built a 6 MW pilot plant and now intends to ramp annual production to 80 MW come 2014.

Kanjorksi isn't phased by the CPV industry's mixed fortunes. "This is a consolidating period of the industry, but it's not unique to concentrated photovoltaics or even solar power in general," says Kanjorksi. "We've kept our heads down on developing our modules and have tried to develop the most cost effective, high performance module we could. We think it's the best on the market and now we have to ramp that up."

SiC: Survival of the fittest?

Following the demise of SemiSouth, what does the future hold for other SiC power transistor manufacturers, asks Compound Semiconductor.

In March 2012 , it announced a $18m capacity expansion; two months later, it sampled the industry's first 650V SiC JFET power transistors. But in October 2012, the US-based developer of SiC high power transistors, SemiSouth, closed. To say the sudden shutting of the Mississippi University spin-off was a surprise and a disappointment to many in the industry would be an understatement.

The possibility of a buyout is highly unlikely, given that chief-technology officer, Jeffrey Casady, has moved to SiC semiconductor heavyweight, Cree. So what will be the impact on the SiC device industry? As Philippe Roussel, analyst at France-based Yole Développement puts it: "This is bad news for the industry. SemiSouth was promising a lot, they were a key competitor to Cree, and finally they fail. Psychologically speaking, this is not a good sign."

Roussel suggests a key reason for SemiSouth's demise was its size. With a headcount of at least 100, the company was significantly larger than its counterparts; for example, United Carbide and GeneSiC, both in the US, hire no more than two dozen employees. And while many express shock, industry re-shaping has been rife with the last two years peppered with mergers and acquisitions. For example, in 2011, Fairchild bought TranSiC, with Infineon buying SiCED soon afterwards.

Despite industry consolidation, myriad device makers remain, jostling for market-share in an industry that arguably has yet to truly take off. While manufacturers of PV inverters have been snapping up SiC devices at an unexpectedly high rate the electric vehicle industry has yet to do the same. The jury is still out on whether automotive-related businesses will opt for SiC transistors or skip the technology and adopt GaN or silicon variants instead. And in the meantime, Roussel expects more industry casualties. "I have a suspicion that other companies may close down as well. A big question mark still exists whether SiC will be implemented in the electric vehicle and hybrid electric vehicle market," he says. "Until this happens, the market size will be limited. Is there enough space here for ten to fifteen companies? For the big names such as Infineon and Cree I have no doubt they will survive, for smaller companies, I just don't know."

Will the likes of Toyota and other electric automotive-related manufacturers choose SiC transistors? Device manufacturers can only wait and see. Photo credit: Mariordo (Mario Roberto Durán Ortiz)

Industry winners

One factor set to influence which industry player will survive is its flavour of transistor. To date, businesses are focusing on MOSFETs, JFETs, BJTs and IGBTs. Without a doubt, Cree leads the MOSFET pack, followed by the likes of Mitsubishi Electric, Fuji Electric, Rohm, Toshiba, ST Microelectronics and Shindengen, Japan. Meanwhile, Shindengen and Fairchild are also working on BJTs while United SiC, for one, forges ahead with the IGBT. SemiSouth was focussing on SiC JFETs – is this where it went wrong? The business frequently touted easier and cheaper manufacturing as a key advantage of this transistor but on the flip-side its vertical structures required non-standard driver schemes. In contrast MOSFETs are discrete devices offering chip-to-chip replacement with an IGBT or silicon MOSFET.

"JFETs are normally-on devices, and as far as we know, this is not welcomed in the industry," says Roussel. "SemiSouth designed a normally-off device that was going through qualification. This is a guess, but maybe the product didn't reach expectations, especially compared to the MOSFET. Its JFET was unique."

"We now have two MOSFET providers – Cree and Rohm – delivering off-the-shelf products," he adds. "This is the holy grail for system integrators... so maybe the industry asked the question, why should I choose your JFET?"

Recently, Cree unveiled its first commercially available SiC power module, providing proof that life in the SiC device industry goes on. But as Roussel concludes: "The market will live without SemiSouth, but will the industry become cautious and think, 'this company was so wonderful so why did it fail?' We now have to convince manufacturers that this SiC IC technology is robust and can deliver."

SiC MOSFETs tipped for the top

Which SiC transistor will industry choose? Compound Semiconductor talks to Jeff Casady, ex-chief technology officer of SemiSouth and now at Cree, to find out more.

IN NOVEMBER 2012, US-based Cree unveiled a 1200 V SiC power module based on MOSFETs and Schottky diodes. Operating at up to 100 kHz frequencies and targeting high power converters, industrial motor drives, solar inverters and uninterruptible power supplies, the device is significant. It not only joins the industry's increasing army of SiC devices targeting tomorrow's high voltage, energy efficient power converters, but crucially, it uses MOSFETs.

Jeff Casady, one-time chief technology officer at recently shuttered SiC JFET developer, SemiSouth, and now product portfolio planning manager at Cree, says we can expect more: "As far as Cree and the rest of the market goes, we are now seeing substantial performance, availability and reliability improvements in MOSFETs, almost on a weekly basis. Costs are falling fast and there are going to be several more announcements coming early next year from Cree. I imagine our [MOSFET] competitors, primarily Rohm, will be doing the same thing."

For more than a decade, myriad organisations have honed SiC semiconductors to tolerate higher voltages and temperatures than silicon, while ensuring the devices switch more rapidly with lower losses. Cree, Rohm, ST Microelectronics and many more have focused on the tried-and-tested MOSFET, Infineon is forging ahead with its JFET, Fairchild recently released a 1200V SiC BJT, and United SiC is working on IGBTs. But with industry consolidation setting in – as evidenced by SemiSouth's recent demise – will this diverse range of transistors remain? As Casady now says: "When you talk to customers, they always wanted the MOSFET."

According to Casady, this transistor was once a technical challenge for SiC, but not any more. "We're seeing a lot of aggressive design-in activity and we think the MOSFET market in SiCs is going to be very large," he adds. So why does he think the MOSFET could emerge as the hot favourite? Put simply, the device is a known entity for designers used to driving silicon HBTs and MOSFETs.

"These people want a device to replace silicon, and the SiC MOSFET is something they really understand," explains Casady. "They understand how to drive it and it's also got a body diode as most silicon sets do. We know that competitors looking at bipolar [transistors] and JFETs have a much more difficult conversation with their customers as they are not used to those parts."

But it's not all about silicon-based semiconductors. Manufacturers of GaN ICs have already made in-roads into higher voltage markets, with 600 V devices readily available. Many players assert that 1200 V GaN ICs will be good-to-go within a few years, and crucially, the cost of these devices will drop more rapidly than SiC

SiC transistors allow high efficiency, compact, light weight systems, cutting total system costs in applications such as solar power. Credit: USAF

versions. Could the GaN IC outpace both silicon and SiC in high power, high voltage applications, including the all-important hybrid electric vehicle market? Casady thinks not. Focusing on electric vehicles he says: "I don't think GaN will do well here as the reliability requirements are so stringent."

As he asserts, SiC devices have been in the market for at least a decade – compared to the few years notched up by GaN – and are already used in high reliability applications from solar and wind turbine inverters to industrial power supplies."Manufacturers from the automotive market needs years of field data from these high reliability markets before they choose a new technology," he says. "[SiC] is already going into markets that require twenty years of reliability [data]. It will be really challenging for GaN to come in and do that."

But perhaps most pertinent is that Casady's new found employer has a choice. "We could choose to use GaN or SiC in any of these applications," he adds. "But for hybrid electric vehicles, and all these 600V and higher power electronics applications, from my vantage point, it seems SiC is the clear choice."

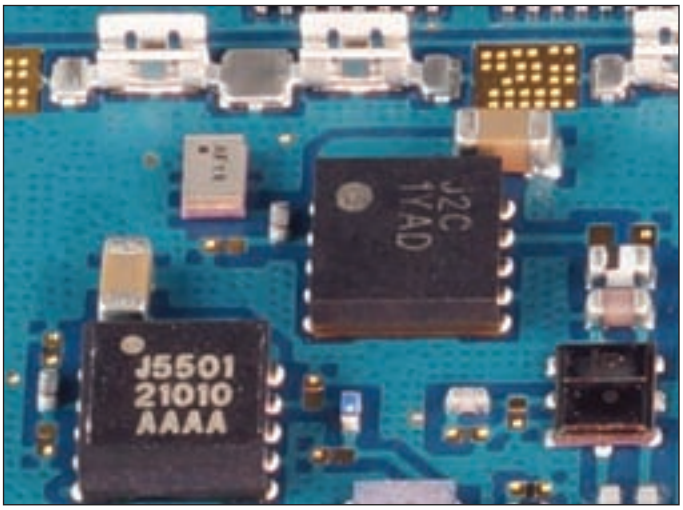
CMOS amplifiers get ready to kick GaAs

Samsung's Galaxy smartphones are amongst the first mass-produced 3G handsets to feature high-performance CMOS power amplifiers. Will silicon displace GaAs in this sector ?

2012 WAS A GOOD YEAR for Texas-based Javelin Semiconductor. Following a string of announcements that South Korean IT giant, Samsung Electronics, had chosen its CMOS power amplifier for Galaxy smartphones, the wireless IC start-up has at last proven that CMOS can rival GaAs in the 3G handset market. As Brad Fluke, Javelin chief executive says: "We are now shipping in numerous handsets... manufacturers will be able to [take advantage] of the benefits of our PAs across all 3G designs worldwide."

But will they? And if they do, what does that mean for GaAs-based power amplifier heavyweights such as Avago, TriQuint, RFMD, Skyworks and Anadigics?

As part of his 'Samsung Galaxy Appeal Teardown', Jim Mielke, vice-president of engineering at ABI Research, US, showed that the Javelin CMOS power amplifiers matched, and even outperformed, GaAs counterparts in some tests. For example, the CMOS power amplifiers equalled GaAs efficiency across all power levels up to 22.5 dBm, and actually beat GaAs counterparts at lower power levels. Cost-wise, both power amplifiers can be manufactured for less than $0.40. However, GaAs power amplifiers are significantly smaller than CMOS equivalents, and as Mielke adds: "Achieving efficiency at higher power outputs is still an issue for CMOS power amplifiers, although [the technology] is getting better and that's why Javelin has managed to develop the 3G power amplifiers."



Rival semiconductors: The Javelin J5501 CMOS B1 PA alongside a BII GaAs PA (J2C) Credit: Business Wire)

Efficiency versus integration

The Javelin CMOS 3G power amplifier is based on a mixed-signal architecture, including an input matching network, tunable bandpass filtering – to reduce interference between wireless interfaces such as WiFi and Bluetooth – and an output matching network.

The device also integrates the necessary circuitry for power regulation, bias and power control. And this could be the killer for GaAs. While CMOS struggles to maintain efficiency at higher power outputs, the potential to, say, integrate the power amplifier and transceiver in a single chip may yet be the biggest draw for designers who could even choose to trade GaAs efficiency for CMOS integration.

"You can do much higher levels of integration in CMOS and maybe someday all components will be on one device," comments Mielke. "That will never happen with GaAs."

But Mielke will not commit to a silicon take-over yet. First, he's closely watching how the industry responds to the imminent launch of a CMOS power amplifier from US-based wireless chip-set leader, Qualcomm. He believes that if the company's amplifier is a success, alongside the existing wins from Javelin and Black Sand Technologies, CMOS power amplifiers can expect single digit market share numbers next year, with GaAs maintaining at least 90 percent of the market.

"But if this [CMOS] market is as successful as it looks like it could be, these figures could almost flip flop, so in the next five years, CMOS could have an 80 percent market share," he adds. "And I would expect this trend to carry on to 4G"

Past experience indicates that once a CMOS solution emerges to replace a rival compound semiconductor technology, industry has tended to move *en mass* to the silicon implementation. Will history repeat itself? As Mielke points out, CMOS has been trying to make its mark in power amplifiers for a long time and still hasn't quite made it.

"But then I look at the growth of components in the RF area as well as antenna switches and almost everyone has transitioned to CMOS," he adds. "I can see it happening in the power amplifier sector too. I think it's for real this time."

Emerging markets to save sapphire substrates?

As sapphire substrate makers brace for a year of consolidation, 2013 could deliver the killer application.

WILL 2013 be a year of two halves for manufacturers of sapphire substrates? Overcapacity and falling substrates prices look set to trigger industry consolidation but emerging applications, including RF antenna switches and even smartphone display covers, could soften the blow.

"Right now it is very difficult for sapphire substrate makers to be profitable," says Eric Virey, senior analyst for LED devices and materials at Yole Développement. "In the last couple of years we've seen lots of new entrants in the market. Demand for substrates has been increasing, but not as fast as capacity, so now prices are fairly low."

As Virey points out, 2-inch wafer prices have reached rock bottom while prices have also plummeted for 4-inch wafers. "It's still possible to make money on 6-inch wafers, but competition is increasing and market prices are also coming down; in most cases prices will be below $200 per wafer," he adds. Slow substrate demand from LED manufacturers has also intensified market competition, and now, industry attrition and consolidation looks set to be the only way forward.

Virey expects new entrants from China,Taiwan and Korea will fall first. As he points out, around two years ago these players were quick to adopt turnkey crystal growth equipment developed by Eastern Europe manufacturers, despite having little if any experience of growing crystals.

"[Turnkey] equipment can produce high quality crystals, but still has a learning curve," he says. "I've heard horror stories of companies getting very low yields... certainly a lot of early adopters in Taiwan and Korea struggled before getting yields right. So a lot of newcomers may disappear even before selling a single wafer."

Virey also suspects more successful players will consolidate, despite qualifying crystals and ramping up production with a reasonable cost-structure. For example, Taiwanese wafer maker Sino-American Silicon Products (SAS) has already merged its sapphire substrate unit with Crystalwise Technology, and more of the same is expected from Taiwan as well as China and Korea.

But while sapphire substrate makers from the West watch events in the East unfold, surely all are scrutinising what the LED industry will do next. Today, more than 80 percent of LEDs are fabricated on sapphire substrates, but as LED manufacturers push the industry to produce 8-inch wafers and beyond, many are also eyeing silicon substrates with a view to fabricating LEDs on depreciated CMOS equipment and slashing manufacturing costs.

"I would say that pretty much every single tier one LED maker is carrying out research and development into GaN on silicon. They simply can't afford not to look at it," says Virey. "But this doesn't mean they have put silicon on their roadmaps." With manufacturing yields for GaN on silicon still a challenge, an industry transition to silicon doesn't yet make economical sense, and as Virey adds: "I'm also not expecting any impact from GaN-on-GaN in the short term... the price of substrates also needs to come down a little bit."

However, as Virey is eager to point out, there is more to sapphire substrate manufacturing than LEDs. US-based Peregrine Semiconductor has already achieved vast success with its sapphire-based antenna switches (see p. 55). The company has shipped more than one billion silicon-on-sapphire RF switches, which have been have been designed into some of the most well-known smartphones, including the iPhone 4S. But while the company is now developing sapphire-based power amplifiers and tunable RF filters, which can only bode well for substrate makers, the best may be yet to come. The last year has seen a lot of excitement over the possible use of sapphire as a replacement for cover glass in mobile phones. Prototypes are reported to exist and if these reach the market place, the impact on the industry will be profound.

In 2012, the smartphone market reached nearly 0.9 billion units. Given a typical smartphone size of 65 cm^2, nearly 59 billion cm^2 of glass would have been used in smartphones in that year alone. If you take into account that in the same year the LED industry consumed a much smaller 970 million cm^2 of sapphire, the impact of a switch from glass to sapphire is clear. As Virey puts it: "Even a 5 percent adoption of sapphire in smartphone displays would have manufacturers demanding much larger volumes of sapphire than LED manufacturers. It's too early to say what will happen, but I strongly believe by the end of this year we could start seeing some smartphone models using sapphire."

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Agenda Day 1 4th March 2013

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Chaired by

Dr Andrew Nelson, IQE President and Chief Executive Officer

Joined BT Research Laboratories in 1981, leading the group responsible for the development of MOCVD technology for the manufacture of opto-electronic devices for optical fibre communications. He subsequently managed the technology transfer from BT to Agilent. Together with Mike Scott, he founded EPI in 1988, becoming Managing Director in 1991 and Chairman and Chief Executive Officer in 1996. Dr Nelson was appointed Chairman and CEO of IQE Plc in April 1999 and became CEO in February 2002 when he split his role and Dr Godfrey Ainsworth was appointed to the role of Chairman.

Keynote speaker

Dr Wilman Tsai, Intel Corporation, Program Manager of Technology Manufacturing Group, Intel

III-V CMOS for High Performance & Low Power Logic Devices

To continue CMOS device scaling per Moore's Law, the use of high mobility channel materials such as compound semiconductor is necessary to achieve high logic device performance at low power operation. In this talk, some of the critical processes and modules of implementation of III-V semiconductor channels will be reviewed. These include III-V growth on Si, high k dielectrics and junctions. The need of low defect density in III-V CMOS processing will be also discussed.

Asif Anwar, Strategy Analytics, Director Strategic Technologies Practice

What's the Future of GaAs Microelectronic Manufacturing

Despite the continuing penetration of GaAs into the high volume smartphone market and related wireless sectors, 2013 is shaping up at the time of writing to be a difficult year for the industry. GaAs device manufacturing faces multiple challenges including the ever present question over what strategies companies should adopt vis-a-vis in-house manufacturing flexibility versus cost effective outsourcing. External challenges also continue to dog GaAs manufacturing as other technologies successfully encroach on areas once considered almost a proprietary domain for GaAs devices. Strategy Analytics presents our latest views on these questions and other issues related to the future of GaAs microelectronic manufacturing.

Dr Thomas Uhrmann, EV Group, Business Development Manager

Wafer-Level Packaging of Compound Semiconductor Devices

Wafer level packages (WLP) of compound semiconductor and other radio frequency devices has gained considerable importance. Major benefits, such as reduced package size and low cost, high-volume batch packaging established a business of WLP in mobile handsets and other devices. From a technical view, WLP of compound semiconductors - such as GaAs, SiC, GaN or InP - using gold pads, fragile air bridges, trenches and cavities, differs much from Si-based WLP. Wafer bonding is a central process for this process flow, where cavities are sealed by different techniques and materials. On the contrary to this cap-based WLP approach, shell-based packaging is the second prominent approach to WLP. Discussing both approaches forms main content of this contribution.

Michelle Bourke, Oxford Instruments, Senior Product Manager

Review of The Various Deposition Techniques and Their Uses in Compound Semiconductor Devices

As the world of Compound Semiconductor devices and their applications develop the associated manufacturing techniques must progress also. Chemical vapour deposition (CVD) has been known and used for a number of years and the performance targets on the material continue to be demanding. At Oxford Instruments we have maintained our development of deposition methods and in this paper we will review the history that now includes ICPECVD and Atomic Layer Deposition and their uses in Compound Semiconductor Device manufacture.

Gunnar Stolze, Oclaro Inc, Vice President, GlobalSales

Industrial and Consumer High Power Lasers

High-power lasers are quickly expanding into more industrial and consumer applications where high performance, reliability, cost efficient designs and high-volume manufacturing are key requirements. In addition, new emerging markets are appearing that can take advantage of laser diode technology, such as 3D sensing, optical interconnects, optical and finger navigation and display technologies. In this presentation, Mr. Gunnar Stolze from Oclaro, the leading provider of high-power lasers, will explain how laser diodes and VCSELS have matured to effectively address these high-growth markets. This will include a history of high-power lasers and then a technical overview of how they are uniquely meeting the needs of these new markets today and in the future.

Malcolm Harrower, Indium, Sales Manager Europe

Overview of CS Critical Elements – Indium, Gallium and Germanium

The aim of the talk is to inform about the sources of some of the key metals on which the CS industry is based and to show the various market factors which help to shape the industry in these metals. A summary of extraction sources and supply routes, using global statistics to demonstrate an overview of the world-wide supply and demand situation. This will show how, despite some erroneous adverse publicity concerning availability, these important metals are more than capable of helping the Compound Semiconductor industry to develop far into the future.

Silvia Schwyn Thöny , Evatec, Senior Process Engineer

Improving LED efficiency: Advances in current spreading and DBR coatings

Optimised ITO current spreading layers and DBR coatings make important contributions to the enhancement of the LED efficiency. ITO sputtering processes without damage to the GaN crystal structure will be presented with ITO contact and sheet resistances matched to the doping level of the p-GaN cap layer in order to guarantee optimal current spreading, thus improving the output power of the LED. DBR mirror coatings are an important element enhancing extraction efficiency. Essential factors for high performance DBR mirrors are both the appropriate initial mirror design and tight process control techniques capable of individual layer thickness accuracy in the nanometer range during manufacture. Practical results using "in-situ optical thickness monitoring" during deposition will be presented.

Dr. Kolja Haberland, LayTec AG, Chief Technology Officer

In-Situ Monitoring - The Key to MOCVD Production Process Control and Yield Enhancement

In-situ metrology is a key enabling technology in today´s LED and Laser production by MOCVD. Especially for GaN based LED devices it is common understanding, that in-situ reflectance, temperature and curvature measurements are mandatory for device development and production yield control. With the industry moving to larger wafer sizes, the most important parameter for LED yield remains the control of the GaN surface temperature during deposition of the active quantum well material. In the talk recent results from LED production on 6" sapphire by tight wafer surface temperature control via uv pyrometry will be shown. Beyond this, state of the art in-situ methods for process development, yield enhancement and statistical process control will be presented for LED, HBT, CPV and GaN/Si high power applications.

Dr Michael Lebby, Translucent Inc, General Manager & Chief Technology Officer

Challenges & Opportunities of Using Epitaxial GaN, GeSn, & Rare Earth Oxides on Large Format Silicon Wafers for Power Electronics, Solar, & Lighting

Optoelectronic and electronic technologies and products that have been based on semiconductors have grown quickly over the past decade, with many examples from industrial, military, and now consumer markets that utilize solar cells, LEDs and power FETs. This talk will review the status of these green applications and the need for economies of scale as product volumes increase.The challenge of these new green opportunities is to figure how to successfully put compound semiconductor optoelectronic and electronic technologies onto large (150mm and 200mm) SEMI standard silicon wafers. The talk will show that rare earth oxides (REO) for GaN-on-Si and Ge-on-Si offer scalable solutions that are cost effective, exciting, and will enable large, low cost, flat semiconductor platforms for energy efficient Power FETs, high performance LEDs for solid state lighting, and high efficiency solar cells for concentrated photovoltaics.

Noriyuki Matsubara, Panasonic Europe, Dry Etching and Photolithography Engineer

Dry Etching Technology for III-V Devices

The presentation will give an overview about latest dry etching technology for III-V devices. Target topics are recess etching for GaN HEMT devices and trench etching for SiC Trench MOSFET devices. We will also present plasma dicing solutions for Si-based LED wafer and other wafer products: Si dicing ,GaN dicing and other materials. We will discribe special values against conventional dicing methods such as mechanical dicing and laser dicing. Various process flows will be discussed. We will also present typical equipment characteristics and needs and review Panasonic APX300 Dry etching machine concept and capabilities.

Gregg Wallace, Temescal, Managing Director

Fundamental E-Beam Coating Collection Efficiency & Paths to Improvement

For 20+ years, electron beam guns have been used in liftoff processing and while throughput remains fundamental to COO, little was published about collection efficiency limits of classic liftoff processing. Generally, uniformity masks are used beneath hemispherical, rotating substrate carriers to "trim" variation from the electron-gun's flux product which is best described as cosine based radiation from a point source. As carriers are enlarged allowing for increases in wafer and batch size, the mask must also grow to "trim" the same source of non-uniformity in the flux. This presentation explores the limits of the classic liftoff metal process offering alternatives to enhance signifcantly material collection efficiency.

Pars Mukish, Yole Développement, Market & Technology Analyst

New Trends in LED Industry: A focus on China and GaN-on-Si LEDs

Growth of the LED industry has come initially from the small display application and has been driven forward by the LCD display application. Nowadays, the industry is entering its 3rd growth cycle: General Lighting, the next killer application of LEDs.This new wave will be impacted by two major trends: The development of the LED Industry in China and the development of GaN-on-Si-LEDs. In this presentation, we will discuss about impacts of the entry of Chinese players in the LED industry at the levels of supply chain, competition, price. Also, we will also define the potential of GaN-on-Si LEDs and how this technology could evolve in the LED market.

Dr Schang-jing Hon, Epistar Corporation, Associate Vice President

High-Voltage LED for General Lighting Application

The breakthrough in high power GaN LED's efficiency makes the adoption of these solid state light emitting devices into general lighting application earlier than expected before. However, cost is one of the most important factors for the adoption of the general lighting application. So far, the most popular driving current for 1mm square die is about 350mA. In order to improve the lumen per cost, there is a trend to increase the driving current up to 1.5A or even higher. As well known, the droop effect plays an important roll for LED operating at high current density. Among the many factors affecting the droop effect, current crowding effect has pronouncedly degraded the performance of the LED at high current density. In the paper we propose a novel high-voltage LED structure to achieve the extreme high power LED with high efficiency and low cost for manufacturing. The design of a series multi-junctions connection is used for high voltage LED chip. The advantages of high-voltage LED are to provide the LED device with high efficiency due to the better current spreading character and to simplify the driving circuit by using high voltage and low current operation condition.

Professor Tao Wang, Seren Photonics, Scientific Advisor

Improving LED Performance

InGaN/GaN multiple quantum well (MQW) based blue/green light emitting diodes (LEDs) have been commercialized. However, the performance of current white LEDs is still far from the final target, namely, 200_260 lm/W. Therefore, it is necessary to further improve the optical output of blue and green LEDs. In response to the requirement, a number of challenges need to be met: Self-built internal electrical fields in InGaN/GaN MQWs, which cause a fundamental limit in further improving optical performance of LEDs, especially for the LEDs in the green spectral region; Efficiency droop under injection currents for a practical application; Manufacturing costs due to epiwafers, in particular, growth of LEDs on non-polar/semi-polar GaN substrates. Seren Photonics Ltd (Sheffield, UK), in collaboration with the III-nitride Optoelectronic research team of University of Sheffield, has developed a nanotructuring approach for fabrication of blue/green LEDs with a massive improvement in optical performance, but based on standard commercialised (not best) epiwafers. Furthermore, the Sheffield team has also developed another simple but cost-effective approach using III-nitride nanostructure, leading to a great improvement in the crystal quality of both semi-polar/nonpolar GaN templates on sapphire, which are ideal for growth of high performance blue/green LEDs.

Marianne Germain, EpiGaN, CEO EpiGaN nv

GaN epiwafers for power and RF electronics: from development to production

While the key advantages of GaN-on-Si technology for next generation power electronics are better and better recognized (among others: higher efficiency, higher power density, more compact and lighter power converters…), EpiGaN launched, in 2012, its own production site for GaN-on-Si epiwafers for electronics, with wafer diameter up to 150 mm. EpiGaN production wafers include its unique in-situ SiN surface termination, demonstrated to act as efficient surface passivation and optimal III-Nitride surface stabilization. We will review EpiGaN key steps towards larger market adoption of GaN technology, while we demonstrated the first 200 mm SiN/AlGaN/GaN epiwafers suited for electronics, showing the same excellent electrical characteristics as smaller wafer diameter and excellent uniformity (below 2%).

Agenda Day 2 5th March 2013

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Dr Andrew Nelson, IQE President and Chief Executive Officer

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Keynote speaker

Dr Yifeng Wu, Vice President, Product Development, Transphorm

Status of High-Voltage GaN Power Electronics

With the completion of JEDEC qualification of the first 600V GaN devices in 2012, progress in GaN Electronics has moved from dream to reality. These GaN transistors and Schottky diodes started sampling in 2011 and lower-cost versions of GaN-on-Si devices became available for sampling in February 2012. This presentation focuses on the performance of these exciting new devices in Power Electronics applications. Topics include brief fundamentals of GaN, real-world advantages over competing technologies, device specifications and package schemes, and then expand to switching characteristics, tolerance to transients and reliability, which demonstrate product maturity necessary to gain industry acceptance.

Daniel Cline, Senior Analyst, Lux Research

WBG Devices Electricity Grid Opportunity

With significant investment and rapid improvements in performance of high-power-grid-tied inverters and converters, manufacturers are being forced to examine their choice of power electronics transistors and circuit topologies to continue raising the bar. As incremental improvements in performance for conventional silicon-based inverters are decelerating, materials-based device innovations like silicon carbide and gallium nitride stand to keep pace with these demands - notably, increasing reliability and reducing cost. This talk will provide an insight in to how the new material-power electronics is likely to influence the solar PV industry, highlighting the cost, performance and reliability improvements that can result by switching to these new materials. It will analyze the potential effects of such adoption on the balance of systems, clearly differentiating system level advantages compared to present systems. Further, it will examine how development and progress in the solar sector can be applied to the broader on-grid application of these emerging power electronic devices.

Dr Philippe Roussel, Business Unit Manager, Yole Developpement

GaN vs SiC in Power Electronics-Status & Roadmap to 2020

GaN is now envisioned as the competing technology that can disrupt the expected natural and organic growth of the SiC business. Originally we thought GaN devices could have created turbulence in the SiC area starting in 2011 by proposing 600V devices with a tip-point at 1.2kV. However it seems that the GaN technology achievements have been delayed compared to the previous roadmap and only 200V GaN devices are available in volume as of now. Thus, at the moment, the 600V blurry region where SiC and GaN are supposed to fight is safe for SiC as no devices can compete yet.

Dr Frank Schulte, Vice President, Aixtron Europe

MOCVD - Enabler for Mobility & Energy Efficiency

Many industrial applications are looking forward to increase mobility and mostly at the same time increasing energy efficiency and saving and/or generating energy. That is true like for communication devices, automotives, solar cells or energy transport. MOCVD for Compound Semiconductor Material is being in a lot of these applications one of the key technology which must provide high sophisticated/high complex layer structures with high quality produced at low cost of ownership. In this paper the deposition technology will be reviewed under the aspect of fulfilling the complex requirements of providing the necessary equipment. Key parameters like wafer sizes, yield, and reproducibility will be considered and further cost saving resulting from growing on Silicon substrate and use well established Silicon semiconductor process and platforms will be discussed.

Ms Ann Hughes, Business Manager for Gases and Metalorganics, SAFC

Innovation to Maximise Production Uptime

With materials for Compound Semiconductors and Metalorganics in the maturity phase, the industry is moving towards developing efficiencies, optimisations, and related value chain innovations. As such, improving delivery systems, optimising processes, improving efficiency, and perfecting quality and uniformity have become the new value differentiators. This presentation will expose some of the novel ways in which SAFC Hitech is working to reduce total cost of ownership in areas like bulk delivery systems and improved bubblers.

Bryan Bothwell, Strategy and Business Development Manager, TriQuint Semiconductor

Maximizing Gallium Nitride Product Solutions & Foundry Services for Advanced RF Design Success

Gallium Nitride (GaN) is the key enabling technology for RF markets due to its higher power, efficiency and temperature operation combined with wider bandwidth than Gallium Arsenide (GaAs). As a world pioneer in GaN, TriQuint has developed this technology for markets across commercial and defense applications. GaN is ideally suited for radar, communications, test equipment, electronic warfare and similar broadband systems. TriQuint's business model combines research and development leadership with product and foundry channels to not only enable RF solutions at the price points customers need today, but provides the advanced technology required for future RF and adjacent market growth.

Dr Markus Behet, Global Market Segment Manager Power Electronics, Dow Corning Corporation

Large Diameter SiC & GaN/Si Substrates as Cost-Effective Solutions for Power Electronic Applications

As global society seeks new sustainable, high-efficiency energy sources that also reduce dependence on fossil fuels, corporations worldwide are stepping up R&D efforts to address this growing demand with cost-effective, high-performance alternatives. One industry sector is starting to significantly outpace the others; that sector is power electronics. Devices using wide bandgap semiconductors like SiC or GaN are significantly more durable, faster, energy and cost-effective for greater efficiencies over devices made from other semiconductor materials. This conference presentation will discuss in depth the power electronics industry and recent progress for SiC and GaN/Si wafer technologies and what these high-performance semiconductors offer to power electronics manufacturers and global society at large.

A.J. Nadler, General Manager, Research Development & Engineering, RF Micro Devices (RFMD)

Gallium Nitride for High Voltage Power Electronics

After over thirty years of silicon device and process evolution, today's power devices have reached the theoretical performance limits of the basic material. The further improvement to these silicon-based devices is expected to be incremental at best. Today, the best silicon devices used in power electronics switching applications have limitations that waste power and switch too slow. These limitations significantly impact both the cost and performance of power conversion systems. To provide further improvements to power conversion, wide-band gap semiconductors such as Gallium Nitride (GaN) provide a path forward to significantly reduce system cost and improve performance in many power conversion applications. The technical and commercial challenges in realizing the benefits of GaN in high voltage power switch applications are considered and reviewed by the authors.

Dr Vijit Sabnis, Vice President Technology, Solar Junction

Really High Efficiency Triple-Junction Solar Cells

High-efficiency multijunction solar cells are the engines that drive CPV and space power systems. Solar Junction is the only entity to successfully develop dilute-nitride compound semiconductors suitable for multijunction solar cells. The dilute nitrides, in conjunction with other conventional compound semiconductors, form a suite of bandgap-tunable, lattice-matched materials for full spectral utilization of both terrestrial and extraterrestrial solar radiation. Solar Junction has achieved a world record efficiency of 44% and today delivers the highest-efficiency triple-junction solar cells to the CPV market with median production efficiencies exceeding 42%. In this presentation, we will discuss how Solar Junction's product and technology roadmaps will help drive CPV's penetration into the PV market and serve as the foundation for next-generation space power systems.

Dr Rainer Krause, Director Smart Cell Incubator Unit, Soitec

PV Chip Development

The paper gives an introduction into CPV cell/wafer development for 4 junction technology using Soitec's proprietary smart cut technology. It is discussed how to make high efficient CPV cell re-using advanced III-V materials to reduce cost and material use. Making a high performing CPV cell with ideal band gap's and in a current matching technology. Also it is important to demonstrate the capability to manufacture lattice matching on epi level. Driving cost further down the substrate materials like Germanium has to be replaced by less expensive materials, like silicon etc. The discussion is also about development collaboration and effective R&D management to align such a multi partner approach.

Dr Tudor Williams, Senior Systems Engineer, Mesuro Ltd

Improving RF Measurement

Time to market and reducing engineering overheads are key factors in ensuring commercial success in today's competitive markets. This presentation explains how the use of active harmonic load-pull to perform 'WaveForm Engineering' can dramatically reduce the time to market and the engineering resource required for the development of high efficiency power amplifiers. The ability to engineer waveforms and to understand their relationship to fundamental circuit theory allows the engineer to design and test the matching circuit prior to committing to expensive prototyping or manufacturing processes, and make scientifically-driven, first-pass designs a reality.

Dr Ertugrul Sönmez,
Director Business Development, MicroGaN

Addressing Emerging Power Market

Erwin Ysewijn, VP Sales & Marketing, Azzurro

GaN on Si. Large Size High Voltage Wafers Showing Superior Electrical Performance & Volume Production Track Record

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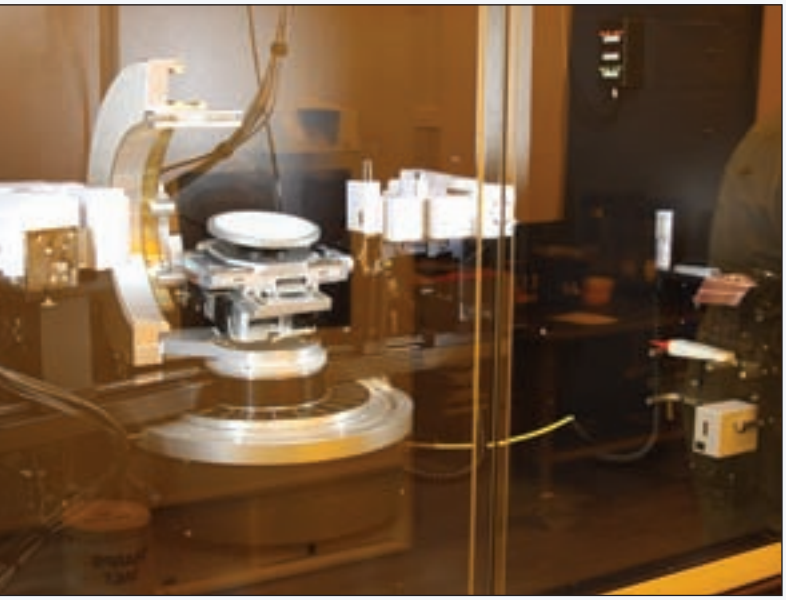
Plessey slashes LED costs

High-quality growth of LEDs on silicon is notoriously difficult, with stresses and strains causing wafers to bow. But these problems are not insurmountable: Plessey Semiconductors is now churning out GaN-on-silicon LED chips from flat epiwafers using a recipe developed at the University of Cambridge. Richard Stevenson reports.

You'll need deep pockets to buy an LED bulb that can replace a 60 W incandescent. If you insist on the best that money can buy, you'll go in search of the Philips bulb that won the Department of Energy's Lighting Prize, and have to fork out $30. If you are willing to sacrifice efficiency and colour quality, you'll be able to trim a few dollars off your outlay, but you must still expect to pay over $20.

Retailing for these prices makes the 60 W-equivalent LED bulb the preserve of the early adopter. Claims of 15 year lifetimes and efficiencies exceeding those of the compact fluorescent are undeniably attractive, but most people are not going to get their wallet out until prices fall substantially – maybe to $10 or less.



An X-ray diffraction tool scrutinizes the crystal quality of the LED epiwafers

Bulb prices will tumble when LED chips are made more cheaply, because these devices account for a very high proportion of the cost of the bulb. According to the most recent Solid-State Lighting Manufacturing Roadmap that was published in August 2012, in 2011 the LED package accounted for more than half of the total manufacturing cost of the bulb.

One of the most promising options for trimming the costs of LED manufacture is to switch substrates, replacing sapphire with silicon. This platform is not just cheaper; it allows wafer processing on lines that were installed many years ago for making silicon-based products, so there is the opportunity to either create LED production lines with minimal capital expenditure, or to outsource LED manufacture at very competitive rates.

Savings associated with making LEDs on silicon are well known within the industry, with several companies trying to develop technologies for producing this type of device. Lattice Power from China has arguably led the way, bringing to market the first white-emitting, GaN-on-silicon LEDs, which were made on 2-inch GaN substrates. It is developing a process for 6-inch silicon wafers, which should enter production this year.

Meanwhile, the Californian outfit Bridgelux has developed warm-white LEDs in it labs that deliver 125 lm/W at a drive current of 350 mA, and its technology is now being used by Toshiba to make devices on 200 mm silicon. In addition, the likes of Samsung, Osram, Azzurro and Plessey Semiconductors are developing technologies for GaN-on-silicon LEDs on 6-inch or 200 mm silicon substrates.

Although Plessey has no background in LED manufacture, it could well be the pacemaker in this sector: Its management is adamant that it has a very competitive technology.

"We're convinced we are 18 months ahead of anyone else that is talking about GaN-on-silicon 6-inch," says company chief operating officer, Barry Dennington. He has found it "impossible" to acquire any 6-inch epiwafers, and concludes that rivals firms are yet to produce a sustainable source of this material.

Plessey has been sharing its GaN-on-silicon LEDs that are fabricated at its Plymouth fab with potential customers since autumn 2012, and the company plans to launch its first products in the first quarter of this year.

The GaN-on-silicon technology that Plessey has originates from the research group of Sir Colin Humphreys at the University of Cambridge. The GaN-on-silicon growth process developed there formed the core IP of the spin-off CamGaN, which Plessey acquired in February 2012.

This IP addressed the biggest challenge of producing GaN-on-silicon wafers, which is the deformation of their geometry that stems from substantial differences in the expansion coefficients of GaN and the underlying substrate. Wafers that are flat at the deposition temperature, typically 1000 °C, can bend and flex during cooling, so that when they are removed from the growth temperature, they can be bowed to such an extent that the epiwafer is cracked and cannot yield working devices.

It is possible to prevent this from

happening by inserting a carefully selected stack of layers into the epiwafer that address the stresses and strains in this structure. The researchers in Humphreys' group have mastered this on their single-wafer 6-inch reactor, using the combination of an AlN nucleation layer, a complex buffer structure and layers of AlGaN and GaN. Inserting a SiN layer into this structure cuts the threading dislocation density.

Dennington claims that one of the great features of the Cambridge recipe is the complete neutralisation of the bow and mismatch in the crystalline structure between silicon and GaN. The result is particularly impressive because these wafers, which are sufficiently flat for processing in silicon lines, have a buffer that is just 2.5 μm thick. "We think competition is around 6-8 μm-thick," remarks Dennington. "So ours is thinner, helping us with wafer bow, and giving us better throughput through the reactor."

Although the acquisition of CamGaN by Plessey is a perfect fit, it is not one that many would have foreseen during the latter part of the previous decade. It's not just that the Plessey 6-inch silicon line was in the hands of X-fab at that time (see box "The evolution of Plessey Semiconductors"); back then Humphreys' team was involved in a £3 million GaN-on-silicon LED project headed by RFMD's Newton Aycliffe operation, and involving QinetiQ, Forge Europa and the UK branch of Aixtron. It seemed that if LEDs were ever going to be made in high volume in the UK, production would be out of the RFMD fab.

Plessey is manufacturing its GaN-on-silicon LEDs on an Aixtron reactor with a capacity of seven 6-inch wafers. The tool is fitted with various in-situ monitoring tools, which measure the curvature of the wafer and its temperature

However, although the engineers at the Plymouth site were not involved in this project, they have been more than just observers in the development of this technology."[Humphreys] had grown some GaN-on-silicon wafers, and we had a 6-inch wafer facility, so we took some wafers and helped with some very early LED structures," explains Dennington. Plessey Semiconductors' CEO, Micheal LeGoff, kept a close eye on the progress of this technology, and then snapped up the company in February 2011.

"We don't know who else we were bidding against," remarks Dennington, implying that he doesn't know if Plessey fought off bids from the likes of RFMD. "Obviously it's a business deal, but I do believe there was some passion amongst some of the people involved in CamGaN and Cambridge to see that this technology would be planted in a British company."

Plessey's acquisition also led to its participation in a European Consortium called "Consumerising Solid-State Lighting", which had previously included Cambridge University and QinetiQ as partners in the project. "The Consumerising Solid-State Lighting programme was chaired by Philips, and the focus was to create a $9.95 lamp that would replace the 60 W incandescent bulb," explains Dennington, who adds that Plessey is the only LED manufacturer in that programme.

Alongside the transfer of IP to the Plymouth fab, the acquisition of CamGaN involved the transfer of a handful of employees, who are former post-docs from Cambridge University. "We have plans in the future to open up a Cambridge lab, so that our Cambridge employees can work locally," says Dennington, who explains that these staff currently split their time between the fab and offices within the university.

After the acquisition of CamGaN closed, the former post-docs had access for one week every month to the Thomas Swan single-wafer reactor, which they used to produce 6-inch GaN-on-silicon material. But since the arrival at the Plessey site of the Aixtron Crius II XL, a reactor capable of accommodating seven 6-inch wafers in a single growth run, they have focused their attention on the higher throughput tool.

Aixtron or Veeco?

The Plessey management found it tough to choose between an Aixtron and a Veeco tool for their 6-inch manufacturing line. "They are both excellent machines," says Dennington, "and both companies were very, very eager to be associated with Plessey." The development of the growth technology on an Aixtron showerhead machine tipped the balance in favour of a tool from the Aachen outfit.

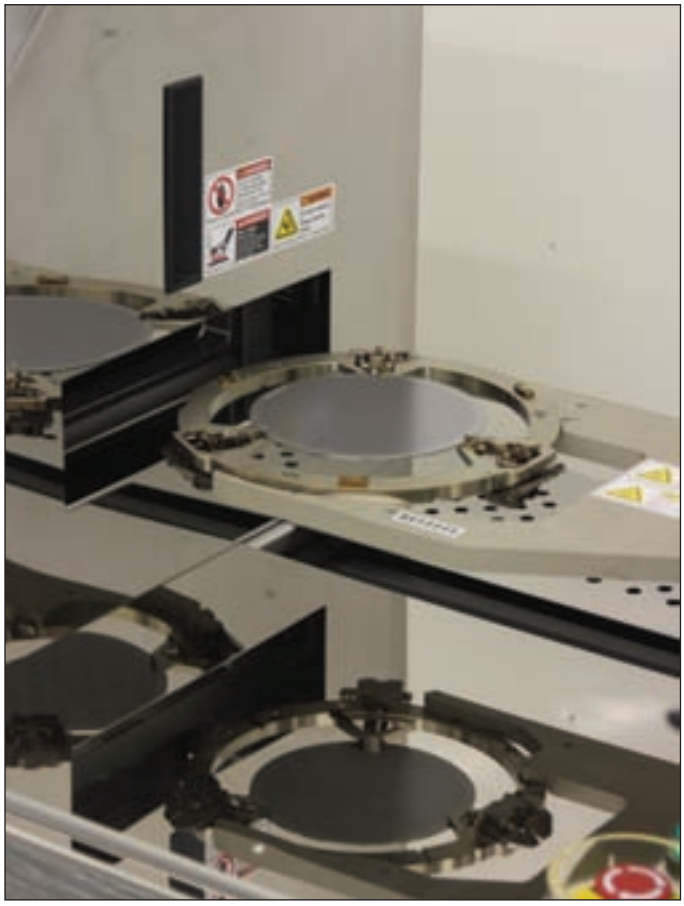
Getting the Crius II XL up and running has gone very well. "[It] was delivered, installed and commissioned on time," reveals Dennington. Since then, engineers at this site, supported by technical staff from Aixtron, have employed a step-by-step approach to developing the 6-inch GaN-on-silicon growth process, which began with GaN deposition on 2-inch sapphire. The quality of the material produced with this process met the expectations of the Aixtron staff, who use this as a benchmark for installation. 6-inch sapphire then replaced the 2-inch substrates, prior to the introduction of the Cambridge recipe and standard silicon wafers with thicknesses of either 750 μm or 1 mm.

One of the features of the Thomas Swan reactor installed in Humphreys' group is its comprehensive suite of *in-situ* monitoring tools: It has a Laytec instrument for determining wafer bow from measurements of light reflectance off of the epiwafer's surface, and it is equipped with an Aixtron Argus instrument for determining temperature profiles. Both tools are fitted on the Crius XL II to monitor growth processes within the reactor.

The acquisition of CamGaN did not give Plessey a finished product: It just received a process capable of repeatedly growing, on silicon, flat nitride epiwafers with active regions producing internal quantum efficiencies of 80-85 percent. The engineers at Plymouth have taken this as a basis for producing a range of LEDs.

"We've been able to produce lateral LEDs for some time – there's no challenge in that – and we are now focusing on the vertical LED," explains Dennington. Light extraction in this class of LED is enhanced through the introduction of mirror layers and a roughening of the chip's surface.

Modifications to the 6-inch line to equip it for LED manufacture have been relatively minor, and include the addition of a wafer bonder and an X-ray diffraction tool for scrutinizing epilayer crystal quality. Operating at three growth runs per day, with seven 6-inch wafers per load, the line is capable of churning out 2 million 1 mm by 1 mm LEDs every week. And this capacity is set to increase, because Plessey's business plan includes the installation of three more MOCVD tools. "With the efficiency of running four machines together, we don't think we just have to multiply 2 million die by four," claims Dennington. "We have modelled that we can get up to 10 million die per week from four reactors."



Silicon absorbs the light produced by the LED, so it is removed with a process that begins with bonding the epiwafer to a carrier wafer

Once the die are made, they are sent off-site for packaging, as either single die or chip-board products. "We have an external partner," explains Dennington, "which is one the traditional IC assembly houses that wants to move into this area."

It is also possible that Plessey will team up with a strategic partner that will make GaN-on-silicon LEDs overseas. "This is partly likely because of capacity," explains Dennington, "but as we are more

Operating at three growth runs per day, with seven 6-inch wafers per load, the line is capable of churning out 2 million 1 mm by 1 mm LEDs every week. And this capacity is set to increase, because Plessey's business plan includes the installation of three more MOCVD tools. "With the efficiency of running four machine together, we don't think we just have to multiply 2 million die buy four, we have modelled that we can get up to 10 million die per week from four reactors," says Plessey COO, Barry Dennington.

successful at selling higher volumes to certain customers, they will expect a dual source through risk management."

To accommodate those wishes, the management at Plessey have started discussions with Asian lighting companies.

The company has wasted little time in using the technology it acquired to make LED products. In autumn 2012, it provided potential customers with 'demonstrators', which are LEDs that indicate the latest progress in device performance, and it provided quotes, some for sales to 2015. And early this year it is releasing 0.4 mm by 0. 4 mm and 1 mm by 1 mm LEDs.

Thanks to the low cost associated with the GaN-on-silicon platform, one would expect that LED prices can be competitive, while still generating a healthy bottom line for the company.

As Plessey's sales rise, it's possible that other GaN-on-silicon LED manufacturers will also grow their revenues. This means that there could then come a time when claims of patent infringement are rife, as companies try to gain the upper hand over their rivals.

"In the LED market, acquisitions are made to capture IP: It's quite a weapon," argues Dennington. "But we are confident that we have got a very powerful IP." The company is currently filing patents. However, these do not detail some of the black-art related to epitaxy, which Dennington and his colleagues believe will remain a secret even if rivals get their hands on Plessey's LEDs and probe them with various techniques.

The company's vision for its future goes beyond being a tremendously successful GaN LED manufacturer, and includes a move into the production of smart lamps. "We could expand the fab here," enthuses Dennington. " We have a space at the back of this building to build another factory. It could be wafer manufacturing, or it could be a lighting company."

The latter move could be a smart one, because it could ensure success after LED light bulb sales have plateaued and homes are full of affordable, long-lasting bulbs drawing just a handful of watts, but putting out the equivalent of a 60 W incandescent.

The evolution of Plessey Semiconductors

UK-based international electronics, defence and telecommunications company Plessey formed in 1917, and forty years later it created a division known as Plessey Semiconductors. This off-shoot initially produced devices from fabs based around Swindon, but in 1987 it boosted capacity with a site in Plymouth that was opened by Prince Charles. The Plymouth fab featured a 6-inch silicon line that was built to fulfil a large demand for telecom products, which were sold to Plessey Telecommunications and other telecoms companies. However, in addition to these products, which were deployed in an emerging digital telephone infrastructure, the company made components for the military, the automotive industry, and for TVs and set-top boxes. In addition, Plessey Semiconductors manufactured products for GSM basestations, winning contracts with Ericsson mobile.

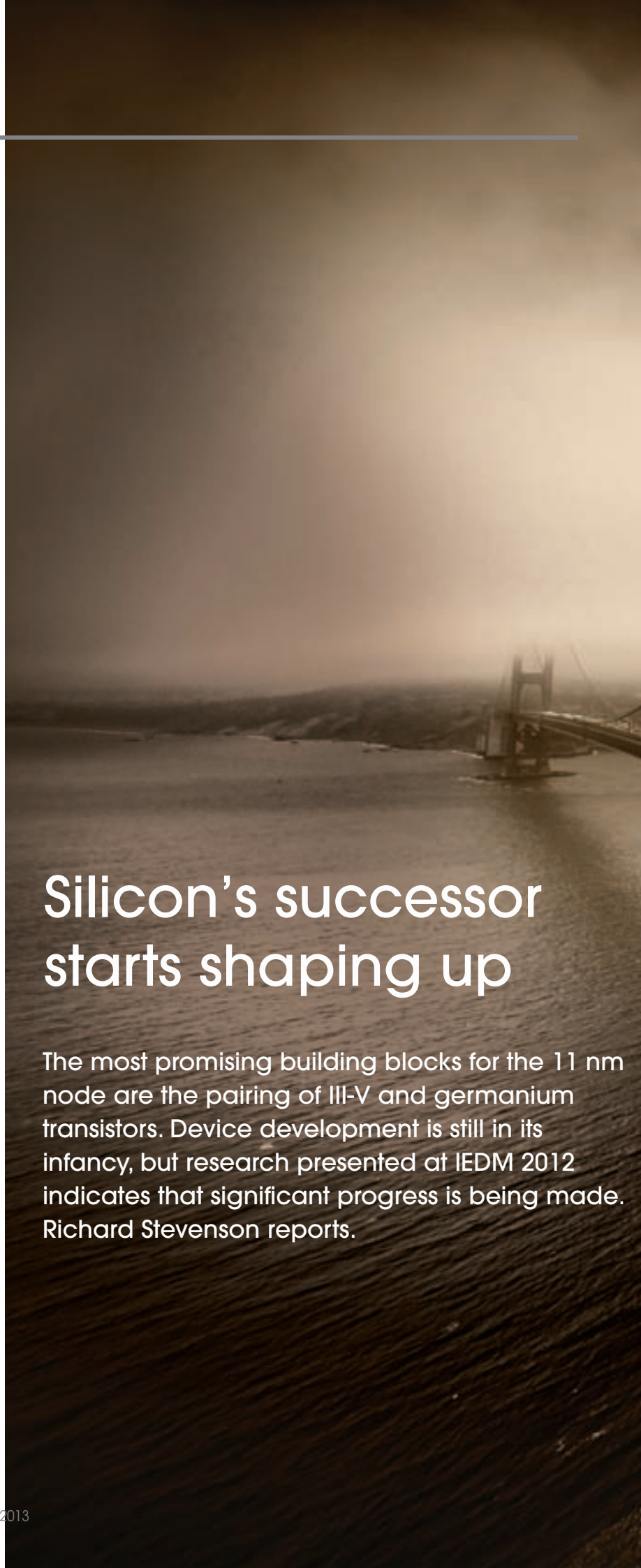
In the late 1980s, Plessey acquired Ferranti Semiconductors, a move that provided the firm with additional manufacturing facilities in Oldham, Manchester. And in 1995 Plessey was involved in another acquisition, with GEC taking over the Plymouth site that was subsequently known as GEC Plessey Semiconductors. This takeover brought further investment, with the installation of an 8-inch line. However, at that point GEC owned Marconi Microelectronic Devices, and it had more manufacturing sites around the UK than it needed.

Plessey Semiconductors was put up for sale and bought by the Canadian telecoms giant Mitel. The firm split in two, retaining its name for its telecoms business, and launching Zarlink to represent its semiconductor efforts. Ownership of the site by Zarlink didn't last long, and in 2002 X-fab took it over,

Processes developed at the Plessey Semiconductors site at Cheney Manor, Swindon (pictured here in the late 1950s, when it was jointly owned by Philco) have been transferred to the Plymouth site

running the plant as a foundry. By 2009 this facility did not fit with the needs of that company, and in 2009 Michael LeGoff, Plessey Semiconductor's current CEO, acquired it, plus the Swindon fab that was owned by Zarlink.

To carry out these acquisitions, LeGoff briefly formed a company called Plus Semi, before gaining permission to regain the name Plessey Semiconductors. He has been careful to retain key staff from the Swindon facility, and has transferred many of the processes from this fab to the one at Plymouth, which is now used for all of Plessey Semiconductors' manufacturing. Today, in addition to the GaN manufacturing line, the site runs many other processes, including a CMOS process, a SiGe process, a BiCMOS process and a silicon-on-insulator process.



Silicon's successor starts shaping up

The most promising building blocks for the 11 nm node are the pairing of III-V and germanium transistors. Device development is still in its infancy, but research presented at IEDM 2012 indicates that significant progress is being made. Richard Stevenson reports.

Silicon is running out of steam. Using this material to maintain the march of Moore's law is getting more and more challenging, and engineers are now close to exhausting their list of options for realizing device improvements that must come with every round of scaling. They have already turned to new, novel oxides to stop leakage currents from escalating; they have introduced strain to zip electrons and holes through the channels at higher speeds; and most recently, they have re-written the rulebook for transistor design and started to manufacture a three-dimensional MOSFET, known as either a Tri-Gate device or a FinFET, in order to enhance electrostatic control. Next on the agenda is to scale these 22 nm devices to the 16 nm node, but beyond that, a more radical approach is needed to maintain the performance improvements wrought from the introduction of every new node, such as a 20 percent power reduction per transistor.

Trimming power consumption, which prevents IC overheating, is not a trivial task. That's because power consumption depends on several factors. At lengths scales of 90 nm and above, most losses result from dynamic power consumption, which is proportional to the clock frequency and the square of the transistor's operating voltage. But at the smaller nodes, leakage currents dominate. These are proportional to the operating voltage, and can result from leakage at the gate, the junction and the source-drain region.

Reducing the operating voltage is the best way to maintain Moore's law to the 11 nm node and beyond, because this minimises dynamic power consumption and leakage currents. Cutting the operating voltage of silicon transistors, which now operate at about 1.1 V, is very tricky, but big reductions are possible by introducing new materials with higher mobilities. The most promising ones are listed in the International Technology Roadmap for Semiconductors (ITRS). Turning to the combination of III-Vs for the electron channel and germanium for the hole channel is seen as the most likely way forward, because this pair of materials combine high mobilities with a significant level of maturity.

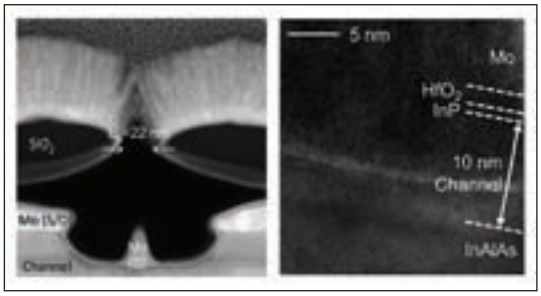


Figure 1. Researchers at MIT have fabricated InAs quantum well transistors with a gate length of just 22 nm (left). A high-resolution transmission electron microscopy image reveals the high material quality of this stricture (right)

However, before these materials can make an impact at the 11 nm node, which will be introduced in foundries in 2018, several questions must be answered: Can III-V and germanium transistors work well at this length scale? What stack of materials should be used to insulate the gate from the channel? What transistor architecture should be adopted? And how should these transistors be formed on 300 mm silicon, which is the only substrate that can be considered, because billions of dollars of foundry equipment has been built around it.

At the International Electron Devices Meeting (IEDM) in San Francisco that was held from 10-12 December 2012 engineers from a variety of backgrounds offered answers to all these questions. Contributions from delegates included: Promising device results on InGaAs MOSFETs with a gate length of just 22 nm; new architectures for boosting drive current; improved gate dielectrics for electron- and hole-conducting channels; and wafer-bonding technologies for forming III-V transistors on a silicon substrate.

Shrinking the gate

The team that has pioneered the fabrication of III-V MOSFETs with incredibly short gate lengths is Jesús del Alamo's group at MIT (see Figure 1). These engineers have built planar InAs quantum well MOSFETs with a HfO_2 gate dielectric that produce encouraging performance at an operating voltage of just 0.5 V.

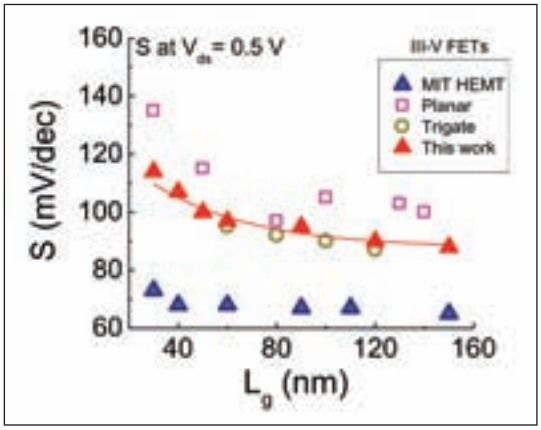


Figure 2. The sub-threshold swing of MIT's planar InAs quantum well transistors is comparable to Intel's Tri-Gate devices

Corresponding author of the IEDM paper detailing this effort, Jerome Lin, believes that there are four important aspects to the team's work. "First of all, it's scalability," argues Lin. "For the lateral scaling, we have demonstrated III-V MOSFETs with the smallest gate lengths so far. They deliver fast electron transport and electrostatic integrity down to a 30 nm gate length." In addition, he says that these devices have shown that vertical scaling is possible. "In order to have the required electrostatic integrity to meet the short-channel-effects goal, we have developed an advanced gate stack." This has an equivalent oxide thickness (EOT) of less than 1 nm.

The second important aspect to MIT's work is the self-aligned contact metal process. Lin claims that although this is essential for making a CMOS device, it rarely features in the fabrication of III-V MOSFETs.

According to Lin, the two other breakthroughs described in his paper are the promising performance of the gate barrier and a fabrication route using a "MOS-like" process. "In the front-end, the process is lift-off free and gold-free."

The team produced its planar devices on MBE-grown, InP-based epiwafers from Intelliepi. These structures feature a complex, 10 nm-thick channel with a 2 nm InAs core, clad by 3 nm and 5 nm layers of $In_{0.7}Ga_{0.3}As$. Processing began with the sputtering of molybdenum onto these epiwafers, followed by CVD deposition of SiO_2, mesa isolation, and the formation of the gate pattern via electron-beam lithography. Reactive ion etching (RIE) patterns the molybdenum and SiO_2 layers, before annealing in nitrogen gas removes RIE damage. A variety of etching techniques then removes some of the epilayers, including a technique that involves plasma oxidation and dilute sulphuric acid. This removes about 0.9 nm of InAlAs or InP per cycle.

With this approach, the team can leave just 1 nm of InP above the channel. Onto this they add 2 nm of the dielectric HfO_2 by atomic layer deposition (ALD). Evaporation of molybeum creates the gate contact, which is patterned by RIE and has a gate length defined by the recess opening in SiO_2. A pad formation process, which finishes device fabrication, is the only lift-off step. It occurs at the backend of the process.

Transistors operating at 0.5 V and featuring a 30 nm gate length produce a transconductance of 1420 μS/μm. Electron channel mobility is 4650 $cm^2V^{-1}s^{-1}$ in long channel transistors. Sub-threshold swing in these planar devices is just 114 mV/decade, which matches the best finFET III-V devices and is superior to any other planar MOSFET (see Figure 2). Having a low sub-threshold swing is highly desirable, because it enables the device to

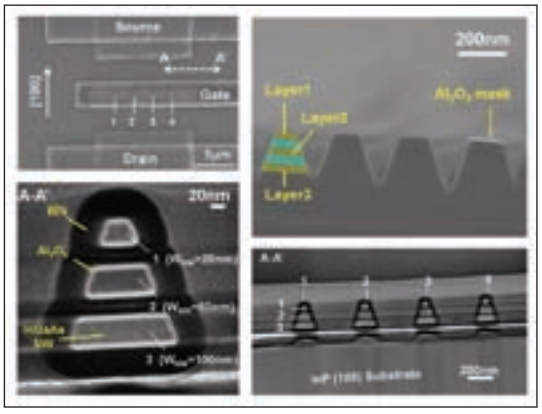


Figure 3. Peide Ye's team at Purdue University have refined the architecture of their three-dimensional III-V transistors by introducing a two-dimensional array of channels. A top-view of these devices, known as 4D transistors, is provided in the top left image. The top right image shows a cross-sectional SEM image of an InGaAs/InP fin structure fabricated by dry etching, using a hard mask made from Al_2O_3 and grown by atomic layer deposition. Bottom left: Cross-sectional image shows a 3 by 1 InGaAs nanowire stack. Bottom right: A 3 by 4 nanowire array

turn off sharply. Further improvements could be possible, because a similar device with a 300 μm gate produces a sub-threshold swing of just 69 mV/decade.

The team have compared the performance of their gate structure with an Al_2O_3 gate dielectric. Plotting capacitance as a function of voltage reveals features that are indicative of slow traps close to the mid-gap in the Al_2O_3-based device – these are not present in the structure containing HfO_2. This is encouraging, but Lin insists that there is still more work to do: "We need to reduce trap levels to where not only the best performance, but also the best reliability, can be obtained."

Intel's launch of three-dimensional transistors could signal a departure away from the use of the traditional, planar MOSFET architecture to build microprocessor chips. However, Lin argues that the phasing out of planar devices is not a foregone conclusion: "Many papers from industry at the latest IEDM have reported competitive results on planar, ultra-thin-channel silicon-on-insulator FETs. It remains a question which one, or both, will prevail."

Lin claims that the recent work at MIT demonstrates that planar III-V MOSFETs with a thin channel can offer strong competition to three-dimensional variants: "An important concern for the III-V FinFET is dry-etching damage, which is difficult to anneal in compound semiconductors. Nevertheless, at the 10 nm gate length regime, the FinFET geometry might be the only one that can deliver the required combination of performance and short-channel effects."

From 3D to 4D

One of the pioneers of three-dimensional III-V MOSFET is Peide Ye from Purdue University. His group, working in collaboration with researchers at Harvard University, have recently improved the performance of their gate-all-around nanowire MOSFETs, and also taken them in a new direction that they refer to as the fourth dimension – this involves stacking the nanowires horizontally and vertically (see box "Into the fourth dimension" for details of the architecture of the device and how it is made, and Figure 3 for images of this structure.)

"The 4D transistor, in principle, can boost drive current and keep the best electrostatic control by the gate-all-around design," says Ye. He believes that this device delivers the drive current required for the 11 nm node, but its off-state performance needs to be improved.

Advances in the performance of three-dimensional transistors and the introduction of four-dimensional variants build on the work presented by Ye's team at IEDM 2011. At that meeting in Washington DC they unveiled the first III-V gate-all-around nanowire MOSFETs, which had a relatively high EOT that limited the device's transconductance, sub-threshold swing and drain-induced barrier lowering (DIBL). The DIBL is an important figure of merit, because it provides an insight into the electrostatic integrity of the device, and how its performance will be impacted by shrinking device dimensions.

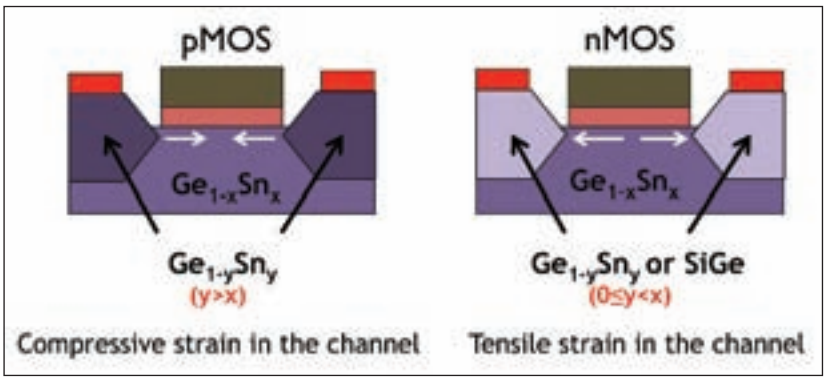


Figure 4. A research team led by engineers at the University of Stanford is developing GeSn MOSFETs. Compressive strain can boost the mobility of holes in the p-channel, while tensile strain is needed to enhance electron mobility in the nFETs

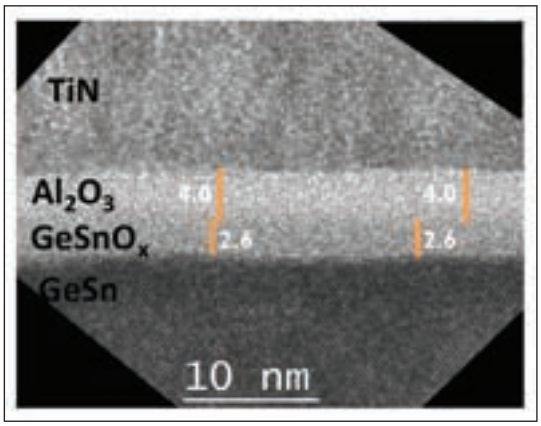


Figure 5. Cross-sectional TEM image of a GeSn MOSFET produced by a collaboration led by researchers at Stanford University. This image reveals that the $GeSnO_x$ layer formed by the oxidation process is just 2.6 nm thick

They have now addressed these weaknesses by halving the thickness of the Al_2O_3 gate dielectric from 10 nm to 5 nm, which has improved electrostatic control. In addition, they have boosted the mobility in the channel by switching the composition from $In_{0.53}Ga_{0.47}As$ to $In_{0.65}Ga_{0.35}As$. Thanks to these changes, typical values for sub-threshold swing in devices with a 50 nm long channel have fallen from 150 mV/decade to just under 100 mV/decade, while DIBL has plummeted from 210 mV/V to just 50 mV/V. Transconductance has also risen, hitting 1.1 mS/μm at a drain-source voltage of 0.5 V.

Results for the four-dimensional transistors, which sport an $In_{0.53}Ga_{0.47}As$ channel and a 10 nm-thick Al_2O_3 gate dielectric, are also encouraging. Measurements on a transistor with a 4 by 3 nanowire array with 200 nm long channels produce a transconductance of 0.6 mS/μm at a drain-source voltage of 0.5 V. This value, plus that for the perimeter-normalized drive current, are similar to those produced by the three-dimensional transistors described at IEDM 2011.

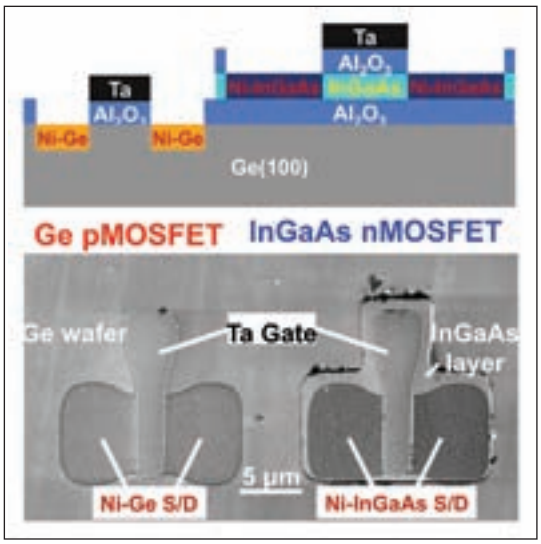


Figure 6. Germanium pMOSFTS and InGaAs-on-insulator nMOSFETs have been built side-by-side on germanium substrates by engineers at the University of Tokyo

Taking these devices and producing them in foundries will be challenging. "The more complicated the structure of the device, the greater the problems of reliability and manufacturability," admits Ye, who would be delighted to team up with an industrial partner to tackle these issues.

Options for the p-FET

Although germanium is the leading candidate for the hole channel, SiGe and GeSn could yield better results. The latter enables an increase in hole mobility: According to a IEDM 2011 paper presented by a team headed by researchers at Stanford University, switching from a germanium channel to a GeSn alloy with just 3 percent tin boosts hole mobility by 20 percent.

More recently, these engineers from Stanford have developed a complimentary electron channel in collaboration with researchers at imec, KULeuven and GlobalFoundries. According to corresponding author of the paper detailing this work, Suyog Gupta, the attraction of using GeSn for the *n*-channel – rather than the likes of InGaAs – is that it enables a ubiquitous platform for seemless integration of CMOS logic and silicon-compatible photonics (see Figure 4). "We intend to use germanium tin as a single material platform of high-performance logic and optoelectronics," explains Gupta, who points out that this alloy is the only group IV material with a direct bandgap, which makes it a very attractive candidate for providing light emission.

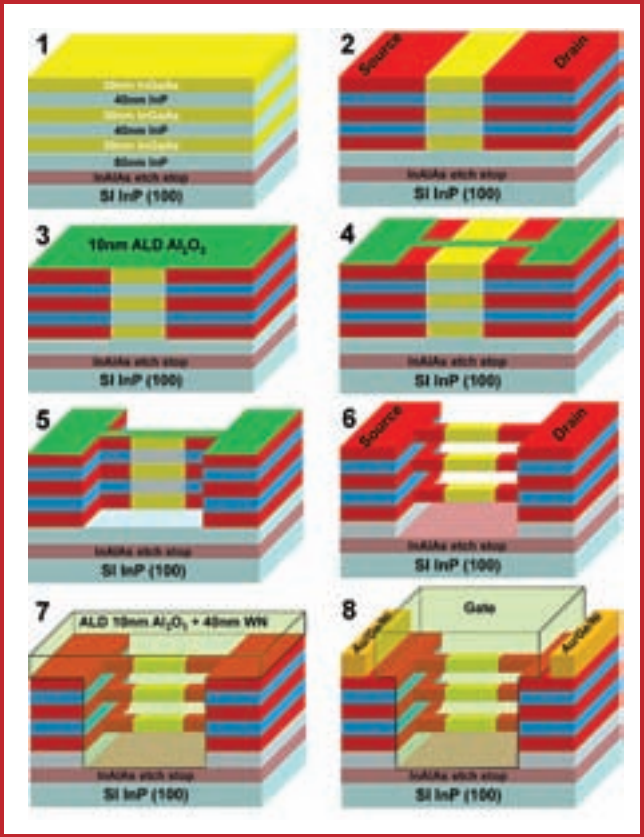
One of the biggest challenges facing the pioneers of germanium and GeSn nMOSFETs is to develop a process that yields high-quality surface passivation. "We have solved this issue for both germanium and germanium tin and achieved a very low high-K/semiconductor interface trap density," explains Gupta. Fabricating high-quality gates begins with ALD of a 1 nm-thick layer of Al_2O_3. Oxidation at 400 °C in ozone then creates an interfacial layer of $GeSnO_x$ or GeO_x, which has a thickness of 2.6 nm, according to cross-sectional transmission electron microscopy images (see Figure 5). These gate stacks have a high-quality interface, according to plots of capacitance as a function of voltage that show negligible frequency dispersion in depletion and accumulation.

Gupta explains that one of the benefits of the improved passivation process is enhanced electron mobilities in the nMOSFETs. The room-temperature mobilities in the team's transistors, which contain between 6 percent and 8.5 percent tin, can get close to 400 $cm^2V^{-1}s^{-1}$. However, electron mobility in these devices is still inferior to those with

Into the fourth dimension

The four-dimensional transistors that are being pioneered by Peide Ye's team at Purdue University feature a two-dimensional array of InGaAs nanowires. Fabrication begins with the growth of epiwafers on InP substrates. This involves deposition of a 10 nm-thick undoped InAlAs etch stop layer, followed by an undoped 80 nm InP sacrificial layer and a stack of pairs of InP and InGaAs layers: three $In_{0.53}Ga_{0.47}As$ channel layers that are 30 nm thick, sandwiched between 40 nm InP layers. Uniform doping of the source and drain contacts is realized by a two-step silicon implantation process, using energies of 20 keV and 60 keV and a dose of 1 x 10^{14} cm^{-2}. Dopant activation resulted from rapid thermal annealing in nitrogen gas for 15 s at 600 °C.

A 10 nm-thick Al_2O_3 hard mask, deposited by atomic layer deposition (ALD), paved the way to the formation of fins with a height of 200 nm. These were defined through etching in a mixture of chlorine gas and oxygen, a pairing that is superior to BCl_3 for yielding high quality sidewalls. Subsequent etching in a solution based on hydrogen chloride released the nanowire arrays, before the structure was passivated in 10 percent $(NH_4)S_2$. After this step, the wafers were immediately loaded into the ALD tool for deposition of Al_2O_3 at 300 °C, followed by the growth of WN at 385 °C.
The last steps of the fabrication process involved etching to form the base in a mixture of methane and oxygen, and electron beam evaporation of Au/Ge/Ni, followed by lift-off to define source and drain contacts. After forming the source/drain alloy at 350 °C, Cr/Au test pads were defined.



germanium channels. That's because the mobility is held back by growth on relaxed germanium buffers, which cause the GeSn to be under biaxial compression, due to its larger lattice constant than germanium. "The compression is one of the reasons why we see an improvement in hole mobility [when switching from germanium to germanium tin]," explains Gupta, who reveals that this strain also reduces the speed that electrons zip through the material. The next step for the team is to form relaxed GeSn. "We believe that this is important, since we expect relaxed germanium tin to show performance enhancements over germanium."

Improving gate stacks

Very little work has been carried out so far on the unification of post-silicon nFETs and pFETs. This has been accomplished on a germanium platform by a team from the University of Tokyo headed by Shinichi Takagi and Mitsuru Takenaka (see Figure 6), and at the most recent IEDM they reported electron and hole mobilities of 1800 $cm^2V^{-1}s^{-1}$ and 260 $cm^2V^{-1}s^{-1}$, respectively. This represents electron and hole mobility enhancements of 250 percent and 130 percent, respectively, compared with silicon.

Takagi explains that this work is in its infancy: "In this feasibility study the channel length is pretty long. It is 50 or 20 micrometres, though shorter channel devices are also operating." The operating voltage for these devices is about 2 V.

The paper that they presented at IEDM details a number of recent breakthroughs, including the development of germanium nMOSFETs and pMOSFETs. Built on native substrates, this pair of transistors combined very high mobilities for this material system with very few interface traps and a low EOT. For example, transistors with an EOT of just 0.82 nm and 0.76 nm have produced electron mobilities of 754 $cm^2V^{-1}s^{-1}$ and 690 $cm^2V^{-1}s^{-1}$.

They key to all this success is the novel process for producing the gate, which is a stack of HfO_2, Al_2O_3, GeO_x and germanium. ALD is used to deposit a thin film of Al_2O_3, before oxygen plasma treatment creates a GeO_x film under this layer (see Figure 7). GeO_x does not get too thick, because the Al_2O_3 acts as an oxygen barrier, and experiments by the team have shown that just 0.5 nm of GeO_x can reduce the density of interface traps. The addition of HfO_2 is needed, because Al_2O_3 has a relatively low

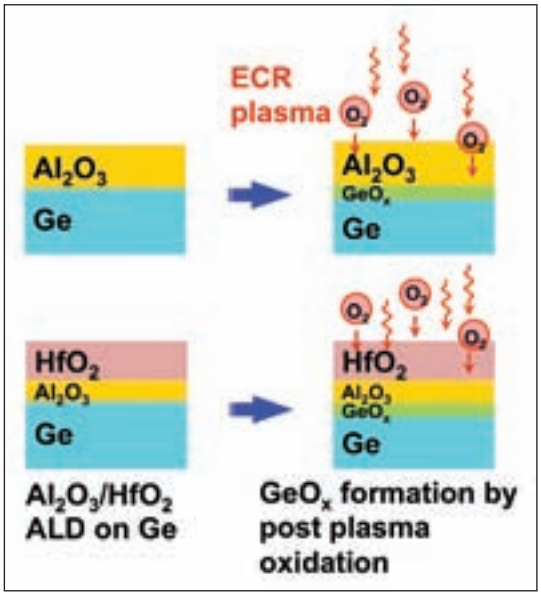


Figure 7. Researchers at the University of Tokyo create GeO_x films below Al_2O_3 layers via oxidation with an ECR oxygen plasma

permittivity, and limits the EOT to 1 nm. Just using HfO_2 on top of GeO_x is not an option, as these layers intermix, creating an interface with many traps.

Creating a $HfO_2/Al_2O_3/GeO_x$/germanium stack leads to an EOT of just 0.76 nm. "According to the ITRS 2011 [roadmap], EOT at the 11 nm node is 0.76-0.61 nanometres for high-performance applications, 0.86-0.75 nanometres for low operating power applications and 1.1-0.9 nanometres for low standby power applications," explains Takagi. "So, although 0.76 nanometres might not really be enough for high-performance applications, it is pretty close."

Takagi and his co-workers have also developed a process for forming germanium-rich MOSFETs on silicon substrates (see box "Building on silicon" for details of this process). This creates a highly strained channel, helping to enhance hole mobility to a value eight times higher than that found in silicon MOSFETs.

When InGaAs, rather than germanium, is used for the electron channel, the indium content is often used to adjust the strain and ultimately the mobility. Takagi and co-workers, however, have been able to decouple the influence of strain from the impact of adjustments in InGaAs composition. "We have changed the strain under a given indium content by using relaxed InGaAs buffers with different indium contents, allowing us to extract the effect of strain on mobility."

The team from Tokyo have formed these transistors on silicon. One way to do this is to etch narrow trenches in silicon wafers, and deposit material into these groves to form the channel of the device. Takagi says that in terms of productivity, this approach is the most attractive option, because the only additions to the CMOS process are selective growth processes. "The difficulty [with this approach] is the channel material quality – the lattice mismatch between silicon and both III-Vs and germanium is so large, and so many defects can be introduced into the channels. Aspect ratio trapping can mitigate the density of dislocations, but the material quality has not been proven yet."

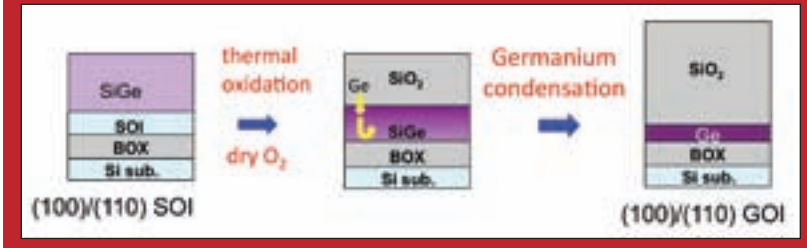
Direct wafer bonding

Takagi and his co-workers have taken a different approach to forming III-V transistors on silicon – direct wafer bonding. This "guarantees" material quality, says Takagi, but he adds that it impairs productivity and probably leads to higher production costs. Another downside of this approach is that it is challenging to realize selective formation of III-Vs and germanium on silicon, and this could constrain chip design.

Lukas Czornomaz from IBM Zurich Laboratory agrees with Takagi that direct wafer-bonding delivers very high material quality, and claims that it is the most mature technology for wafer scale formation of III-V and germanium transistors on silicon. "Direct wafer bonding will be the first to allow a proper technology evaluation at dimensions and densities which are relevant for the semiconductor industry."

Building on silicon

Researchers at the University of Tokyo have recently developed a process to form germanium-based pMOSFETs on strained silicon-on-insulator (SOI) substrates. Fabrication of devices begins by taking a SOI substrate, depositing a thin film of silicon on this, and adding a layer of SiGe on top of that (left). This wafer is then oxidized at high temperature, and during this process silicon atoms are preferentially oxidized to form a SiO_2 film, while germanium atoms are rejected and transferred to the SiGe film (middle).



The buried oxide (BOX) layer prevents germanium atoms from diffusing into the silicon substrate, leading to a steady increase in the germanium content in this layer. Meanwhile, silicon atoms in the SiGe layer diffuse to the interface with SiO_2. Once all the atoms of silicon above the BOX are oxidized, a pure film of germanium can be formed (right).

At IEDM 2012 Czornomaz and his co-workers detailed their direct wafer bonding approach (see Figure 8 for an overview). This begins by taking an InP wafer and depositing onto it an InAlAs buffer with a thickness of about 300 nm, a 10 nm $In_{0.53}Ga_{0.47}As$ channel, a 5 nm $In_{0.52}Al_{0.48}As$ back barrier and a 30 nm buried oxide (BOX).

A dose of hydrogen is then implanted into the stack, with concentration peaking in the buffer layer (see Figure 9), before the wafer is bonded to a silicon substrate. Thermal splitting separates this structure in two, creating one wafer that is used for making MOSFETs, which has a silicon substrate topped with a BOX, channel, back barrier and some of the InAlAs buffer. This buffer is subsequently removed with a wet chemical etch.

"The BOX has two functions," explains Czornomaz. "It first serves to promote the bonding between silicon and III-Vs, which are two very heterogeneous materials. But it also provides the semiconductor-on-insulator architecture which is needed for device scalability at very small dimensions."

Initially, the team produced devices with channel lengths down to 250 nm. Values for sub-threshold swing at a source-drain voltage of 0.5 V are typically about 100 mV/decade, and DIBL is around 20 mV/V, which is comparable to Intel's Tri-Gate devices with similar gate lengths. More recently, the team has reduced gate lengths to 22 nm – results on these devices will be published shortly.

Development of the wafer-bonding process has used 100 mm wafers, because that is the preferred size at the corporation's new Binnig & Rohrer Nanotechnology Center in Switzerland. The team now needs to scale this process to 300 mm, the diameter of silicon wafers used in today's leading foundries, and this will require a move away from using III-Vs substrates, because they are too small. "We plan to demonstrate that the same approach can be done with III-Vs grown on a large silicon wafer as a donor wafer, which would make it suitable for any wafer size," explains Czornomaz.

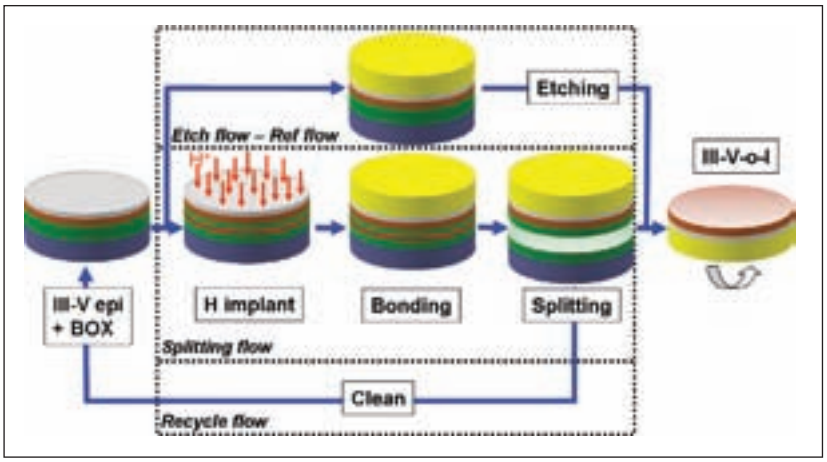


Figure 8. Engineers at IBM have formed InGaAs MOSFETs on silicon using a direct wafer bonding process. Hydrogen implantation into the buffer enables this layer to split under thermal activation

The effort of Czornomaz and his co-workers, plus those at Stanford University, Tokyo University, MIT and Purdue University, show that significant progress is being made towards the introduction of III-Vs and germanium-based transistors on a silicon platform. Further gains are sure to follow in the coming months, and many of them will be reported in the papers given at IDEM 2013.

This meeting, which will be held in Washington DC from 6 to 13 December, will provide a snapshot of what's been accomplished to maintain the march of Moore's law at the 11 nm node and below – and just as important, what still needs to be done.

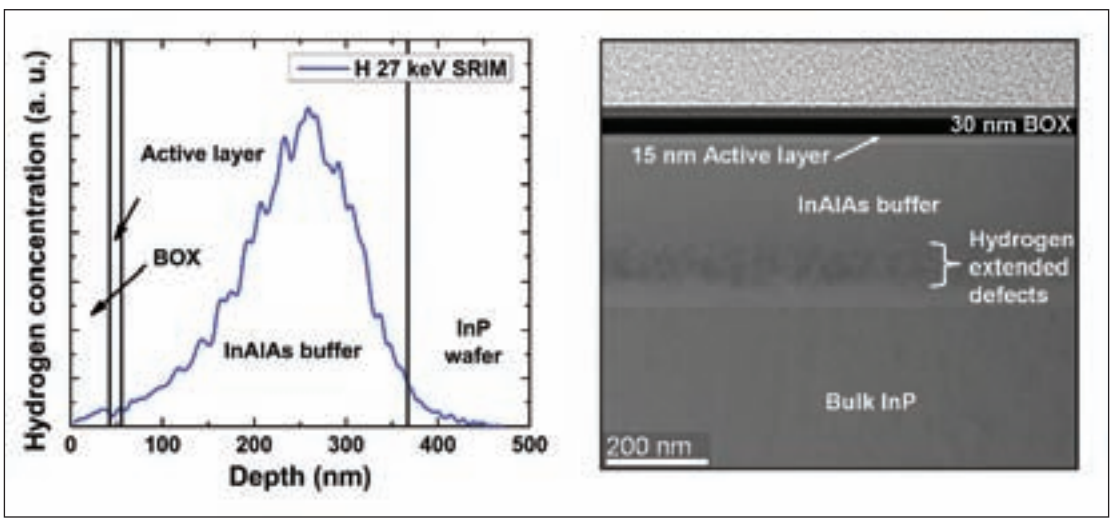


Figure 9. Simulation indicates that a 27 keV implantation of hydrogen leads to a dose that peaks in the centre of the InAlAs buffer (left). Although hydrogen implantation creates defects in the buffer, they are not seen in the active layer channel, which contains the channel and back-barrier (right)

CS industry awards 2013

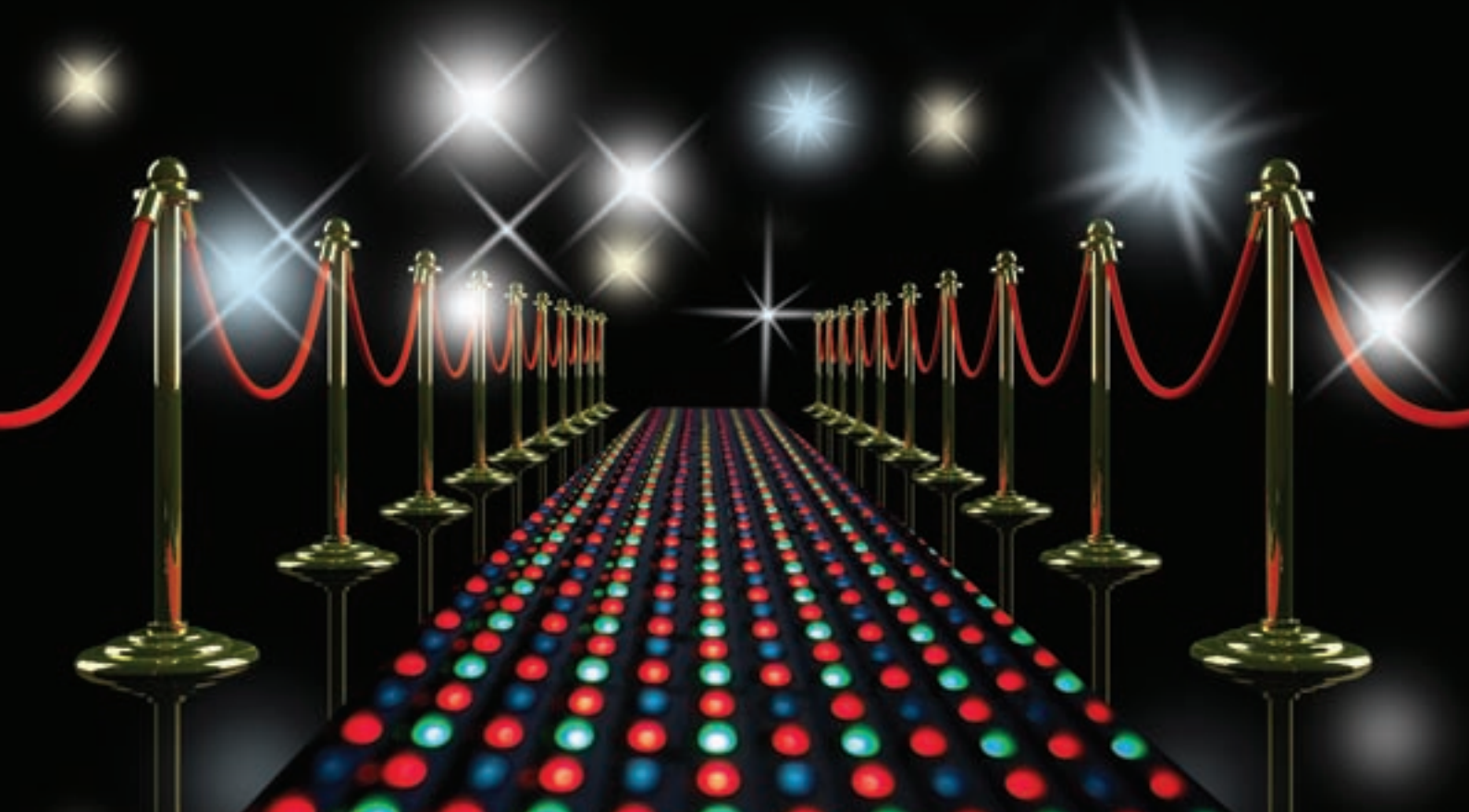
The 2013 CS Industry Awards recognise success and development along the entire value chain of the compound semiconductor industry from research to completed device, focusing on the people, processes and products that drive the industry forward.

From backlighting TVs to empowering mobile devices and harnessing the sun's energy, compound semiconductor chips are playing an ever-increasing role in modern life. This is set to continue, but who had the biggest breakthroughs? Which pioneering companies from around the globe created the best opportunities for the compound semiconductors industry?

The CS Industry Awards 2013 will recognise success and development along the entire value chain of the compound semiconductor industry from research to completed device, focusing on the processes and products that drive the industry forward. The CS Industry Awards will remind us what is good about the industry - the companies who drive it with their technical expertise and customer orientated perspectives.

Welcome to our shortlist for 2013, they represent the best and the brightest serving the compound semiconductor industry today.

www.csawards.net



Substrates & Materials Award

CREE

150-mm 4HN Silicon Carbide Epitaxial Wafers

In 2012 Cree successfully developed new high quality low micropipe 150-mm 4H n-type silicon carbide, (SiC) epitaxial wafers. Cree's latest advancement lowers device cost and enables adoption for customers with existing 150-mm diameter device processing lines for 150-mm epitaxial wafers with highly uniform epitaxial layers as thick as 100 microns.

SiC is a high-performance semiconductor material used in the production of a broad range of lighting, power and communication components including, LED power switching devices and RF power transistors for wireless communications. Cree's 150-mm diameter single crystal SiC substrates enable cost reductions and increased throughput while bolstering the continued growth of the SiC industry. Cree's ability to deliver high volumes of 100-mm epitaxial wafers is unrivalled in the SiC industry and the latest 150-mm technology continues to raise the standards for SiC wafers.

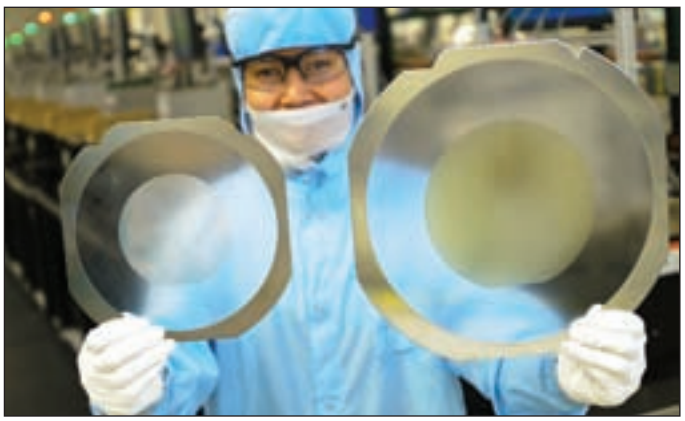
Cree's vertically integrated approach offers customers a complete solution for high quality 150-mm SiC epitaxial wafers providing industry leaders within the power electronics market the stable supply they demand.

What industry challenge does this address?

Cree is successfully addressing the lack of availability of affordable high quality SiC materials within the power electronics market.

How does it solve the problem?

Cree leads the SiC materials marketplace in driving to larger diameters and this latest advancement lowers device cost and enables adoption for customers with existing 150-mm diameter device processing lines. Cree's vertically integrated approach offers customers of a complete solution for high quality 150-mm SiC epitaxial wafers providing industry leaders within the power electronics market the stable supply they demand.



Kyma Technologies

10-Inch Diameter Aluminum Nitride on Sapphire Template Product

Kyma Technologies, Inc., a supplier of crystalline aluminium nitride (AlN) and gallium nitride (GaN) materials and related products and services, announced in 2012 the successful demonstration of a 10-inch diameter aluminum nitride (AlN) on sapphire template.

Kyma's AlN templates are manufactured using its patented plasma vapour deposition of nanocolumns (PVDNC™) technology, which provides GaN LED manufacturers with throughput, cost, and performance benefits. LED manufacturers can choose Kyma's PVDNC™ AlN templates as a replacement for bare and patterned sapphire substrates by manufacturers of blue, green, and white light emitting diodes (LEDs).

Until recently, the wafer diameter standard for GaN LED wafer manufacturing has been 50mm (2"). Recently, sapphire manufacturers have made much progress in increasing the size of sapphire boules from which ever larger sapphire substrates can be sliced, with sapphire diameter demonstrations up to 12" being achieved by certain sapphire providers. (The 250-mm (10-inch) diameter sapphire substrate was provided courtesy of Monocrystal, of Stavropol, Russia.)This has enabled some of the major GaN LED manufacturers to begin transitioning to larger diameter sapphire, up to 150-mm (6-inch) in some cases, to enhance manufacturing throughput and to achieve better economies of scale. Kyma believes the LED community will begin looking beyond 150mm (6-inch) diameter in the next few years.

In 2011 Kyma announced the successful commissioning of its new high volume PVDNC™ AlN template manufacturing tool and the demonstration of the world's first 300mm (12-inch) diameter AlN on silicon template that is suitable for high quality gallium nitride (GaN) growth.

Kyma's 10" diameter PVDNC AlN on sapphire template is pictured along with smaller diameter (6" and 4") products.

Rubicon Technology

6-inch sapphire substrates

Rubicon Technology is an advanced electronic materials provider that is engaged in developing, manufacturing and selling monocrystalline sapphire and other crystalline products for light-emitting diodes (LEDs), radio frequency integrated circuits (RFICs), blue laser diodes, optoelectronics and other optical applications. The company applies its proprietary crystal growth technology to produce very high-quality sapphire in a form that allows for volume production of various sizes and orientations of

substrates and windows. Rubicon is a vertically-integrated manufacturer with capabilities in crystal growth, high precision core drilling, wafer slicing, surface lapping, large-diameter polishing and wafer cleaning processes, which the company employs to convert the bulk crystal into products with the quality and precision specified by its customers. The company is the market leader in larger diameter products to support next-generation LED, RFIC and optical window applications.

Light Emitting Diodes (LEDs) are the future of lighting because they are environmental friendly, durable, have much longer life and consume considerably less energy than traditional lighting sources. LEDs are used for backlighting in nearly all mobile applications such as cell phones and GPS systems. Rapidly growing applications for LEDs includes larger display backlighting for notebook computers, desktop monitors and LCD televisions as well as giant LED displays for stadium signage and electronic advertising. LED streetlights and LED replacement bulbs for commercial and residential lighting are also beginning to displace existing lighting solutions.

Sapphire is the predominant substrate material used as the foundation to produce a vast majority of all blue, white, green and UV LEDs. Sapphire substrates are also used to produce blue laser diodes for applications such high-definition DVD players and gaming systems.

LED production is now migrating to larger diameter sapphire wafers which fit well with Rubicon's cost effective, large diameter ES2 crystal growth and sapphire fabrication technologies. Their proprietary ES2 crystal growth technique along with expertise in wafer fabrication enables the company to deliver customised products tailored to meet customers' needs.

Compound Semiconductor Manufacturing Award

AIXTRON

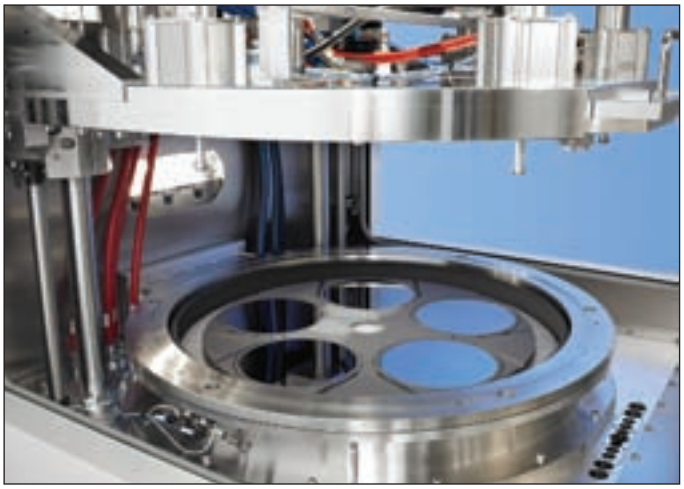
G5+ : 5 x 200mm GaN-on-Si MOCVD Reactor

With its latest product AIX G5, AIXTRON SE has introduced a 5x200 mm GaN-on-Si (Gallium Nitride on Silicon technology package for its AIX G5 Planetary Reactor® platform). Following a customer-focused development program, this technology was designed and created in AIXTRON's R&D laboratory and consists of specially designed reactor hardware and process capabilities. It is now available as a part of the AIX G5 product family and any existing G5 system can be upgraded to this latest version.

- Suited for GaN power electronics as well as for LED on Si applications it addresses the industry's key requirements in a unique way
- Highest throughput with 5x200 mm reactor capacity
- Uniformity pattern with rotational symmetry
- Behaves like a silicon single wafer reactor and therefore enables highest yields targeting greater than 95% area in spec and controlled wafer bow of 20μm min-max final bow
- Capability to use standard thickness 200 mm silicon wafers
- Industry-wide the only reactor that enables managing the temperature gradient through the wafer
- In-situ temperature profile tuning
- Customised wafer carrier temperature optimisation according to customer device requirements

What industry challenge does this address?

GaN-on-Si technology is the technology of choice for power electronics applications and additionally a very promising candidate for high performance low cost HB-LED manufacturing. It is assumed that LEDs on 200mm Si is the disruptive technology that enables manufacturing cost reductions of 60%, compared to today's mainstream 100mm sapphire. The challenge was to develop a reactor that produces GaN based devices on silicon



without compromising the performance or yield currently obtained on sapphire or smaller size silicon substrates. The technology must provide high-yield growth of GaN devices on large area substrates meeting the fundamental physical challenges of a strong wafer bow and crack formation as well as the reactivity of Ga with Si.

How does it solve the problem?

Based on extensive numerical simulation, new hardware components and processes were developed. A novel gas inlet was designed that provides unmatched gas phase stability and controllability. The setup delivers excellent process reproducibility uniformity and yield on the full area of all 200 mm wafers. Furthermore temperature management was adapted to the requirements of the large area GaN-on-Si process.

Special focus was put on the bow management. The reactor minimises the vertical heat flux through the wafer which results in the lowest wafer bow. The specific geometry of the reactor provides rotational symmetry of the GaN films. Additionally, a reliable method to reset all chamber conditions was developed meeting the challenges of the Ga-Si chemistry.

ARC Energy

CHES furnace for sapphire crystal growth

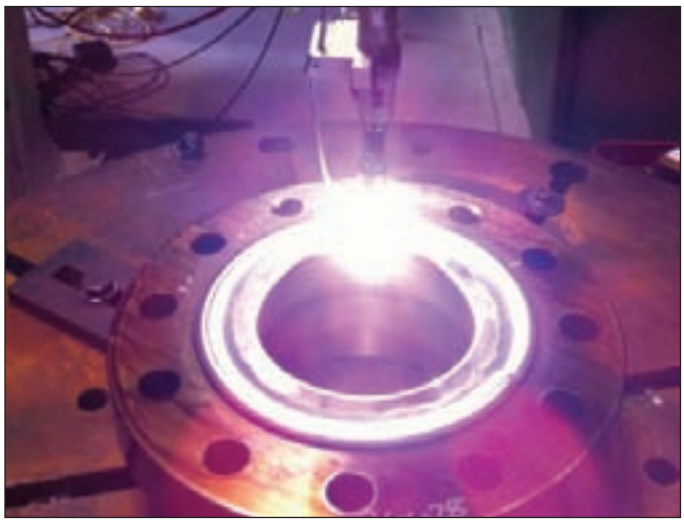
CHES furnaces for sapphire crystal growth use a new technology called Controlled Heat Extraction System. CHES technology furnaces convert more than 75% of the sapphire grown into product which is c-axis sapphire for light emitting diodes (LED) applications. This is compared to 10-35% for conventional technologies. This means CHES furnaces are able to supply High Brightness LED manufacturers with much more efficient sapphire substrates at reduced costs.

This material utilisation improvement was needed as the industry proceeds towards larger diameter substrates. CHES furnaces achieve this efficiency with three features.

Firstly, sapphire is grown on the c-axis of the crystal which matches the orientation required for HB-LED manufacturing. This saves the wasteful method of coring from the side of the boule which results from a-axis growth (process utilised by conventional technologies).

Secondly, CHES furnaces create sapphire boules that are near net shape. This allows further savings and can allow for eliminating the coring step as the outer diameter can be simply ground to shape.

The third feature is very low defect levels. The presence of defects is a major challenge for conventional sapphire growth technologies and greatly reduces yield when growing for large diameter applications. Another benefit to CHES is less bow and



warp during epitaxy. In the MOCVD reactor excess bow and the presence of warp can dramatically reduce LED chip yield. CHES achieves low warp due to the wafers being sliced from a layer of the boule that was grown in a short time creating a single heat time signature. In addition to the growth advantages, CHES furnaces use a high level of automation for crystal growth.

This has dual advantages: less operator training costs and higher consistency in the growth process. These features make CHES furnaces a key technology in reducing HB-LED costs.

What industry challenge does this address?

Sapphire crystal growth has been on-going for about 100 years and it was used as a specialty product because it was expensive. The industry had problems in growing c-axis sapphire hence a-axis was commonly grown. Product requirements of c-axis were cored perpendicular to the growth axis of a-axis crystals.

LED application requires c-axis sapphire substrates in very large quantities. ARC Energy made a paradigm shift by focusing on c-axis sapphire growth and the result is CHES furnaces for sapphire crystal growth. All the above advantages followed.

How does this solve the problem?

CHES furnaces make sapphire substrates affordable and these economies increase with larger diameter sapphire. CHES furnaces operate with more than 75% material utilisation for large diameter. Competing technologies can only reach 10-35% and this yield decreases with larger diameter sapphire. CHES furnaces can today supply the HB-LED industry with the large diameter substrates required to reduce solid state lighting (SSL) costs.

Using 2-inch diameter substrates as baseline for a single MOCVD run 6-inch sapphire provides 55% more LED chips and for 8-inch the advantage is 77%. This represents a dramatic improvement in cost savings for LED chip manufacturing.

Dow Electronic Materials

VAPORSTATION™ III Central Delivery System

The VAPORSTATION™ III Central Delivery System offered by Dow Electronic Materials is designed to deliver metal-organic precursors to multiple CVD reactors from a central supply source cabinet using a high-purity carrier gas.
The system uses an on-board evaporator to convert liquid precursors supplied from a bulk source canister into a vapour phase and is capable of tightly controlling the flow rate of material to the connected CVD reactors. The VAPORSTATION III Central Delivery System is controlled through a touch screen interface providing users with easy operation of automatic and manual modes for set-up safety maintenance and evaporator controls.

This delivery technology enables users to run several reactors with no downtime for precursor cylinder change which provides significant opportunity for increased reactor throughput and lower cost of ownership. Because the system eliminates the need for cylinders at each reactor the footprint for each reactor and the number of components requiring maintenance are both reduced.

Elimination of on-board precursor delivery allows for more consistent process control across multiple reactors and utilising a bulk supply approach maximises the supply of precursor material available for longer production runs. The tool also provides greater process safety in production areas as a result of less material handling and the ability to segregate the precursor supply cabinet from the processing area. As a result, precursors would be plumbed into the processing area for delivery in a vapour form (metal-organic precursors in vapour phase are significantly less hazardous than precursors in liquid phase).

The VAPORSTATION III Central Delivery System is targeted specifically for bulk delivery of MOCVD precursors used in the epitaxial growth process for compound semiconductor devices such as LEDs lasers solar cells and optoelectronic devices. With more than three decades of experience Dow Electronic Materials is the world's leading supplier of MOCVD precursors for the LED industry.

What industry challenge does this address?

The primary challenge addressed by the VAPORSTATION III Central Delivery System is the effort and cost associated with managing small-volume MOCVD precursor cylinders through logistics and in epi processing areas. Reactors configured with on-board cylinders are shut down when the precursor source is depleted and the cylinder is changed out. The constant movement of new and depleted cylinders is inefficient and expensive. There are a number of other challenges that the VAPORSTATION III Central Delivery System addresses including the difficulty and complexity of matching process parameters between reactors as well as maximizing the reactor throughput when using on-board precursor delivery.

How does it solve the problem?

By utilising a single bulk cylinder, up to 37 kg to supply multiple CVD reactors, the VAPORSTATION™ III Central Delivery System eliminates the logistics necessary to manage full and depleted cylinders for each reactor. In addition, the capacity of the evaporator is large enough to allow for bulk cylinder change-out with uninterrupted supply of precursors to the reactors which allows for users to maximise reactor throughput.

The design of the VAPORSTATION Central Delivery System controls enables consistency in material supply to each of the reactors in the production loop. The system allows for precise control of the precursor in vapour phase in a manner not possible with on-board cylinders which contributes directly to better device quality and reduced binning.

EPC

The EPC9102 is an isolated DC/DC 1/8TH brick converter. The design is a 36 V – 60 V input to 12 V output 375 kHz phase-shifted full bridge with 17 A maximum output current. The EPC9102 features the 100 V EPC2001 eGaN FETs in conjunction with the LM5113 100V half-bridge gate driver from Texas Instruments. The EPC9102 demonstrates that a new benchmark in performance can be achieved by using high switching frequency eGaN FETs

coupled with the LM5113 the industry's first eGaN optimised IC driver.

What industry challenge does this address?

Energy savings in servers and telecom equipment has become one of the highest priorities for lowering cost and reducing the environmental footprint caused by our expanded use of cell phones and the internet. The EPC9102 demonstration circuit was designed to showcase the size and improved efficiency that can readily be achieved using eGaN FETs.

How does it solve the problem?

eGaN FETs have lower switching figures of merit versus comparable silicon FETs and offer designers the opportunity to increase the operating frequency of converter designs while decreasing power dissipation. This increase in switching frequency allows a higher power density in the magnetic components. As these components are a major limitation of power density output power can now be increased within a given form factor or the solution size can be significantly without sacrifice to performance.

Metrology, Test and Measurement Award

Agilent Technologies HSTD

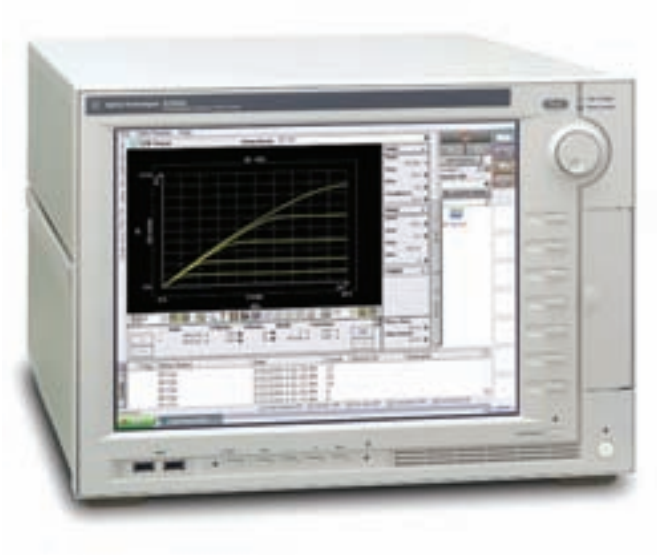
New B1505A Power Device Analyzer

The B1505A is an integrated solution that provides researchers and device / process development engineers of power devices with high-voltage and high-current source and measurement capabilities. The fully integrated curve tracer mode makes it easy for users to take advantage of its PC-based EasyEXPERT software.

The all in one analyzer / curve tracer unit is designed to characterise all current emerging and evolving power devices from sub-pA to 1500A / 10kV (10 μs pulse with μΩ -resistance measurement capability).

Key Features of the Agilent B1505A Power Device Analyzer/ Curve Tracer –

- Wide current/voltage range: 1500 A/10 kV
- Accurate leakage measurement (sub-pA capability)
- Precise on-resistance characterization (Ìø resolution)
- Pulsed measurements as fast as 10 μs
- Medium current measurement at high voltage bias: 500 mA @1200 V
- High power wafer probing support enables testing at > 200 A & 10 kV on-wafer
- True knob-sweep curve tracer functionality
- Integrated thermocouple inputs for temperature measurement
- Oscilloscope view (I/V) function supports output waveform monitoring
- Fully automated measurement & data analysis
- High current/voltage measurements traceable to international standards
- Scalable platform and architecture make it easy to add capabilities as needs change



What industry challenge does this address?

Power devices power modules and power management ICs are a growing device category that requires both high-power and high-accuracy test capabilities. In order to meet emerging standards for improved energy efficiencies power devices must function ever more efficiently even as they continue to become more complex smaller and faster.

New devices using wide band gap materials such as silicon carbide (SiC) or gallium nitride (GaN) have been widely developed in order to achieve higher efficiencies. To meet performance and safety requirements these developments require high-voltage on wafer measurement capabilities of greater than 3000V to reduce development and qualification times.

How does it solve the problem?

Today's new power devices require new and innovative techniques for accurate test and characterization. The Agilent Technologies B1505A meets all the requirements for high current high voltage and medium current measurement at high voltage bias. With its next generation curve tracer architecture and sophisticated software environment it allows detailed device characterization automated test and operator safety with its carefully considered safety interlocks. It comes with a wide variety of dedicated test accessories which coupled with its next generation architecture ensures unparalleled performance and ease of use in power device evaluation and characterisation.

Bruker Corporation

D8 FABLINE metrology for semiconductor manufacturing

The functional units of semiconductor and compound semiconductor devices shrink in size and thickness from generation to generation. In addition, the device structures become increasingly complex – and the process more and more expensive. Thus, the demand for reliable analytics for process development and at-line or in-line quality control increases permanently.

X-ray metrology offers a non-contact and non-destructive method of probing the nanometric scale, which provides various essential parameters without the need to use a reference.
Secondly, the method is known and accepted for many years within scientific, research and development communities for its accuracy and reliability. In many cases just one quick measurement is required to determine sample parameters with a spatial resolution better than 50 Ìm in diameter.
The D8 FABLINE is the Bruker AXS' product line dedicated to semiconductor industries. The instrument consists of two modules. The analytical tool consists of the X-ray metrology unit combined with the EFEM (Equipment Front End Module) for easy FAB automation integration; the Spartan dual load port from Asyst technology allows automated sample change.
The X-ray metrology unit is based on the D8 DISCOVER, the world's leading diffraction instrument for R&D in semiconductor industry.
The D8 FABLINE is the only X-ray metrology instrument with four combined applications:

- High-Resolution X-Ray Diffraction (HRXRD)
  - Single-crystal / epitaxial layer structure, e. g. SiGe
  - Composition, thickness, relaxation
  - Spot down to 50 µm in diameter
- X-ray Reflectivity (XRR)
  - Polycrystalline, amorphous, single-crystal film structure, e.g. HfO_2 on blanket
  - Thickness, density
- Micro X-ray Fluorescence (ÌXRF)
  - Polycrystalline thin film, e. g. HfO_2 on product wafers
  - Composition and film thickness
  - Spot down to 50 µm in diameter
- Grazing Incidence Diffraction (GID)
  - Polycrystalline thin film
  - Identification of crystalline phases, crystallite size.

Jordan Valley Semiconductors

QC3 Fast HRXRD Metrology Tool

The QC3 High-Resolution X-Ray Diffractometer (HRXRD) from Jordan Valley is a true leapfrog technology over the existing HRXRD technology within the market. The QC3 boasts more than an order-of-magnitude improvement in performance compared to other HRXRD systems, with scans taking seconds rather than minutes or even hours. This provides LED manufacturers a dramatic improvement in quality control of LED devices, with more wafers and higher sampling within wafers possible.

The development and market launch of QC3 demonstrates the success of JVS' 2008 acquisition of Bede's HRXRD and compound semi technology. Furthermore, it reinforces JVS management's ability to apply its business model and expertise in providing the semiconductor market with enabling, high-throughput systems with low cost-of-ownership, achieving market dominance with a valued, customer-preferred product.

Features and benefits:

- Productivity and Precision: The QC3 has a dedicated and optimised HRXRD system for LED quality control. As a result of its high intensity, the system gives higher precision and throughput compared to other HRXRD systems.
- Automation: The system operates with fully-automated alignment, measurement and analysis of wafers, conducting batch wafer measurements with optional robot or multi-sample plates. The multi-sample plates allow up to 20 wafers to be loaded into the system for measurement without requiring a robot. For the automated analysis of the data spectra, the QC3 uses tried and trusted industry-leading RADS software for automated analysis which will automatically analyse the collected data and report the results for specific wafers, batches, chambers. This reporting can be extended to host reporting if required.
- Economy: QC3 incorporates XRGProtect™, to ensure the tube lifetime is maximised. It also has an Eco-mode; ensuring system power consumption is reduced when there is no measurement being performed.
- Simplicity and Reliability: The system is so reliable and easy to use, that no expert is required to operate the system.

Device Design and Packaging Award

CREE

New 50A Silicon Carbide (SiC devices)

Cree's latest technology breakthrough enables 50 Amp Silicon Carbide (SiC power devices) bringing efficiency and cost savings to a broader range of high-power applications. Cree's new family of 50A SiC devices can reduce the cost of power electronic systems while providing improved energy efficiency.

What industry challenge does this address?

These new 50A SiC devices allow a new generation of power systems with record-setting energy efficiency and lower cost of ownership than with conventional technologies.

How does it solve the problem?

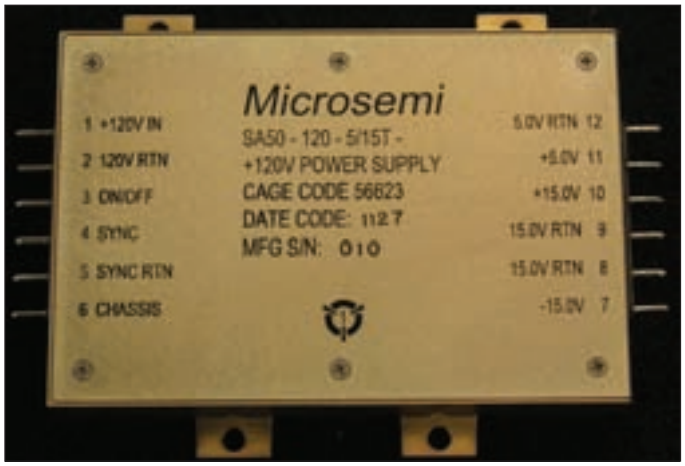
The new devices available in die form are designed for high-power modules for applications such as solar power inverters uninterruptible power supply (UPS) equipment and motor drives. Using the Cree® SiC 50A devices power electronics engineers can set new standards for system cost of ownership through reduced size lower-cost bill of materials (BOM) and improved efficiency. The larger die extends the benefits realised with Cree's 20 Amp SiC MOSFETs to power applications up to 500 kW making it possible to replace less capable conventional silicon IGBTs in high-power high-voltage applications.

These new 50A SiC devices which also include a 1200V Z-FET SiC MOSFET and three Z-Rec® SiC Schottky diodes will enable a new generation of power systems with record-setting energy efficiency and lower cost of ownership than with conventional technologies. The new devices available in die form are designed for high-power modules for applications such as solar power inverters uninterruptible power supply (UPS) equipment and motor drives. Using the Cree® SiC 50A devices, power electronics engineers can set new standards for system cost of ownership through reduced size lower-cost bill of materials (BOM) and improved efficiency.

Microsemi

Radiation Hardened Isolated DC/DC Converters (SA50-120)

Microsemi's SA50-120 is a family of radiation-hardened surface mount technology packaged 120 volt input 50 watt output fully isolated DC-DC converters. This family dramatically improves system weight efficiency and reliability while reducing cost. The high-reliability converter is available with single dual and triple outputs which provide military and commercial satellites with



continuous protection against naturally occurring "total dose" and "single event" ionised radiation which can negatively impact system performance. In addition to improving quality by leveraging automated and repeatable surface mount technology processes the SA50-120 series allows designers to maximise board real estate resulting in a similar package and weight density to hybrid alternatives.

Microsemi's new DC-DC converters feature a fully isolated power supply capable of driving high-reliability point-of-load (POL) converters used to "step down" power to devices such as customisable system-on-chip (cSoC) solutions and field programmable gate arrays. Additional features include a fully isolated synchronisation scheme to manage system noise spectra.

What industry challenge does this address?

Existing satellites use two stages of regulation: Solar panel voltage (approximately 120 volts) is switched with an isolated DC to DC converter to 28 volts at typically 67-75% efficiency. The 28 volt bus is then switched to the target voltage of 5 /- 12 volts by an isolated DC to DC converter with a typical efficiency of 67-75%.

Nearly HALF of the power is lost. Further the historical use of low efficiency radiation hardened hybrid devices have lead times of up to 38 weeks and have been fraught with delivery delays of up to two years.

How does it solve the problem?

The SA50-120 DC to DC converter eliminates the intermediate voltage of 28 volts by directly converting from the solar panel voltage to the target voltage at an astounding 86% efficiency. An entire regulation block is eliminated dramatically reducing the weight of the overall power system increasing the reliability by using fewer components and reducing cost.

By using radiation hardened hermetically sealed SMT devices procurement and assembly time is reduced to about 20 weeks.

Osram Opto Semiconductors

Direct Emitting Green Laser Diodes

In 2012, Osram Opto Semiconductors launched its first direct green diode lasers. The two compact laser diodes have an optical output of 30 and 50 milliwatts and a particularly high beam quality so they represent a milestone in the development of miniature projectors for mobile devices such as smartphones and cameras. Projection units for laser shows, point lasers and line lasers will also benefit from the new technology.

Direct green diode lasers are an important step toward powerful pico projectors. It means that the old laborious way of producing green light by doubling the frequency of infrared laser is no longer needed. The new technology enables high colour rendering and excellent contrast to be achieved. The wavelength of the new PL 520 laser diode of 515-530 nm produces precisely the right green for projection applications. Its optical output is 50 mW and its efficiency is typically 5-6 % at present. The PL 515 offers an output of 30 mW in a wavelength range of 510 to 530 nm. With a package diameter of only 3.8 mm the laser diodes enable the dimensions of projection units to be reduced considerably.

The lasers have a very high beam quality – in other words an extremely narrow beam that spreads out only slightly thanks to its small divergence angle. In the case of pico projectors, which project the laser light with a MEMS mirror (micro-electromechanical system) without any other optics, the size of the light point determines the image resolution. The beam quality is particularly important. Both laser diodes operate in single mode, which means they emit only a single transverse oscillation mode.

Direct emitting lasers can be better modulated than other laser types, such as frequency-doubled infrared lasers. This is an important property for MEMS-based projectors in which the colour components per pixel result from the emission time of the laser diode. There is also no need to adjust the focus of the projection image. The image is always sharp, even on curved surfaces.

Laser shows, point lasers and line lasers

The single mode lasers open up new possibilities as light sources for laser shows. Their high beam quality enables extremely fine structures to be displayed even over large distances. The projectors also benefit from the high thermal stability and small size of the lasers.

Green diode lasers are also ideal as point or line lasers for measuring distances for example. The human eye is most sensitive in the green spectrum so they offer another important advantage over red laser light. For the same laser output, and therefore the same laser safety class, green light is perceived more easily by the eye than the red light that is usually used. This means that distance meters, such as those used by builders, can be used over larger distances.

By launching one of the first direct emitting green laser diodes Osram Opto Semiconductors is underlining its position in lasers based on indium gallium nitride. The green laser is the result of years of intensive development work in Regensburg. It has been developed as part of the MOLAS project sponsored by the German Ministry for Education and Research and involving technologies for ultra-compact and mobile laser projection systems. In 2010, researchers at the company received the Karl-Heinz-Beckurts Award for development work on the green laser.

SETi

III-Nitride Varactors with Capacitively-Coupled Contacts – new technology platform for RF electron

SETi has developed novel technology platform for monolithic microwave integrated circuits using capacitively coupled contacts (C3 varactors over III-Nitride heterostructures). Novel device type offers simple and robust fully planar alignment- and anneal-free fabrication technology. At 18 GHz the fabricated C3 microwave switches exhibit record low 0.8 dB loss and high 27.5 dB isolation. C3 power limiters offer insertion loss in the range 0.2 – 0.7 dB and wide range of limiting powers 17 – 40 dBm. Novel C3 devices demonstrate full compatibility with III-Nitride electronics and have a great potential for high-performance MMICs.

The C3 varactor consists of two electrodes deposited on top of AlN/GaN/InN heterostructures. Conducting channels in the heterostructures with record high 2D electron gas density (up to 1.5x1013 cm^{-2}) and high electron mobility (up to 2500 $cm^2/(V^{-1}\text{-}s^{-1})$ form metal-like conducting plates. The electrodes form capacitively-coupled contacts with 2DEG channel with low impedance at RF frequencies typically above 2 GHz. The C3 varactor can be turned off by applying the voltage across any of

its contacts exceeding the pinch-off voltage. C3 varactor does not consume significant DC bias current in addition it offers several important advantages as an RF device: (1) it has no gate so the total channel length is more than two times smaller than in HFET with the same source – gate and gate-drain spacing and hence about the same breakdown voltage (2) it has no ohmic contacts this eliminates annealing the need to align the gate and further increases the breakdown voltage due to lower edge roughness (3) it can be controlled using either positive or negative bias polarity(4) provides a built-in DC block.

What industry challenge does this address?

Modern RF systems require low loss high switching power high linearity low power consumption and broad range of operating temperatures. None of the existing RF devices simultaneously meets these requirements. PIN-diodes require at least 20 mA forward bias current to be turned on they also need bias filters with bulky high-precision and expensive inductors. MEMS are vulnerable to hot switching their switching times are limited to a few microseconds and many MEMS subtypes require high operating voltage and vacuumed packaging. Si MOSFETs and GaAs HEMTs suffer from low breakdown voltages and cannot achieve the required linearity levels.

How does it solve the problem?

The III-Nitride C3 varactor design meets all requirements mentioned above for RF control applications. C3 varactor offers high-yield simple and robust anneal-free alignment-free fabrication technology fully compatible with Power Amplifiers and the other MMICs.

Industry Innovation Award

Brolis Semiconductors

Development of novel GaSb based optoelectronics

Brolis Semiconductors develops novel optoelectronic components and materials based on GaSb material platform using their key knowledge of molecular beam epitaxial growth of very complex compounds. The company founders have demonstrated a number of first-of-a-kind GaSb type-I lasers operating at room temperature at wavelengths above 3400 nm. The team has established a state-of-the-art MBE and laser diode facility in order to commercialise the technology and bring the beyond-state-of-the-art devices to market already next year.

What industry challenge does this address?

Brolis Semiconductors develops technology for devices for wavelength range 1800 - 4000 nm which lacks reliable compact laser sources operating in continuous wave at room-temperature. Their MBE technology offers unique opportunities for development of new generation thermal imaging photo-voltaic and ultra-high-speed and low power consumption technologies based on antimonides.

How does it solve the problem?

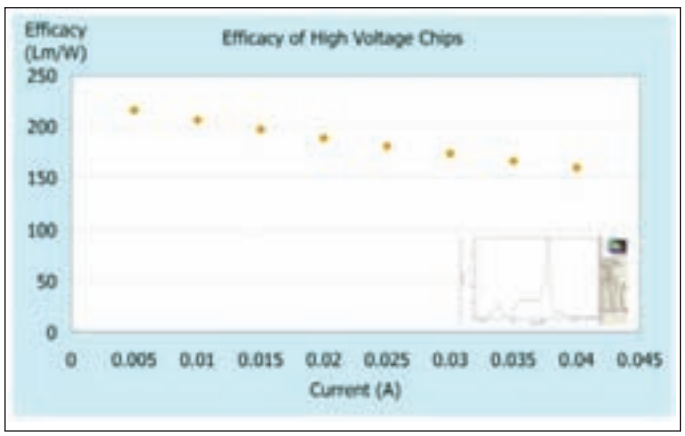
The Brolis technology brings the availability of ultra-compact power efficient electrically pumped room-temperature operating laser diodes in the 1800 nm - 4000 nm wavelength range for numerous applications in defence industrial process monitoring medicine and research. The epitaxy service provides unmatched quality antimonide and arsenide epitaxial wafers for thermal imaging TPV CPV and new generation HEMT and HBT applications.

EPISTAR LAB

Warm White High Voltage Chipset

With its outstanding efficacy, higher CRI, and competitive lm/$, the solution of direct red platform is widely used in warm white application. In 2012 EPISTAR LAB successfully achieved the warm white efficacy of 216 lm/W, with an operating current of 5 mA and CRI of 87 Ra at CCT of 2700K. Under a typical driving current of 15mA (or about 1 W operation equivalent), the luminous efficacy of 197 lm/W was achieved.

EPISTAR LAB adopts several technologies in high voltage chips, such as the novel substrate transfer process, lower MQW light absorption, fine structure for increasing the photon extraction efficiency, improvement on the current spreading uniformity, and



improved MQW structure with excellent IQE and lower forward voltage. The superior performance warm white HV chipset is suitable for retrofit, professional lighting, and luminaires applications. EPISTAR continue to develop more advanced technologies to enhance product performances and work closely with downstream customers to provide better LED lighting solutions to the market.

TriQuint
Reach Further • Reach Faster™

TriConnect™ 802.11ac Wi-Fi Solution for Mobile Devices

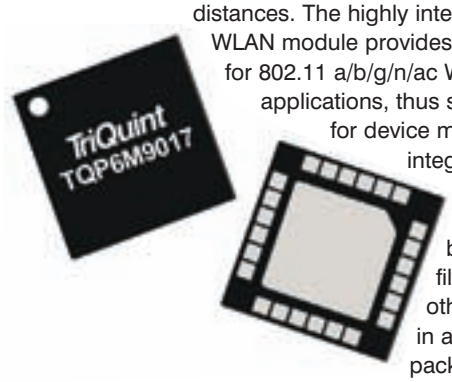
The TQP6M9017 is the industry's first 802.11ac Wi-Fi RF module for next-generation mobile devices. In addition to supporting three to four times faster download speeds for video streaming and other multimedia applications, the high-performance WLAN module improves the wireless experience by enabling connectivity from greater distances. It allows nearly 60% further range than its award-winning predecessor, thanks to advances in output power technology.

What industry challenge does this address?

As demand for Wi-Fi proliferates worldwide, consumers have developed an ever-growing appetite for faster mobile data rates to support video streaming and other multimedia applications -- at faster rates than current-generation 802.11n Wi-Fi. In addition, consumers want Wi-Fi from greater distances, while mobile device manufacturers want to simplify WLAN design with ever smaller components.

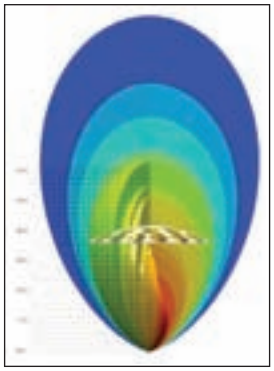
How does it solve the problem?

With data rates up to 1.3 gigabits per second, the new IEEE 802.11ac standard will deliver transfer rates three to four times faster than current-generation 802.11n Wi-Fi. In addition to supporting faster download speeds, TriQuint's TriConnect™ TQP6M9017 high-performance WLAN module improves the wireless experience by enabling connectivity from greater distances. The highly integrated, dual-band WLAN module provides a complete solution for 802.11 a/b/g/n/ac Wi-Fi and Bluetooth applications, thus simplifying RF design for device manufacturers. It integrates two power amplifiers for the 2.4 and 5 GHz frequency bands with a switch, filtering, baluns and other components — all in an ultra small 4x4mm package.



Temescal

Auratus Deposition Enhancement Methodology



Auratus is a proprietary optimisation methodology for lift-off electron beam evaporative coating that incorporates patent pending technology to achieve unprecedented levels of uniformity precision and collection efficiency. Auratus enables Temescal customers to coat wafers with near perfect uniformity resulting in more consistent better quality products and fewer defects.

Temescals Auratus methodology also has the capability to increase the effective deposition rate enabling customers to increase throughput. Temescal's Auratus process enhancement methodology is available on select Temescal systems. Temescal the expert in metallization systems for the processing of compound semiconductor based substrates provides the finest production evaporation systems available. Temescal systems provide controlled multi-layer coatings of materials such as Ti Pt Au Pd Ag Ni Al Cr Cu Mo Sn SiO_2 and ITO with highly repeatable guaranteed uniformity and performance metrics. For over a decade Temescal has been dedicated to mapping and better understanding the dynamics of the flux cloud. Through extensive testing and research we have collected hundreds of vapour cloud maps and used these maps to advance and automate the process of lift-off uniformity mask design.

What industry challenge does this address?

At the heart of every electron beam evaporation system is a vapour cloud a unique repeatable flux distribution characteristic of radiation from a point source. But these flux clouds vary based on a variety of factors in the deposition process — like deposition material deposition power crucible size the use of a crucible liner and beam spot focus. With precision lift-off coating on a conventional box coater an inefficient optimisation to the flux cloud typically results in an excessive use of process metals. Auratus solves the problem of optimizing processes to the vapour cloud improving efficiency and reducing waste.

How does it solve the problem?

Auratus helps Temescal customers efficiently maximise the uniformity and throughput of their deposition process. By ensuring that wafers coating is managed with an optimal relationship of the wafers to the vapour cloud, uniform deposition can take place with less wasted material. Also by eliminating opportunities for waste Temescal customers are able to benefit from even greater improvements in process efficiency.

R & D Award

CREE

New Generation 50V GaN HEMT Technology

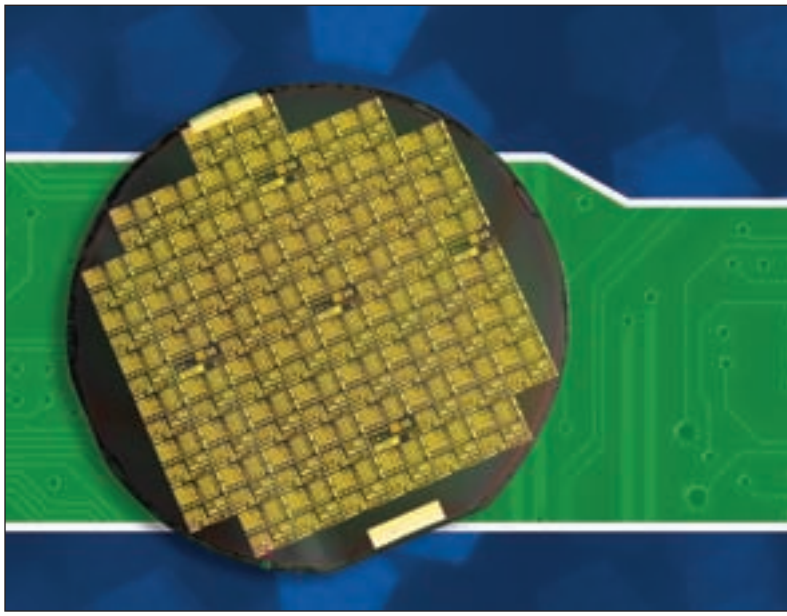
Cree has a range of 50V GaN HEMT devices which offer a significant reduction in the energy needed to power cellular networks. Radio base station power amplifiers have demonstrated performance improvements of more than 20 percent over incumbent technology at 2.6 GHz operating under the latest 4G LTE signals. This increased power amplifier efficiency could save an estimated 10 TWh per year the equivalent power output of two nuclear power plants.

What industry challenge does this address?

The world's cellular network is estimated to consume more than 100TWh of electricity per year: (approximate value of $12 Billion US Dollars) and 50-80 percent of the networks' power is consumed by the systems' power amplifiers and feed infrastructure.

How does it solve the problem?

Cree's new 50V GaN HEMT products can have a large impact in not only helping cellular network operators and OEMs reduce operational and capital expenses but also in reducing global energy consumption.



TriQuint
Reach Further • Reach Faster™

Near Junction Thermal Transport Program

The $2.7 million Near Junction Thermal Transport (NJTT) program funded by the Defence Advanced Research Projects Agency (DARPA) seeks to triple the power handling performance of high power gallium nitride (GaN) transistors. TriQuint's NJTT approach is based on developing GaN transistors on polycrystalline diamond substrates prepared by chemical vapour deposition (CVD). The CVD diamond substrate shows over five times better thermal conductivity than standard SiC.

TriQuint extracts less than 1μm-thick active AlGaN/GaN heterostructure layers originally grown on Si substrates and attaches them to 100μm thick CVD diamond substrates using an advanced wafer bonding technique. This enables the most effective thermal spreader material to be placed very close to the device junction. TriQuint uses a proven AlGaN/GaN heterostructure to achieve 6 W/mm of RF power comparable to today's standard GaN devices.

Thermal simulations predict that TriQuint can achieve 3x power handling goal for the output power level, which can enable reduction of today's active device size by one third, or alternately, allow today's standard unit cell devices to operate at significantly lower junction temperatures. TriQuint is using extensive epitaxial characterization to ensure device quality, material and thermal modelling and micro-Raman thermography to verify results.

What industry challenge does this address?

A key challenge is to prepare GaN-on-Diamond wafers for 100mm manufacturing lines while maintaining the thermal boundary resistance at the GaN and diamond interface below a critical level and simultaneously keeping GaN surface quality suitable for good RF performance.

This is being achieved through innovative methods of lifting AlGaN/GaN epitaxial layers from proven high RF performance GaN-on-Si wafers, identifying / eliminating poor thermal conductivity layers of the AlGaN/GaN films, and preparing high thermal conductivity diamond substrates using chemical vapour deposition (CVD). Other challenges include attaching AlGaN/GaN films to the diamond substrates by precisely controlled adhesive bonding and developing necessary new processes to fabricate high performance devices and circuits in GaN-on-Diamond material.

How does it solve the problem?

Thermal simulations performed before TriQuint began the NJTT program clearly indicated that 3x or greater power handling improvements of GaN-on-Diamond transistors could be achieved through this approach. During the course of the program, TriQuint has shown improvement of thermal boundary resistance of the material and negligible change in the electronic properties of the AlGaN/GaN heterostructure before and after the epitaxial transfer on diamond substrate.

High Efficiency Germicidal UV LEDs

Through a DARPA program (CMUVT): Compact Mid Ultraviolet Technology and with assistance from Army Research Labs Sensor Electronic Technology Inc. (SETi) has performed a research program that has led to dramatic improvements in performance of UV LEDs operating in the germicidal wavelength range. SETi is the world leader in the development and commercialization of Deep UV LEDs (LEDs shorter than 365nm). SETi's product portfolio covers the entire wavelength range from 240nm to 365nm and includes LED's, LED lamps, LED light sources and fully integrated custom solutions. SET's, Deep UV LEDs were first introduced into the market in 2004 following an earlier DARPA development and for which SETi was recognised by DARPA in their 50 year anniversary Success Stories. Over the past 8 years SETi has made many technological improvements to its LEDs but has focused much of its attention to improving reproducibility and reliability for customers in highly demanding markets including scientific instrumentation, life sciences, military and space exploration. In this time SETi has obtained conformance with ISO9001 AS9100 and has been space flight qualified.

Over the years the efficiency of these devices has seen some modest improvements and commercially available LEDs operate at 1-2% wall-plug efficiency (WPE). However the result of this current R&D effort has to date seen an increase in WPE to over 8%.

What industry challenge does this address?

Based in the AlGaN materials system Deep UV LEDs often suffer from extremely low WPE due to high dislocation densities in the epi low internal quantum efficiency (IQE) low injection efficiency and poor extraction efficiency. SETi has previously solved these issues to a point where Deep UV LEDs can be commercialised however this new R&D program takes Deep UV LED performance to a new level.

How does it solve the problem?

Improvements of the internal quantum efficiency by reduction of the threading dislocation density and of the light extraction by using UV transparent p-type contact layer UV reflecting ohmic contact and chip encapsulation with optimised shape and refractive index allowed us to obtain the external quantum efficiency of 10.4% at 20mA CW current with the output power up to 9.3 mW at 278nm for AlGaN based deep ultraviolet light-emitting diodes grown on sapphire substrates.

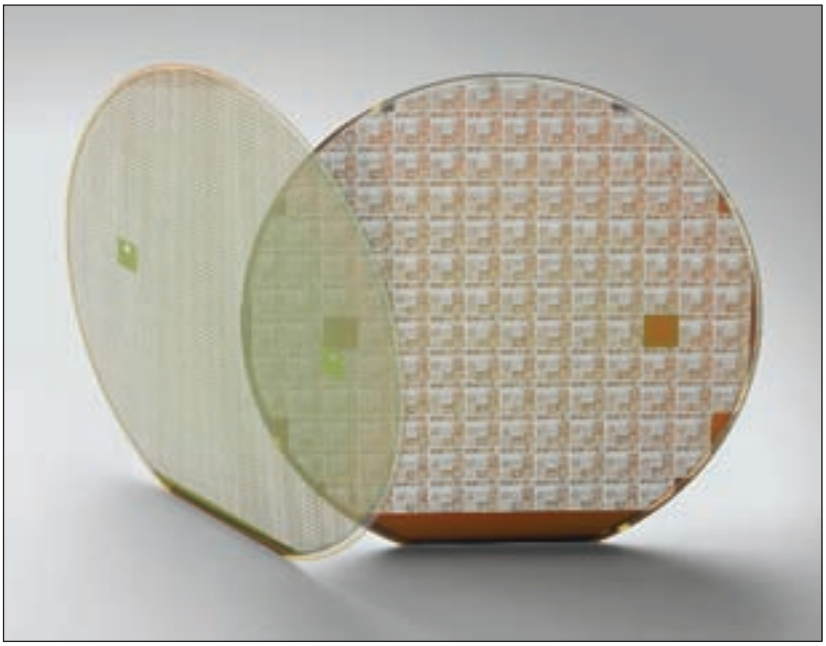
Silicon-on-sapphire:
Rising value in next-generation wireless networks

Introductions of new wireless communication standards are forcing makers of RF front-end components to build products with higher linearity. Silicon-on-sapphire devices excel in this area and, thanks to our UltraCMOS process and accelerated roadmap, the performance gap is expected to continue to grow, versus known competitive technologies such as GaAs, says Rodd Novak from Peregrine Semiconductor Corporation.

Operators of wireless networks continually strive for higher efficiencies, faster data rates and lower latency. Their quest leads them to introduce new schemes for data transmission. One of the most recent is the 4G Long Term Evolution (LTE) mobile communications standard, which is gaining widespread adoption around the world. A significant proportion of US operators have rapidly deployed the LTE standard, and those in Europe, China, and the rest of the world are not far behind.

The introduction of a 4G LTE network brings with it a number of technical challenges that impact many of the RF Front End (RFFE) components in User Equipment (UE), such as Power Amplifiers (PAs), filters, antennas, and switches. Adjustments and improvements in these components are needed in order to deliver smaller, more integrated RFFEs that have the high isolation and high linearity needed to keep pace with advances in UE and the supporting infrastructure.

It is possible to address all of these requirements with legacy compound semiconductor technologies. However, there is an alternative. The silicon-on-sapphire (SOS) process – an advanced form of silicon-on-insulator (SOI) technology – enables RFFE components with the scalable integration,



Peregrine manufacturers its switches using silicon-on-sapphire technology

consistent performance, and benefits of the most widely used semiconductor technology – CMOS. Additionally, the SOS process allows RF performance equal to or better than GaAs.

At Peregrine Semiconductor of San Diego, CA, we have a patented SOS technology – UltraCMOS – that is an advanced form of the SOI process. UltraCMOS technology involves the formation of a thin layer of silicon on a sapphire wafer. This foundation appeals to IC and process designers because sapphire is a near-perfect insulator – it eliminates nearly all of the parasitic capacitance and leakage currents associated with the bulk node.

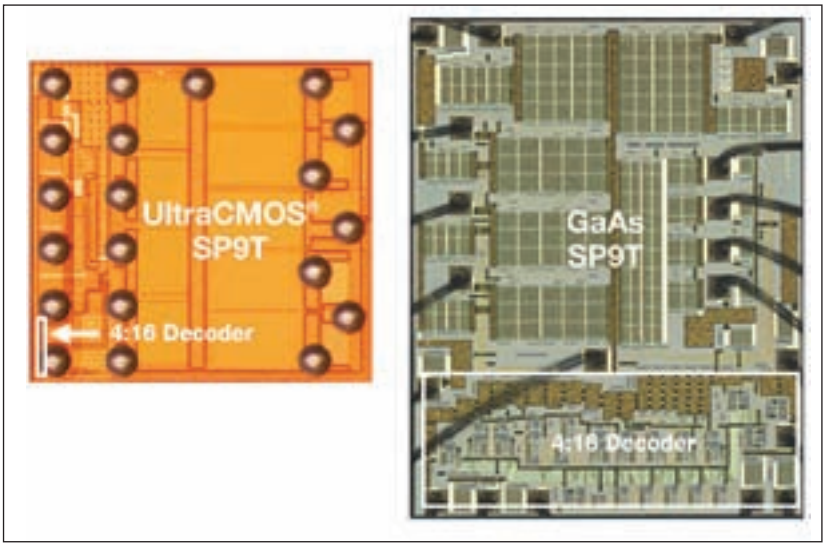


Figure 1: Due to the monolithic integration that UltraCMOS technology enables, a typical SP9T UltraCMOS switch is roughly half the size of a typical SP9T GaAs switch

This technology is highly valued for the RF switching and antenna-tuning functions in the RFFE of cellular handsets. Over 1 billion UltraCMOS products have shipped into the RFFEs of UE, to date.

A little history

When the first single- and dual-band designs for the RFFE switching function appeared on the market in the late 1990s, they utilized pin diodes, which combined high performance and low cost. However, these diodes required long quarter-wave transmission lines and large forward-bias currents to operate, so they failed to support efficient solutions for the follow-on quad-band architectures, which required a higher number of RF switch paths.

Designers then needed to accommodate the multi-band architectures of WCDMA/GSM networks, which required up to 9 switch paths. GaAs pHEMT and UltraCMOS ICs addressed numerous pin diode implementation issues associated with multi-band operation and, as a result, became the switching solutions of choice. Both technologies were able to support the +65dBm IP3 requirements demanded by the 3GPP specification. However, since then, LTE networks have greatly increased the performance requirements and the complexity of the switch function in UE.

We can address these challenges with our UltraCMOS technology. We have been developing this technology for more than a decade, and in 2004 we entered the mobile wireless communications market with our launch of the first commercial, high-volume SP4T flip-chip RF switch. This product, based upon our UltraCMOS technology, went head-to-head with the incumbent technology of the time – a multi-chip module built from a GaAs pHEMT IC.

Since then, handset architectures have evolved significantly. The number of RF bands and switch paths in mobile wireless applications continues to increase, driving up the value of a highly-integrated monolithic RFIC. Today, over 30 switch paths are present in the RFFE of an advanced LTE handset.

Our technology has a roadmap that outpaces the multitude of other process technologies in the RFFE, which include, but are not limited to, pHEMT, HBT, RF SOI, BiCMOS, GaN, CMOS, and SiGe. Each of these technologies requires process, fab and R&D resources. Additionally, each has a unique roadmap supported by design engineers, process engineers and modelers. However, by definition, these roadmaps have limited synergy and do not enable a path to a fully monolithic, integrated RFFE. This means the R&D resources are diluted, because they must support multiple process

RFFE Process Technology	RF Isolation	Linearity	RF Power Handling	Digital Power Consumption	ESD	Integrated Logic	Monolithic RF SoC
GaAs	✓✓	✓	✓	✗	✗	✗	✗
Bulk CMOS	✗	✓	✗	✓✓	BEST	BEST	✗
SOI CMOS	✓✓	✓✓	✓✓	BEST	✓✓	✓✓	✓✓
UltraCMOS® Technology	BEST	BEST	BEST	BEST	✓✓	✓✓	BEST

✗ Has the function with poor performance and/or is unable to integrate the function
✓ Has/performs the function
✓✓ Has/performs the function well
BEST Has/performs the function very well

Table 1: Silicon-on-sapphire (SOS) semiconductor process technology addresses the requirements of LTE with high-volume, highly-integrated RFICs, and a process and product roadmap that offer performance advancements

technologies. In stark contrast, UltraCMOS technology has a clear path to the single-IC RFFE. As a result, all resources are focused on advancing a singular process, design, modeling, and supply-chain roadmap for the RF Switch, digital tuning and power-amplifier functions in today's handsets.

Sapphire's strengths

A key advantage of UltraCMOS technology is its use of a fully-insulating sapphire substrate. This substrate virtually eliminates the parasitic drain capacitance that is present in bulk silicon, resulting in several major benefits. First, it improves transistor performance, as there is less parasitic capacitance to be charged and discharged with every cycle.

Secondly, the sapphire substrate enables higher isolation between circuit elements, allowing digital and analog blocks to sit next to high-power RF signals. For example, digitally-controlled RF switches that support 40 dBm of continuous power with a third order Intercept Point (IP3) >80 dBm are currently in production.

Another strength associated with UltraCMOS technology is that, unlike GaAs, it enables the integration of RF, analog, passive and digital circuitry on a single die. This high level of monolithic integration results in much smaller die and fewer external components. For example, a typical SP9T UltraCMOS switch is roughly half the size of a GaAs-based equivalent (see Figure 1).

Reducing switch size is highly valued, because it can lead to a smaller overall RFFE, with greater design and layout flexibility, and fewer external components. This is important because the amount of space available for the RF section in RFFE designs continues to diminish, with the battery consuming more and more of the available real estate within a handset (see Figure 2).

An additional benefit associated with UltraCMOS technology is that the products are manufactured with a standard, legacy CMOS process in conventional, qualified silicon foundries, leveraging existing infrastructure. This means second-source requirements can be addressed through twin sets of parallel supply-chain partners, and generational improvements can ramp quickly, through access to expansive high-volume capacity, with proven legacy fabs, and equipment.

Working with foundries, we have improved the performance of our switch. If a switch were perfect, it would have zero 'on' resistance, and zero 'off' capacitance. This is known as the $R_{on}C_{off}$ performance metric. We are getting closer to this ideal, thanks in part to refinements to our manufacturing technology (see Figure 3). Improvements in UltraCMOS' $R_{on}C_{off}$ performance metric average 20 percent per year, vastly outpacing those for other technologies. For example, GaAs switches have advanced by less than 1 percent per annum.

In 2007, we launched products based on our STeP2 "Semiconductor Technology Platform" UltraCMOS single-die technology. Since then, we have

Figure 2: The amount of space available for the RF section in RFFE designs is greatly diminishing, as the battery continues to consume the majority of real estate within a handset

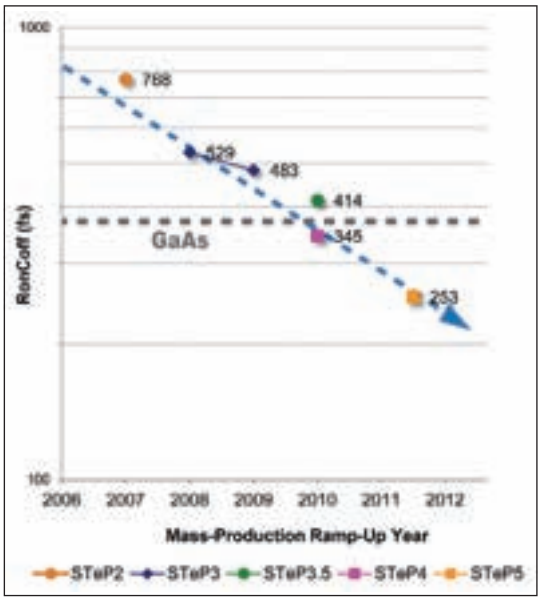


Figure 3: UltraCMOS technology enables advancement in the RonCoff metric of more than 20 percent year-over-year, whereas GaAs technology has seen improvements of less than 1 percent per year

continued to advance our RF switch portfolio. The latest incarnations incorporate our STeP5 UltraCMOS technology, the die size for which is approximately 83 percent smaller than the module size of a comparable GaAs-based product (see Figure 4). The STeP5 process utilizes a "bonded SOS technology" process. Demand for products based upon this process has driven the fastest new process production ramp in our history. According to an October 12, 2012 report from Navian Inc., we are the market leader for the main RF antenna switch for cellular handsets.

Linearity requirements

Perhaps the most prized attribute of SOS over GaAs semiconductor process technology is the high linearity it enables. This is because the introduction of LTE has resulted in linearity becoming one of the most difficult requirements in the RFFE. This is due to the worldwide deployment of LTE in a multitude of scattered frequency bands from 699 MHz to 2690 MHz. The consequence is a magnified RF-interference problem on the cellular networks, which has been compounded by co-existence and the simultaneous operation of multiple radios in today's smartphones, including those for cellular, Bluetooth, WiFi and GPS technology. As a result, consumers experience declines in data rates and dropped calls that stem from harmonic and intermodulation issues.

The relatively severe broadband linearity requirements associated with LTE have increased the required performance and complexity of the handset antenna switch, which is already supported by quad-band W-CDMA and quad-band GSM. For example, a typical antenna switch must now have ten or more switch paths, and a third-order Input Intercept Point (IIP3) exceeding +67 dBm. On top of this, to support the use of the handset for simultaneous voice and data – where two transmit paths operate at the same time – cellular service providers are expecting the need for antenna switches to deliver a IIP3 targeting +90 dBm.

These requirements are challenging for many technologies, but UltraCMOS is up to the challenge. We combine UltraCMOS with inventions such as our HaRP linearity enhancements, and mixed-signal design, to create products that meet the linearity requirements of LTE in a single chip.

For example, our SP10T PE426161 switch has a third order Intermodulation Distortion (IMD3) of -125 dBm in Band V (Uplink: 824-849 MHz, Downlink: 869-894 MHz) – an equivalent IIP3 of

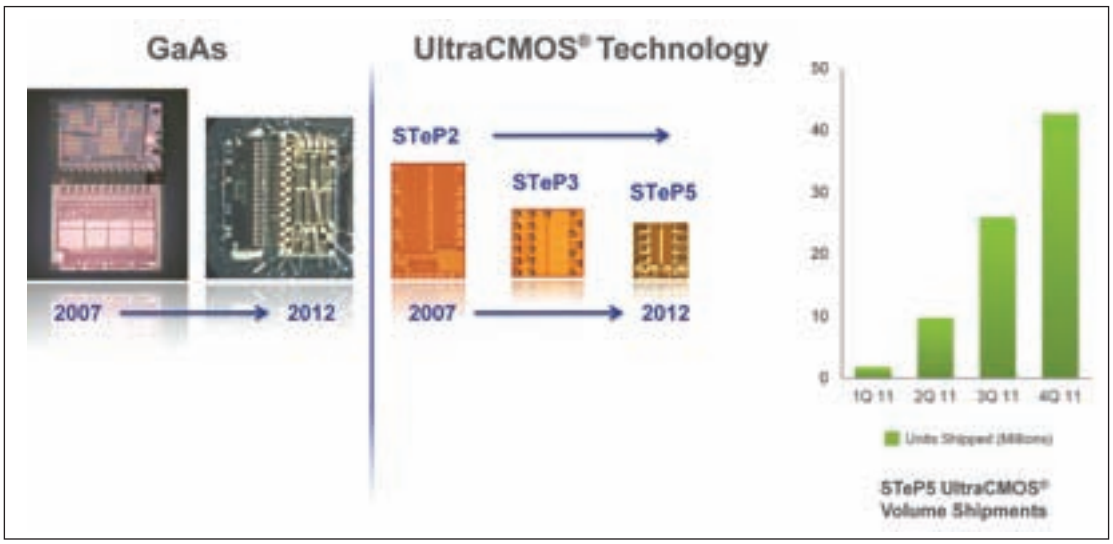


Figure 4: Standard CMOS processing has enabled UltraCMOS technology to advance at a pace that exceeds that of other semiconductor technologies, such as GaAs

When GaAs technology is employed in antenna-switch design, the use of depletion-mode FETs and their biasing requirements limits the maximum achievable linearity for a given device size. On top of this, GaAs, unlike UltraCMOS, has a fundamental flaw – it lacks an insulating gate oxide

+75 dBm. We expect the linearity of our switches to continue to improve as we develop new generations of our UltraCMOS processes, as it has throughout the last five generations. For example, STeP5 switches have demonstrated third-order harmonic improvements of more than 30 dB over that of STeP2 switches.

In comparison, when GaAs technology is employed in antenna-switch design, the use of depletion-mode FETs and their biasing requirements limits the maximum achievable linearity for a given device size. On top of this, GaAs, unlike UltraCMOS, has a fundamental flaw – it lacks an insulating gate oxide. A metal semiconductor junction connects the gate to the channel, and gate current flows into the channel in both the on and off states. The upshot is that, at high power levels, when the GaAs FET gate voltage is modulated, distortion products increase and make it more difficult to meet LTE's stringent linearity requirements.

One of the trends within the handset is an increasing number of signal paths. This drives the need for higher on-die isolation, which prevents the coupling and bonding of signals that can degrade a multi-band RFFE's performance.

For example, in a multiband cellular handset, the PCS1900 transmit band overlaps with the DCS1800 receive band. Without isolation of 35 dB or better, unwanted in-band signals can pass through the filters and desensitize the receiver, resulting in dropped calls. To address this complexity, we launched the SP12T PE426171 switch, which maintains a minimum of 35 dB isolation at 2 GHz on all paths, in a form factor smaller than 3 mm^2.

This product and others in our portfolio meet the requirements of today's 4G LTE networks. The SOS technology on which these products are created enables higher levels of integration, isolation, and linearity than other compound semiconductor products (see table 2 for details).

Switches are not the only SOS product that Peregrine manufactures for the RFFE. We also produce digitally tuneable capacitors, digital attenuators, mixers/upconverters, prescalers and frequency synthesizers.

Our portfolio of over 180 products enables designers to stay ahead of the curve with regard to advances in wireless communication devices and the infrastructure that supports them.

PARAMETER	GaAs	UltraCMOS® Technology	UNITS
Process Technology	pHEMT	SOS (STeP5)	
Die Size*	5.42	2.01	mm2
IDD	591	137	µA
Insertion Loss			
TRX-ANT 880-915 MHz	0.56	0.20	dB
TRX-ANT 1850-1910 MHz	0.77	0.33	dB
TRX-ANT 2500-2690 MHz	1.04	0.53	dB
Isolation			
TX-TX 824-915 MHz	33	51	dB
TX-TX 1710-1990 MHz	45	40	dB
TX-TX 2500-2690 MHz	39	37	dB
IMD3 (881.5 MHz)	-103	-125	dBm
Second Harmonic (2fo)			
@ 880-915 MHz	77	96	dBc
@ 1850-1910 MHz	78	94	
Third Harmonic (3fo)			
@ 880-915 MHz	78	84	dBc
@ 1850-1910 MHz	71	86	

Table 2: Comparison of performance parameters of a commercially-available SP10T GaAs device to those of a commercially-available SP10T UltraCMOS device reveals that UltraCMOS technology performs better across many parameters. Note that the GaAs numbers are for two DIE – one being the RF switch and the other, the controller

Further reading

1. Andoh, Yoshiyasu (Navian Inc). RF Devices/Modules For Cellular Terminal Quarterly Market Report CY2012 2Q, Oct. 5, 2012: page 153.

GaAs lasers eye multiple targets

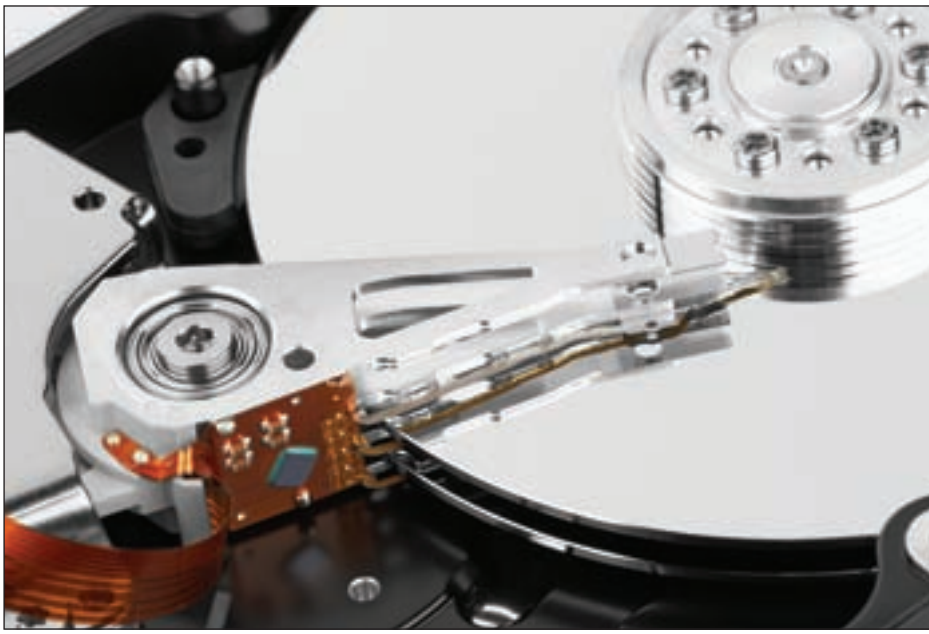
Infrared edge emitters and VCSELs are targeting a growing number of lucrative markets: Gaming, ultra-high density data storage, finger navigation and optical cables for USB and HDMI interconnects. Oclaro's Robert Blum and Karlheinz Gulden discuss them all in detail.

The GaAs-based laser is famous for transforming the way we listen to music. This infrared emitter lies at the heart of every compact disc player, and its role in helping to read the noughts and ones off countless albums has ushered in the era of digitally recorded music that continues to this day.

Less well known are other applications for this laser, which continue to increase in number, enabling the manufacturers of these chips to grow their sales. These infrared emitters are used in a wide variety of optical links and they are seeing greater and greater deployment in computer-related technologies: They are widely used today in optical mice and optical trackpads (also known as finger navigation) as well as gesture recognition systems; and a promising variety of new consumer applications is emerging, such as active optical cables and high-density magnetic recording.

The first class of infrared laser to hit the market was the edge-emitter. It is still widely used in compact disc players and, in a far higher power output format, as a high-reliability source for pumping of Erbium-doped fibres in communication links, where it helps to amplify and regenerate the light transmitted in the long-haul section of optical networks.

More recently, this infrared source has been joined by the VCSEL, which made its commercial debut in 1996. Thanks to the combination of high reliability, lower power dissipation, and lower cost – especially when integration and assembly costs are included – the VCSEL quickly usurped its edge-emitting cousin in the short-reach optical network market.



GaAs lasers could hold the key to increasing the density of data storage on hard disc drives

And the GaAs-based VCSEL continued to evolve. In 2001, as data rates started to exceed 1 Gbit/s, conventional ion-implant manufacturing technology held back performance. But this bottleneck has been addressed by introducing a novel, non-lithographic VCSEL technology – selective oxidation –leading to products with improved lateral current distributions and superior optical guiding within the device. In turn, this has led to higher modulation

Oclaro has produced a 10 Gbit/s VCSEL chip for use in non-hermetic, high-speed optical interconnects

speeds and lower operating currents.

Selective oxidation is still used in today's VCSELs, which play a key role in 10 Gbit/s Ethernet and 8/16 Gbit/s Fiber Channel links that transfer data over distances of up to several hundred metres. Only a few fabs worldwide have mastered the production of these devices, which require state-of-the-art processing capabilities. VCSEL fabrication involves a non-lithographic lateral structuring step and the introduction of a highly strained current-blocking layer close to the active region; and implementing these features to yield a reliable product demands careful optimization of the design and manufacturing process.

The rewards of getting this right are strong sales to datacom markets, which order millions of units every year. That's a significant level of orders for this industry, but it is dwarfed by shipments for consumer applications, which can require 100 million units per year.

One consumer market that the GaAs-based VCSEL has already tapped into is the optical mouse sector. Logitech lead the way in 2004, replacing the LED in the navigation engine with a VCSEL. This switch trimmed power consumption; improved tracking, which is a feature valued by gamers; and thanks to a move from a visible to an infrared source, made the mice more compatible with a glass surface. Thanks to all these attractive features, the VCSEL broke into its first high-volume consumer market, wracking up sales of many tens of millions within a few years.

Similar success could also occur in the finger navigation sector. In 2009, smartphone manufacturer Blackberry, which ships about 7 million handsets per quarter, replaced its mechanical trackball with an optical trackpad. This featured an LED at the time, but again a VCSEL offers several advantages: superior temperature stability; narrower spectral line width; and a symmetrical, more directed beam shape that leads to cheaper collimating optics delivering great performance.

An emerging market for VCSELs is associated with the Light Peak concept. This has evolved into the Thunderbolt interface which can be found on several Apple computers

Short, superfast cables

Another growing consumer application are high-speed optical interconnects. Today, USB cables are in our homes, linking external disk drives and headphones to our PCs, while HDMI cables are connecting our DVD and Blu-ray players to high-resolution displays and flat screen TVs.

Although most USB ports are currently based on the USB 2.0 standard, which corresponds to a data rate of 480 Mbit/s, newer standards have a much higher data rate, such as 5 Gbit/s for USB 3.0 and 10.2 Gbit/s for HDMI 1.3. These conventional, electrical higher-speed cables deliver good performance over short reaches, but this quickly deteriorates as links are lengthened beyond 3 metres.

A promising alternative is to move to optical cables. Interest in this technology has mushroomed following Intel's 2009 announcement of Light Peak, a high-speed optical interconnect for consumer devices using 10 Gbit/s VCSELs. In 2011, the Light Peak concept was implemented in one of the USB ports of Sony's VAIO Z Laptop series, with a fibre optic cable feeding data to and from the media dock. The release of Sony's flagship laptop product thus marked the first commercial introduction of high-speed VCSELs in consumer applications.

Since then, the original Light Peak concept has evolved into the Thunderbolt interface, which can be found on several Apple computers and many peripheral devices today. The connection between devices can be electrical for short very distances, or through active optical cables, which boast a data rate of up to 20 Gbit/s for longer distances. What is common to these active optical cables is that VCSELs are at work, hidden away inside the connector, enabling a cable that is thin, flexible, lightweight, and potentially significantly cheaper than its electrical counterpart.

This migration from electrical to fibre-optic cabling is being enabled not just by high-volume VCSELs, but also new types of fibre

Edge-emitting GaAs-based lasers are starting to be deployed in systems for three-dimensional gesture recognition or skeletal tracking, with chip sales to this sector offering great potential for growth. The most popular product in this area to date is Microsoft's Kinect system, which uses a near infrared laser to illuminate a scene that is then captured with a CMOS detector

optic cables. Corning, for example, has been marketing its bend-insensitive multimode fibre, named ClearCurve, specifically for consumer applications. But cables can also be constructed from plastic optical fibres or other fibre, and in all cases they deliver a significantly longer reach than electrical links, while also being a lot less bulky. These sets of attributes make active optical cables even more attractive to many potential customers, such as those who want to connect their slim HDTVs to surround sound systems without showcasing a thick electrical cable.

Meanwhile, edge-emitting GaAs-based lasers are starting to be deployed in systems for three-dimensional gesture recognition or skeletal tracking, with chip sales to this sector offering great potential for growth. The most popular product in this area to date is Microsoft's Kinect system, which uses a near infrared laser to illuminate a scene that is then captured with a CMOS detector (this imaging system often features an optical bandpass filter matched to the laser wavelength).

Two different approaches are adopted in these systems: A structured light approach, which involves projecting a pattern onto the scene, usually from a continuous-wave, single-transverse-mode laser; or a time-of-flight technology, where a laser that is modulated in burst mode illuminates the scene. With the latter technology, reflected light is resolved in time, enabling calculations of the distances between the device and the objects in the scene. Both approaches favour lasers over LEDs, because their higher modulation speeds make them preferable for time-of-flight technologies, while narrow linewidth and high-optical output power are highly desirable characteristics for the structured light approach.

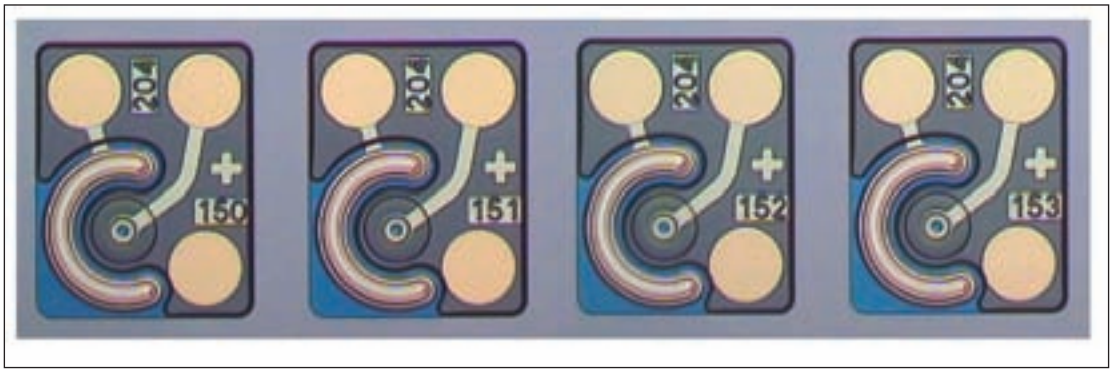
Gesture recognition and skeletal tracking offer a new dimension to gaming, and according to Microsoft and Primesense, 20 million devices have already been shipped for this application. This could be the tip of the iceberg, given that other applications are under discussion, such as the incorporation of similar systems into smart TVs and even handheld tablets. 250 million TVs are sold worldwide every year, and 125 million tablet computers should be sold in 2012, according to analysts DisplaySearch and iSuppli, respectively.

Boosting hard drive capability

Last, but by no means least in the list of emerging high-volume opportunities for the laser, is the hard disk drive (HDD) industry. Here progress is measured in terms of storage density per square inch, and recently Seagate and then also TDK have exceeded the 1 terabit mark by using a technology known as heat-assisted magnetic recording. These two firms, plus WD – collectively, they are the world's three leading disk drive and head manufacturers – are working on this technology, which will employ a laser in each of the heads in a disc drive. Assuming four heads per disk drive, today's market would consume a whopping 2 billion lasers per year.

Introducing lasers into disc drives is a radical step, but one that many insiders believe will have to happen. To increase storage density in disk drives,

300 mW CW single mode laser diode for use in structured light applications



An array of four 14 Gbit/s VCSELs for a 56 Gbit/s active optical fibre

manufacturers can shrink the size of the magnetic bit cells (the "1"s and "0"s), but physics demands that the grain size – or the size of the magnetic domains in the magnetic layer – must shrink accordingly if one wants to maintain the same signal-to-noise ratio. And to further guarantee the stability of the stored information and prevent self-erasing, these smaller grain sizes must be realised in magnetic materials with a high coercivity.

Coercivity is a term that describes how hard a magnetic material is, and materials with high coercivity will only change their magnetization (the pre-requisite for storing information) under very high magnetic fields. Today's magnetic heads, which generate fields of up to 2.4 Tesla and use a perpendicular magnetic recording technology, are now holding back data storage to well below 1 Tb/inch^2.

Higher storage densities are possible by temporarily lowering the coercivity of the magnetic layer in a small area. The trick is to apply localized heat during the write process, thereby decreasing the magnetic field required to re-orient the magnetic domains. This local heat is provided by coupling light into a plasmonic antenna (also known as a near-field transducer) to create heated domains with dimensions of tens of nanometres.

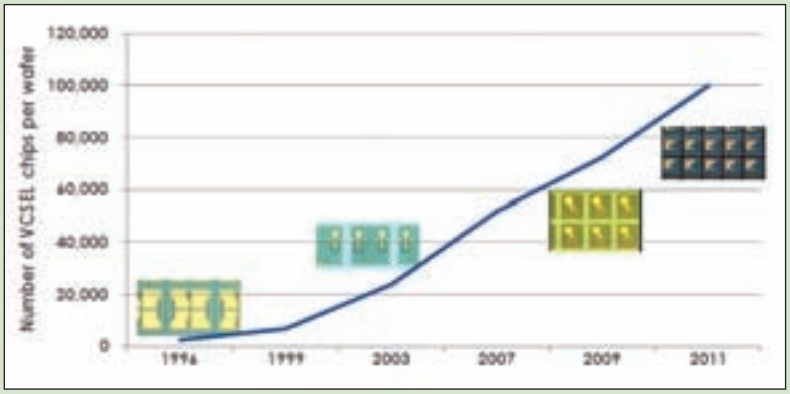
If lasers are to make an impact here, they must combine affordability with high output powers and great reliability. Sources emitting several tens of milliwatts are needed to ensure that enough optical power reaches the recording medium, after it has been coupled to an optical waveguide and focused into a spot of around 50 nm in diameter. And since such a small spot size can't be achieved using classical optics and a laser wavelength of around 850 nm, a near-field optical transducer has to be employed – making use of evanescent waves and near-field optics very similar to those utilized in a near-field scanning optical microscope.

Other requirements for the laser include a very, very small chip size. This aids mechanical design, allowing the emitter to be fitted onto existing read/write heads, and it also trims the cost of production and increases the output from a fab.

This opportunity for chipmakers, plus those in gaming, cabling and finger navigation, highlights the great opportunities for high-volume sales of GaAs-based edge-emitters and VCSELs. Although the CD may be under threat due to the rapid take up of digital downloads, its key component, its infrared source, seems assured of a bright future.

Oclaro's infrared laser pedigree

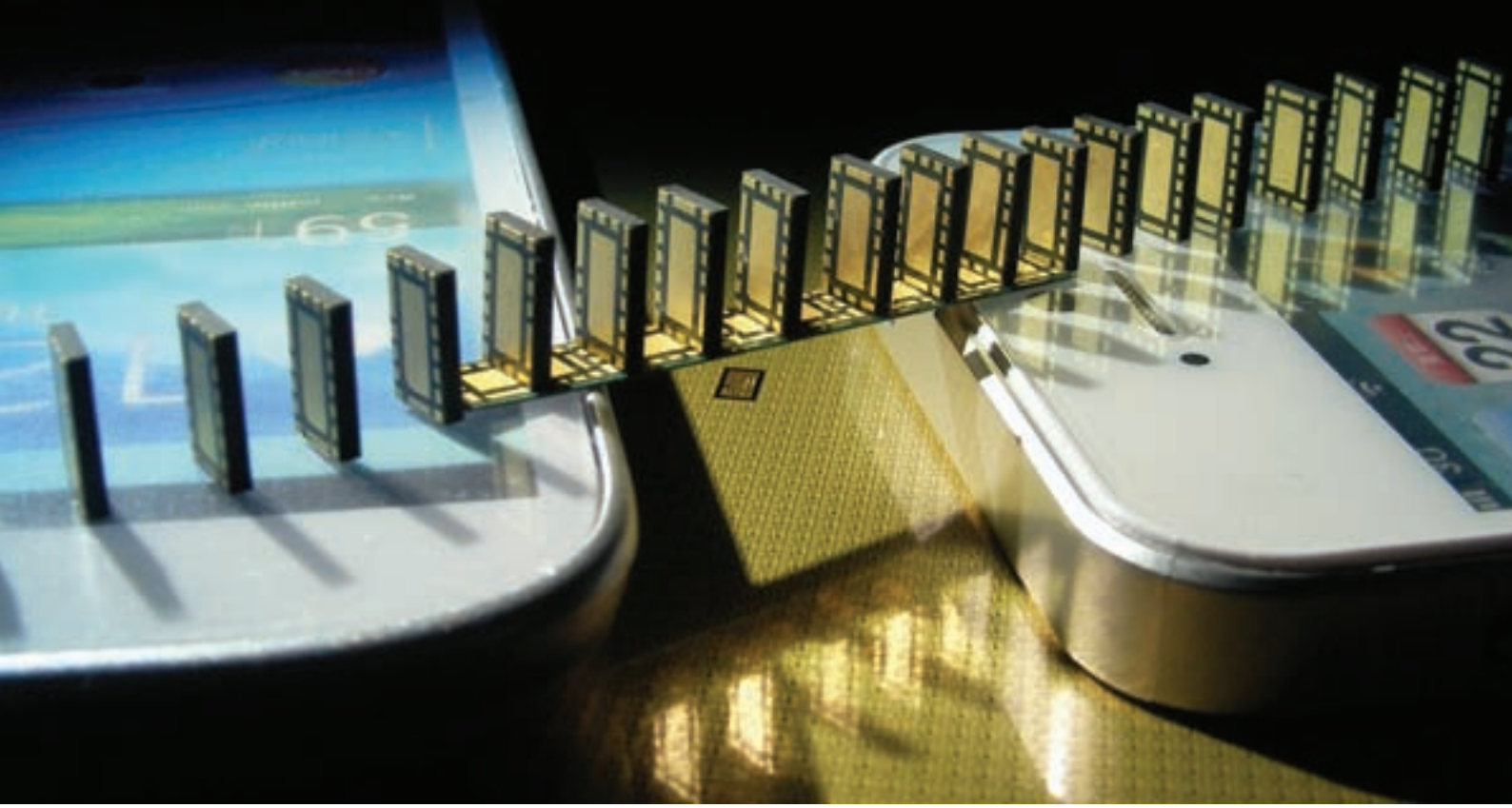
Oclaro has emerged as a leader in the design and high-volume manufacture of semiconductor laser diodes for consumer applications, thanks to its proven expertise and leadership in the design and production of highly reliable, single-mode and multi-mode VCSELs and edge-emitting laser diodes. The company has been involved in VCSEL development and production for more than 15 years, and during that time it has increased the number of VCSEL die on a 3-inch wafer from 2,500 to 100,000, leading to increased chip production at a lower cost. To date, Oclaro has shipped more than 150 million VCSELs and several million edge-emitting laser diodes into both telecom and consumer applications.



Oclaro has dramatically increased the number of VCSEL die that it can yield from a 3-inch wafer

Maverick manufacturing anomalies: What threat to reliability?

Even veterans of reliability measurements struggle to provide customers with predictions of the future reliability of a lot that exhibits early fallout in the factory. That's because, until recently, it's been very difficult to gather the data needed to respond with a specific and satisfying answer, says Bill Roesch from TriQuint Semiconductor.



When you work in manufacturing, you strive for perfection. It may seem like a lofty goal, but it's one that is possible to achieve – at least for most customers, most of the time. However, occasionally it is inevitable that semiconductor failures happen, and it's how you deal with them that matters.

If methods for scrutinizing products passing through the manufacturing line are well chosen, revealing and reliable, it is possible to rout out the vast majority of imperfect parts. But occasionally an anomaly will slip through, ending up inside consumer goods. And when one of these components starts to malfunction, the customer comes calling with a list of really tough questions.

Among the most difficult to answer is this one: What is the risk that we have only seen the tip of the iceberg? This particular question crops up because it helps the customer to get a feel for the answers to several more that are giving them sleepless nights:

How many more problems will I see from this batch? Should I stop production and/or shipments of this material? And should I recall previous material that has already shipped?

Customers are also really anxious to know that the root cause has been diagnosed with complete certainty, and there is absolutely no chance that it will happen again. And afterwards, when the dust has settled and they have had a chance to ponder some more, they will eventually ask a broader question that's along these lines: What is the risk that I'll get more problems?

At TriQuint Semiconductor, like every big chipmaker, we have had to deal with these types of questions from customers. When it happens, we carry out our investigation in a thoughtful manner, using in-depth knowledge of our processes, combined with structured problem solving, to determine the issue. Once we've done that, we contain the situation, hunt down the root cause, verify the solution, implement corrective action, and prevent it from happening ever again. But the question of assessing reliability risk of material that's already in the customer's hands isn't a natural outcome of the corrective action process.

Our quest to measure this risk came to fruition at the end of 2010, when a single part was returned from a customer. We submitted this part for failure analysis and uncovered a rare defect. It was a *déjà-vu* moment, because we had first discovered this type of defect some 12 years earlier (we'll get back to that later). This time, however, we were able to finish the story, thanks to some good fortune on our side: The customer's fallout had happened to coincide with a manufacturing lot that had been split during module assembly and packaging, prior to final test. This split meant that the customer got half of the material, but there were still over 30,000 virgin parts on our site, which enabled us to provide a definitive answer to the customer's toughest question of all: What is my reliability risk?

The situation that we were in is very rare. Normally, by the time an anomalous device is returned to the supplier and analyzed down to the true root cause, the customer has consumed all of the

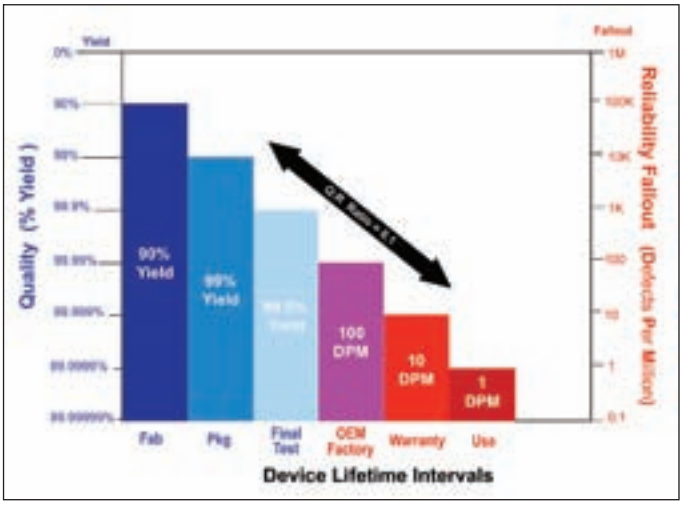


Figure 1. Expected reliability fallout for normal lots

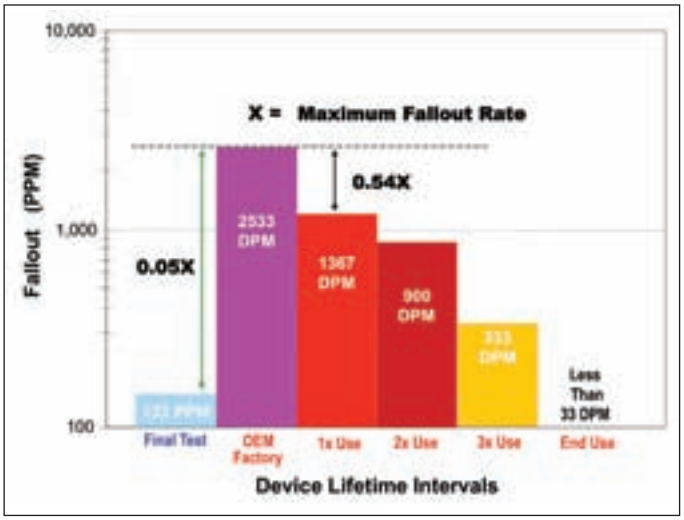


Figure 2. Measured fallout risk for special lot, 0.5 percent total affected parts

batches in question. That makes it incredibly challenging for the supplier to assess reliability risks, because they don't have examples on hand that feature the anomaly. So when a customer asks: "What is my reliability risk?" the supplier's best answer is "What fallout have you seen so far?"

Digging deeper

If you dig into this awkward situation, you'll realise that we have uncovered a true maverick lot. In other words, this is a batch of material that had no anomalies detected by the supplier, yet the lot eventually produced some fallout in the customer's hands. At this point, all the information on the severity of the problem is coming from the customer. This means that unless the supplier can somehow recover a statistically significant sample of the batch that's in question, there isn't any more that can be learned outside of the customer's experience. When this happens the customer is far from happy: When they ask questions to the chipmaker, the response they get is not an answer, but even more questions.

Let's return to our particularly fortunate situation where samples were on hand to assess risk. In this scenario, the task is different from typical reliability success testing, which is used to qualify devices. And the goal is very different too. The focus is no longer capability testing, which is designed to wear out the entire population and measure degradation along the way – instead the hunt is on for defects, which are ideally found in a way that emulates the stress in the lifecycle of a typical consumer device. In our case we decided to age the parts and measure the resulting fallout, because this allowed us to determine the risk in timeframes that are useful for the customer.

Our second slice of luck was that we could detect the particular defect and isolate it from all other forms of degradation with an external electrical measurement, which was performed with production test equipment. We aimed to complete final component testing, closely approximate customer-applied stress,

and then accelerate parts through their useful life span using environmental stressing techniques, introduced as aggressively as possible.

The primary goal was to induce all maverick fallout – without wearing-out the samples – and tally the risk at every stage in the OEM and consumer lifetimes of the devices. Since we had some experience with the failure mechanism, we were able to confidently select a group of reliability stresses with the best chance of inducing trauma that would simulate a customer's lifetime of use (see table 1 for details).

We selected these stages based on the time frames that customers' outline when describing their curiosity about reliability risks. Overarching these stages is a built-in expectation of defects for 'normal' (non-maverick) batches. The inherent expectation encompasses the relationships of quality assessments, made during manufacturing, and the reliability found in the consumer's hands (see figure 1 for details). These expectations are built upon decades of experiences where quality is predictive of reliability. The normal situation is great, with reliability risk reducing at every stage in the life of an integrated circuit. What's more, often the natural decreasing risk is even better than what we've portrayed here as 'normal', which is actually closer to defining the 'boundary' between acceptable and anomalous.

Scrutinizing lots

With our plan, our expectation, and 30,000 samples in hand, we set out on a Friday morning to measure the risk of this special lot of material. By Monday, 150,000 measurements later, we had all the data we needed to precisely answer the tough question for this special lot. On top of that, we had identified a more general relationship, which would come to our aid when answering future questions about this type of scenario.

Even though we gathered most of the data in just one weekend, the results are compelling. That's partly because we had such a massive sample to work with, and partly because our findings were matching the customer's experience (so far) with their suspect population of devices. Armed with all this information, we could now provide a definitive answer to the specific question

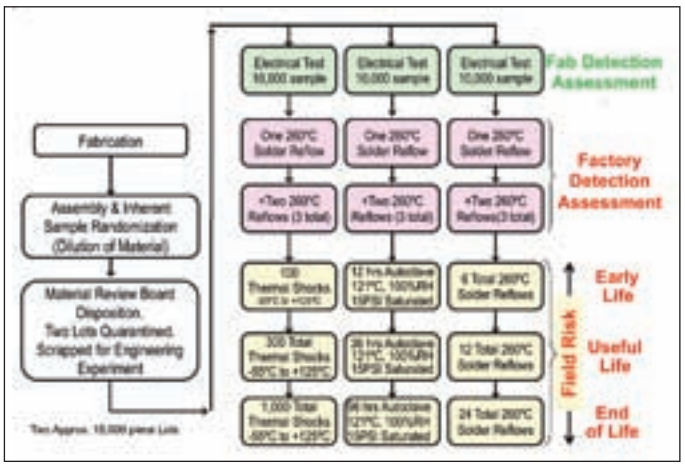


Table 1. Plan for evaluating reliability of lifetime stages

Table 2. Risk assessment results

about risk. Our data enabled us to know what fallout to expect at each stage, plus the relative ratio of fallout to expect for this particular failure mechanism. The relative measure is highly valuable, because we can use the known ratio to make predictions, should other batches be found with different defect concentrations.

We found that it was very difficult to evoke the anomaly during manufacture with our normal suite of module tests. On the other hand, the OEM had the best detection, since their solder reflow process was 20 times better at exacerbating the fallout. The good news was that the fallout in the life stages following reflow was always lower than what the customer would see within their factory. So, in general terms, we could inform our customer that the worst fallout would occur in their factory, and the warranty risk to their customer was about half of the initial factory fallout and would be decreasing throughout the rest of the product's life [1].

We continued to torture the samples with more aging and with multiple stress sequences to squeeze out every last drop of information. So within a few days of the initial weekend results, and after another 175,000 more measurements, the fallout eventually dropped to zero, giving us the final total of affected parts in our special lot… one half of one percent.

Wider implications

To answer the broader questions customers can pose about detection and prevention of maverick lots, we must rewind the clock right back to 1998, when we first saw this mechanism returned from a customer [2]. At that time, we only had the customer's returns to work with, so we studied the mechanism very hard. However, we could never re-create the root cause. What we did do was take preventive action, involving process improvements and design changes. In addition, we developed special test structures to detect the recurrence of this elusive defect. Twelve years on, the structures proved themselves worthy when we discovered a hike in the resistance on special monitors in several wafer lots – the old problem had come back!

In the initial re-discovery, we saw less than one-third of the wafers affected from three lots. The data indicated that the defect-

creating malfunction was intermittent by lot and variable across each wafer within each affected lot. But this initial signal was still enough for us to check for a process commonality and implicate a single process tool as the cause. In spite of the early detection success of our special structures, the sheer volume of production had already carried many lots through the offending tool during the few hours it took to complete the failure analysis. We tried to contain the defective parts by shutting down that tool and gathering up all the material that had gone through it. As a precaution, all of the material through the offending tool was scrapped regardless of the product design or its susceptibility to the malfunction.

Eventually other built-in indicators picked up traces of the malfunction, and more material was brought into containment. As a precaution, we even extended our quarantine to earlier lots, where we were unable to detect any other signals. In effect, by extending the containment earlier and earlier, we provided a time buffer between our customers and the suspect material produced by the malfunctioning tool. In addition to separating suspect devices from our customers, all of this work enabled us to confirm the root cause and verify the corrective action. We utilized additional special test wafers, armed with our most sensitive reliability measurement structures, to verify that we had completely fixed our tool. But in spite of all these precautions, it turned out that the one single customer return, which sparked the risk investigation described in this story, was built on the suspect fab tool just a few days before our time-buffered quarantine!

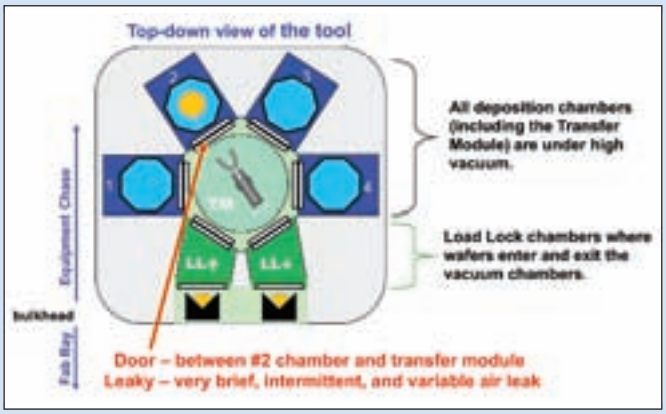
So what are the lessons that we can learn from all of this? Defects can reappear after a decade or more, so good record keeping, well-designed test structures and engineers with lots of experience and good memories are invaluable; but to get to the cause of the problem, having some luck on your side can really help. We did, and by scrutinizing 30,000 virgin parts we were able to tell our customer that the chances that these parts were failing were going to get less and less. It was great to give them a reassuring answer to that most vexing of questions: What is the reliability risk?

Anatomy of an anomaly

Eventually, fab tools wear out. This happens in every fab, including those at TriQuint, where a tiny leak inside the oldest metal deposition system caused the defect that is behind the story described in this feature. This leak occurred only when wafers were transferred by a robotic system from one deposition chamber to another. There are steps in place to prevent leaks, with all the chambers inside the system maintained under vacuum and the gas content monitored all around during the processing steps. However, in this particular case, door movement led to a brief gap to atmosphere. This allowed a puff of oxygen to sometimes find its way to a warm, freshly deposited metal layer before rapidly dissipating into the vacuum.

The pattern of discovery provided a tell-tale sign of an intermittent, miniscule leak. When the door leaked, it introduced imperfections to the edge of the wafer nearest the door. But when the door operated in the manner it was designed to, the wafer was unaffected.

One of the potential impacts of the anomalous oxidation of metal is degradation in the adhesion between layers, which results in an increase of resistance between the upper metal interconnects. TriQuint's fabrication process included ten different escape points, which all detected and contained this



Multi-chamber cluster tool used to deposit several metal layers

type of defect. However, not all the defects were detectable. Combined with physical stresses within the packaged, finished circuit, and with external stress applied by the manufacturing assembly environment, the variation in interconnect resistance could sometimes result in a device malfunction only in the customer's hands.

References:

(1) *Assessing the Reliability Risk of a Maverick Manufacturing Anomaly, William J. Roesch, International Conference on Compound Semiconductor Manufacturing Technology, April 25, 2012, Boston Massachusetts, 83*

(2) *Thermal Excursion Accelerating Factors, William J. Roesch, GaAs REL Workshop, October 17,1999, Monterey California 119*

Following an electron's journey through a GaN HEMT

Impact ionization, carrier trapping and leakage paths prevent the channels in today's HEMTs from providing great transport links between source and drain regions. But improvements should follow, now that these maladies can be exposed with optical and electrical techniques, argue Nicole Killat and Martin Kuball from the University of Bristol.

Sales of GaN HEMTs are rising fast, thanks to the performance that they can deliver in RF and power conditioning applications. However, many of these customers buying these devices – which deliver a very impressive set of characteristics – are, for good reason, concerned over the reliability of the transistors. Often this holds back the exploitation of the full power potential of the GaN HEMT.

To address these concerns, researchers must improve this device's reliability by unmasking and understanding the physical processes provoking device failure. This is happening, with degradation mechanisms in the devices slowly being exposed: Some mirror those found in other types of RF electronics; but others are unique to GaN, and are related to either its material properties, its high

AlGaN/GaN HEMT wafer under electrical and optical testing

electric fields or its high operating temperatures.

Those involved in these efforts must ask themselves one essential question, which will shed light on all the limitations in AlGaN/GaN HEMTs arising from device degradation mechanisms: What happens to the electrons in the device? Or, to put it another way, which obstacles does an electron face on its way from source to drain?

To gain insight into the life of an electron in a GaN HEMT, our team at the University of Bristol, UK, is trying to follow its path through the device and track its behaviour. To do this, we employ a combination of electrical and optical techniques.

We know that once an electron leaves the source, it joins its fellows in the two-dimensional electron gas (2DEG) at the AlGaN/GaN interface, before it is accelerated towards the finish line, the drain, by the high electric field. As the electron heads towards this chequered flag, the chance that it collides with lattice atoms on the way increases. And where collisions occur, it is possible that they spawn a process known as impact ionization. If this does happen, holes formed in the channel layer will create severe device damage once they are accelerated towards the source and gate contact.

This device-degrading event is a common affliction for GaAs HEMTs. Whether it also occurs in GaN HEMTs, however, is far from clear. It's a controversial, hotly debated issue, with some arguing that the bandgap of GaN is too large for impact ionization to occur. In GaAs HEMTs, impact ionization is easy to detect – you simply directly measure the generated hole current. But in GaN HEMTs, the higher leakage currents swamp the expected hole current from impact ionization, diminishing the chances of observation of any potential impact ionization electrically.

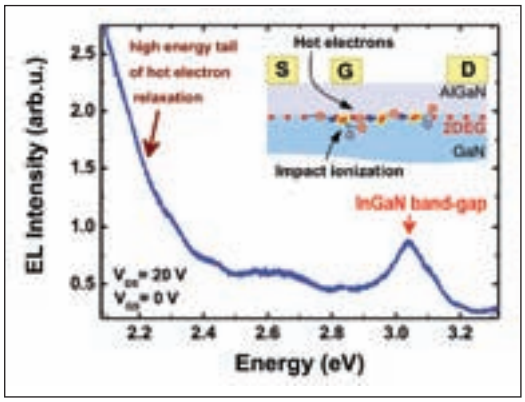


Figure 1. Electroluminescence spectrum produced by an AlGaN/GaN HEMT formed on SiC during on-state operation. This device features an InGaN back-barrier, which enhances the optical output

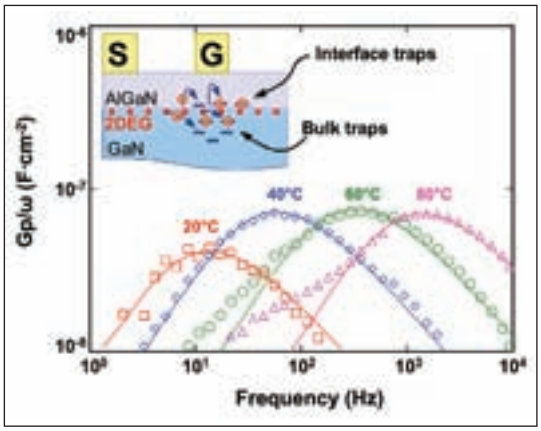


Figure 2. Bulk trap conductance, Gp/ω, can be determined from transconductance measurements as a function of frequency for different base-plate temperatures. The inability of channel electrons to follow the pulsed gate signal leads the conductance to peak at a certain frequency related to the trap-specific time constant. This technique enables the detection of traps at a density of 10^{11} $cm^{-2}eV^{1}$ and below, in particular those located at or near the AlGaN/GaN interface in GaN HEMTs. In this case, the traps were identified as bulk traps with a temperature-dependent time constant ranging from 10^{-2} to 10^{-4} s and an activation energy of 0.7 eV, located in the GaN buffer layer. This device has a 0.25 µm gate length, and the data was fitted to a model (solid lines) representing a continuum of trap energy levels

Optical methods

Hunting for holes with optical techniques offers a more promising route to determining whether impact ionization occurs in GaN HEMTs. Modifying the device structure helps in this endeavour, with the addition of an InGaN back-barrier several nanometres beneath the AlGaN/GaN interface introducing a hole collector and provoking photon emission with very high quantum efficiency. That's not surprising, given that InGaN is the material of choice for forming wells in the active region of blue LEDs.

Electroluminescence (EL) produced by this modified HEMT features a distinct interband recombination peak at the InGaN bandgap, in addition to broad luminescence from hot electron relaxation (see Figure 1). The bandedge luminescence provides evidence of holes in the device, generated at high electric fields and high electron densities. Our measurements show that this strong bandedge luminescence also occurs at cryogenic temperatures, allowing us to rule out hole emission from traps as the hole generation process [1]. Based on these measurements, we can draw the important conclusion that impact ionization is the dominant cause of hole generation and does occur in GaN HEMTs.

More can be learnt about the behaviour of electrons as they pass through the transistor from the low energy tail in the EL spectrum. This reveals that, in the channel of the device, electrons undergo relaxation processes that don't involve recombination with holes. The spectral distribution offers an insight into the temperature of the electron and its fellows, showing that they can easily reach several thousand degrees – ten or more times higher than that of the lattice. Impact ionization and

hot electron relaxation can be accompanied by other mechanisms, such as electron-phonon and interface scattering [2].

Electronic traps

Electrons passing along the channel can face other obstacles. These include electronic traps, which can have a direct or indirect impact on the life of an electron and the related current density. One type of electronic trap is associated with defect states, which capture and release electrons within a characteristic time, thereby modifying the electric field distribution near the device channel. Identifying the location of traps in degraded HEMTs is very challenging. The most common approach is to turn to simulation to estimate the location of the traps, based on a fit to electrical device characteristics. This is a valuable, but rather indirect approach.

In another class of device, a large-area capacitor, gate-capacitance-based measurements, such as conductance techniques, are widely used to evaluate trap characteristics. However, this approach cannot be transferred to short-channel devices, because inaccuracies are far larger, due to the weak capacitance signal offered by the small gate area. In contrast, dynamic transconductance does not require capacitance measurements to extract the trap conductance [3]. In this case, both the interface and the bulk traps are detected and distinguished by analysing bias dependence of the extracted conductance (see Figure 2 for an example of bulk trap conductance). In addition to bulk and AlGaN/GaN interface traps, surface and subsurface traps can impact the path of the electron as it passes along the channel. If the traps are near the gate, they affect the electric field in the channel that governs the electron transport.

UV-assisted transient trapping is capable of locating and identifying electronic traps in GaN HEMTs. This technique involves applying a trap-filling pulse at a high negative gate-source voltage and then recording the de-trapping transient in on-state operation. Exposing the transistor to UV-light prior to the filling pulse can modify the electronic trap population.

We have determined the current transient trapping characteristics for GaN HEMTs illuminated with UV light of different photon energies (see Figure 3). These measurements reveal three trap states with different time constants: Only the slow trap is strongly affected by light exposure. When illuminated with photon energies between the bandgaps of AlGaN and GaN, these devices show a large trapping amplitude, indicating that the traps are located in the AlGaN barrier close to the gate (see the inset of Figure 3).

These traps are probably caused by oxygen reactions at the device surface [4], which can reduce the electric field in the electron channel. The consequences of this are not limited to reduced electron acceleration in the channel, and include partial depletion of the 2DEG and a subsequent decrease in drain current.

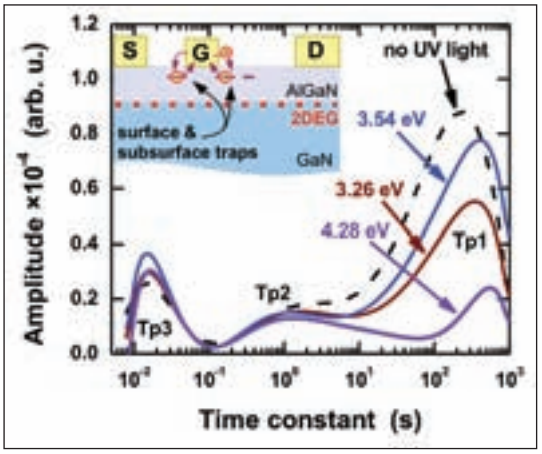
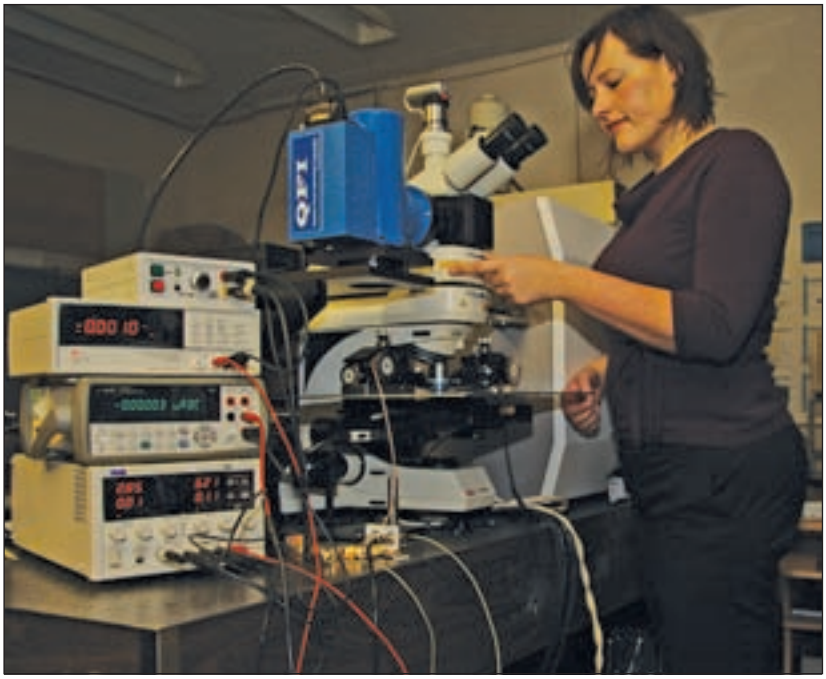


Figure 3. Transient current-trapping characteristics of an AlGaN/GaN/SiC HEMT. A trap-filling pulse was applied at V_{DS} = 0 V, V_{GS} = -10 V, with subsequent transient measurements at V_{DS} = 0.5 V, V_{GS} = 1 V. The current transients are labelled with the photon energy of the UV light exposed to the device prior to measurement

When surface trap density increases during device operation and electrical stressing, leakage pathways are formed through the AlGaN barrier to the device channel. Leakage current then rises during device stress, correlating with the appearance of EL spots during off-state operation [5]. We have noted that there are localised EL spots along the drain edge of the gate – where the maximum electric field is located – that multiply in number during device stress (see Figure 4). The appearance of each new spot coincides with a step increase in the gate



Typical experimental setup used for combined electrical and optical device testing, including Raman thermography, photoluminescence and electroluminescence analysis as well as device stressing and transient trapping analysis

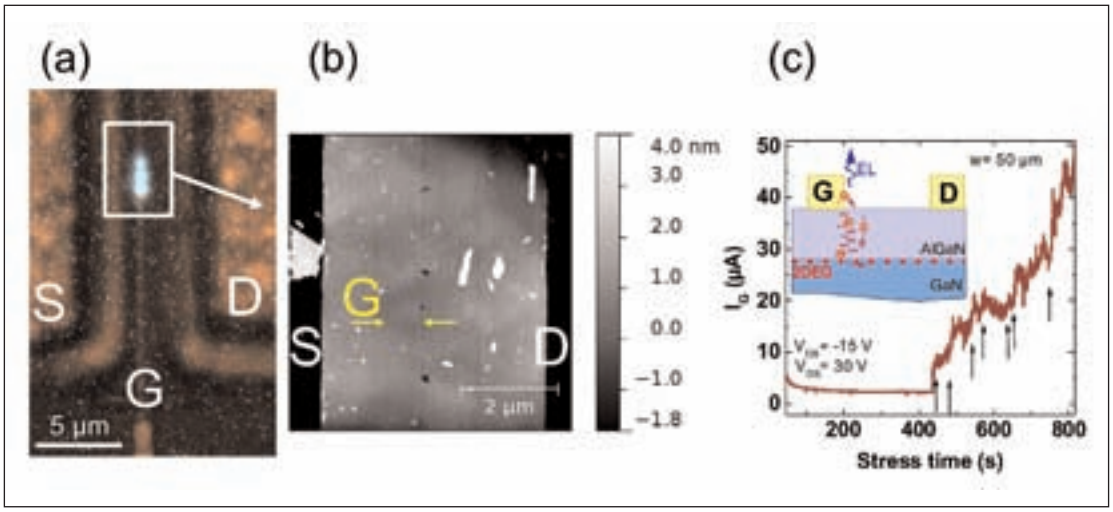


Figure 4. Hotspots in AlGaN/GaN HEMTs. (a) EL image of a representative device after off-state stress overlaid with a white light image (b) AFM image of the area marked in (a) after removal of contacts and passivation layer (c) gate leakage current during off-state stress. Arrows indicate the gate currents steps that coincide with the appearance of EL spots

leakage current (Figure 4(c)), illustrating that this progressive appearance of EL hot spots tracks a gradual 'breakthrough' of the AlGaN layer in the device.

After removing the metallic contact and passivation layer, we scrutinized the semiconductor surface with an atomic force microscope (see Figure 4(b)). Imaging revealed a one-to-one correspondence between EL spots and the generation of large pits on the surface, which are associated with the breakthrough of the AlGaN layer. These observations reveal the direct link between EL spots, surface pitting and the generation of a gate current leakage path during off-state stress (see the inset of Figure 4(c)).

To ensure a safe journey of the electron, gate engineering is often used to trim the maximum electric field near the gate edge. This limits trap generation and the formation of EL hot spots. Common ways to do this are to use field-plates and slanted gates that spread out the peak electric field, reducing its maximum value. Surface trapping subsequently falls, as can be seen in gate lag measurements (see Figure 5). It is also possible to move the peak electric field into the device's barrier layer by including a gate recess [6]. Transistor architectures sporting slant and slant-recessed gates present a low gate lag even after electrical stress, so they are favoured for the fabrication of GaN HEMTs with high device reliability.

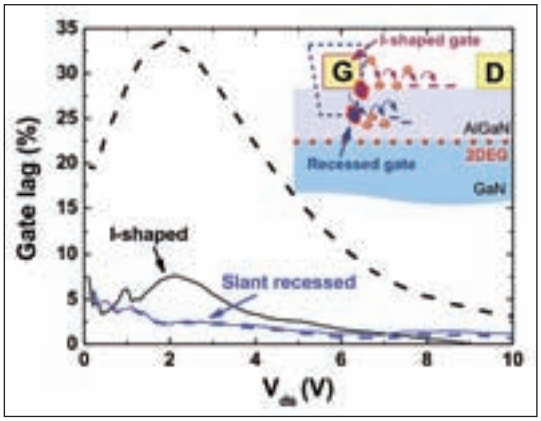


Figure 5. Gate lag for two different gate shapes: I-shaped (black) and slant recessed (blue). Solid and dashed lines show the gate lag as a function of source-drain voltage before and after an off-state stress.

Our efforts show that electrical and optical methodologies can expose many different degradation mechanisms, including impact ionization, charge carrier trapping and leakage path generation. These imperfections can degrade device performance and reliability, so understanding which ones are prevalent in a particular transistor architecture is a major aid to designers, who can reduce the obstacles in the path of a channel electron and give it an easier passage to the drain - its final destination.

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Accounting for droop with Auger recombination and polarization fields

Minimizing polarization fields in LEDs fails to enhance quantum efficiency

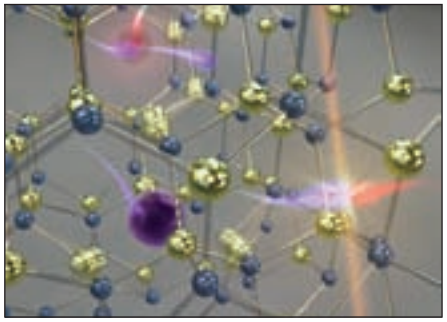
A US team has constructed a model that offers new insights into the interplay of Auger recombination, polarization fields and two of the biggest weaknesses of the GaN LED: Droop, the decline in efficiency at higher drive currents; and the 'green-gap', which is the decline in efficiency at longer wavelengths.

Calculations by the team from the University of California, Santa Barbara (UCSB), and the University of Michigan, account for reductions in droop that can result from a switch from conventional, polar LEDs to non-polar equivalents. According to the researchers, this switch does not, in itself, lead to a higher internal quantum efficiency in the device. Instead, the light output is higher for the nonpolar device because the reduction in polarization fields enhances the radiative recombination rate. This reduction also allows for the introduction of wider wells, which reduce carrier concentrations and non-radiative Auger recombination.

The researchers blame polarization fields for the green gap. To increase the wavelength of LEDs, engineers add more indium to the InGaN quantum well. This increases the strength of the polarization field and cuts electron-hole overlap, leading to a decline in radiative recombination.

The team of theorists, headed by Chris Van de Walle from UCSB, have previously performed first-principles calculations for bulk InGaN. Extending this to the modelling of real devices is not feasible, according to Van de Walle, so this time they are performing Schrödinger-Poisson calculations with the SimuLED package produced by STR Group of St. Petersburg, Russia.

Van de Walle and his colleagues model a relatively simple LED structure: A 200 nm thick *n*-type, silicon-doped layer; a 3 nm-thick InGaN quantum well; a 10 nm thick GaN barrier; a 10 nm-thick $Al_{0.2}Ga_{0.8}N$ electron-blocking layer; and a 200 nm-thick, *p*-type GaN layer. Their background in first-principles calculations has come in useful, because in addition to providing quantitative information, it has equipped them with insights into the mechanisms that come into play in InGaN. "By looking at what the main contributions are to the Auger recombination process, we were able to gain more confidence that the numbers that we were calculating for the bulk are also very relevant for the quantum well," explains Van de Walle.



A radiative process takes place in LEDs (right), with electrons and holes recombining to emit a photon. In a defect-assisted nonradiative process (bottom left), an electron is trapped by a defect (here a nitrogen vacancy, represented by a dark wave function). In Auger recombination, another type of nonradiative process (top left), an electron and hole recombine (assisted by lattice vibrations) but the energy is transferred to a third carrier which is excited to a higher-energy state. Credit: Qimin Yan, UCSB.§

Previous efforts determined that the dominant Auger process in bulk InGaN is one that involves interplay with phonons.

"What we found by analysing the contributions to the Auger rate is that it is the phonons with large momentum that are playing the dominant role in the Auger process."

Large momenta correspond to small spatial distances, which are on a scale of a few atomic bond lengths. The width of the well is more than ten times this, implying that the calculations for Auger processes in bulk material also give reliable rates for this non-radiative mechanism in quantum wells.

Van de Walle and his co-workers have studied droop in polar and non-polar LEDs by considering how the radiative and non-radiative rates vary with polarization fields.

The radiative rate has been calculated before by others, and is known to depend on the square of the overlap of electrons and holes. The formula for the non-radiative rate, however, had to be determined by the team, and they were surprised by what they found. "It turns out that the Auger process and the Shockley-Read-Hall, defect-related process depend on the overlap in exactly the same way – the square of the overlap between electrons and holes."

What this means is that the radiative and non-radiative rates scale in the same manner, so in terms of quantum efficiency, there is no benefit in switching from polar to non-polar material. So is there any benefit associated with non-polar material?

"Of course," says Van de Walle. "The radiated power at a given carrier concentration is higher for nonpolar wells because the electron-hole overlap is larger, which enhances the radiative recombination rate. In addition, you can have wider wells." The far weaker polarization fields allow this, and it enables lower carrier concentrations, which in turn reduce the strength of the non-radiative Auger process.

Switching to non-polar material is not the only route to reducing polarization fields. Fred Schubert's team from Rensselear Polytechnic Institute in Troy, NY, have previously shown that it is possible to reduce polarization fields by modifying the composition of the quantum barrier, an approach that is claimed to trim electron leakage from the active region.

"An additional reason may be the reduced polarization charges at the quantum well-barrier interfaces, which enhance the electron-hole overlap in polarization-matched structures," write the UCSB-Michigan team in its paper.

E. Kioupakis *et. al.* Appl. Phys . Lett. **101** 231107 (2012)

Panasonic's non-polar LEDs combine efficiency and power

Wide quantum wells that are free from internal electric fields combat droop and enable high efficiencies at high drive currents

ENGINEERS at Panasonic's Device Module Developement Centre have fabricated non-polar LEDs on *m*-plane GaN that deliver incredibly high efficiencies at high current densities.

These non-polar, 408 nm LEDs, which have dimensions of 450 μm by 450 μm, operate at light output efficiency of 39.2 percent when driven at a current density of 1000 A cm^{-2}. This corresponds to an output of 1.35 W.

"The efficiency is not a record at low current densities of around 200 A cm^{-2}, but I think it is a record for high current densities of around 1000 A cm^{-2}", says Panasonic's Akira Inoue, who unveiled these results in a paper presented at the 2012 International Electron Devices Meeting in San Francisco in mid-December.

Inoue and his co-workers have also developed techniques to control the radiation pattern produced by the LED.

They can adjust this by altering the surface of the LED packages and the height of the chips, and by introducing a striped texture on the top *m*-plane surface.

These efforts could help the uptake of *m*-plane LEDs in projection displays and automotive headlamps.

"In these applications, engineers must design optical components, such as lenses, mirrors, and prisms," explains Inoue. "The controlled radiation pattern is useful for the optical design.

LEDs produced by the team feature a silicon-doped, *n*-type GaN layer; an InGaN/GaN multiple quantum well; a magnesium-doped, *p*-type AlGaN electron-blocking layer; and a magnesium-doped, *p*-type GaN layer. After dicing of the wafer, chips were mounted face down on ceramic packages made from either AlN or alumina.

The LEDs feature a relatively large recombination region, with three quantum wells with a thickness of 15 nm, sandwiched between 30 nm GaN barriers.

The engineers have selected this design to combat LED droop, the decline in device efficiency at high drive currents. They believe that droop is caused by a combination of electron leakage and Auger recombination.

According to the team, thick wells reduce carrier density, and this minimises Auger recombination, which is proportional to the cube of the carrier density. Meanwhile, the lack of a polarization field within the active region diminishes the electron leakage current, which stems from electrons that fail to recombine with holes in the quantum well and escape into the *p*-type region.

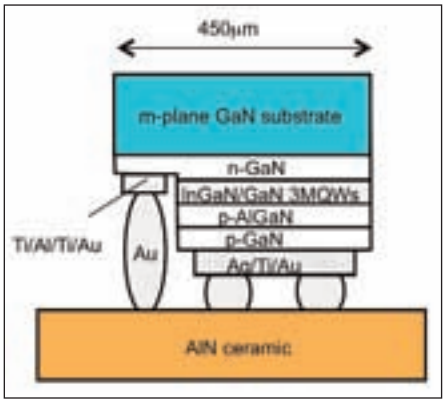
The team's LEDs, which have surface texturing on the top surface to enhance light extraction, produce a peak external quantum efficiency of 51.5 percent at 88 A cm^{-2}. Cranking the current density up to 1400 A cm^{-2} propels the output power to 1.62 W.

Today, the vast majority of LED manufacturing is carried out on sapphire and SiC substrates, with the use of silicon, which is much cheaper, tipped to grow. In comparison, *m*-plane GaN substrates are incredibly expensive, but Inoue believes that there will come a time when these are used for LED production.

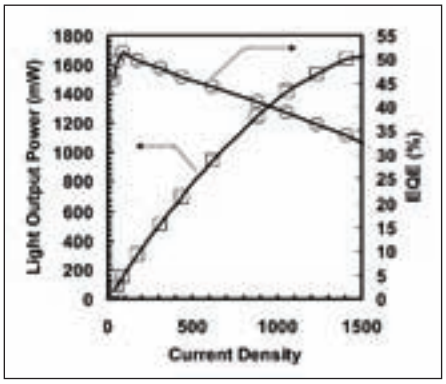
"The price reduction of GaN substrates is going on every year", says Inoue, "and the size of a *m*-plane GaN-LED is only one-third to one-fifth of that of a conventional, high-power *c*-plane GaN-LED at the same rated current of around 1 A."

This reduction in chip size for a given output power trims costs. "We have a plan to begin the commercial production in 2015," says Inoue.

A. Inoue *et al.* International Electron Devices Meeting 2012 pp. 621



Panasonic's 408 nm m-plane LEDs can deliver an output of more than 1.5 W



Panasonic's LED exhibits very little droop. The researchers believe that this stems from thick wells that minimise Auger recombination and a lack of internal electric fields that reduce electron spillover into the p-side of the device

Improving polar InN surfaces to enable the fabrication of *p-n* junctions

Using a simple nitridation process, it is now possible to grow up to 25 nm-thick polar InN films with the surface Fermi level close to the valence band maximum

A FINNISH-RUSSIAN-SWEDISH collaboration is claiming that it has used ammonia nitridation to produce the first polar InN with the surface Fermi level near the valence-band maximum.

In the past, the growth of polar InN films has been hindered due to metallic indium clusters, formed readily during growth, and unintentional *n*-type conductivity of nominally undoped films. These include surface electron-accumulation layers via the Fermi level pinning into the conduction band.

These issues have hampered, for example, the realisation of *p*-type InN layers. This makes it difficult to grow *p-n* junctions in InN layers, which are needed in a wide range of devices.

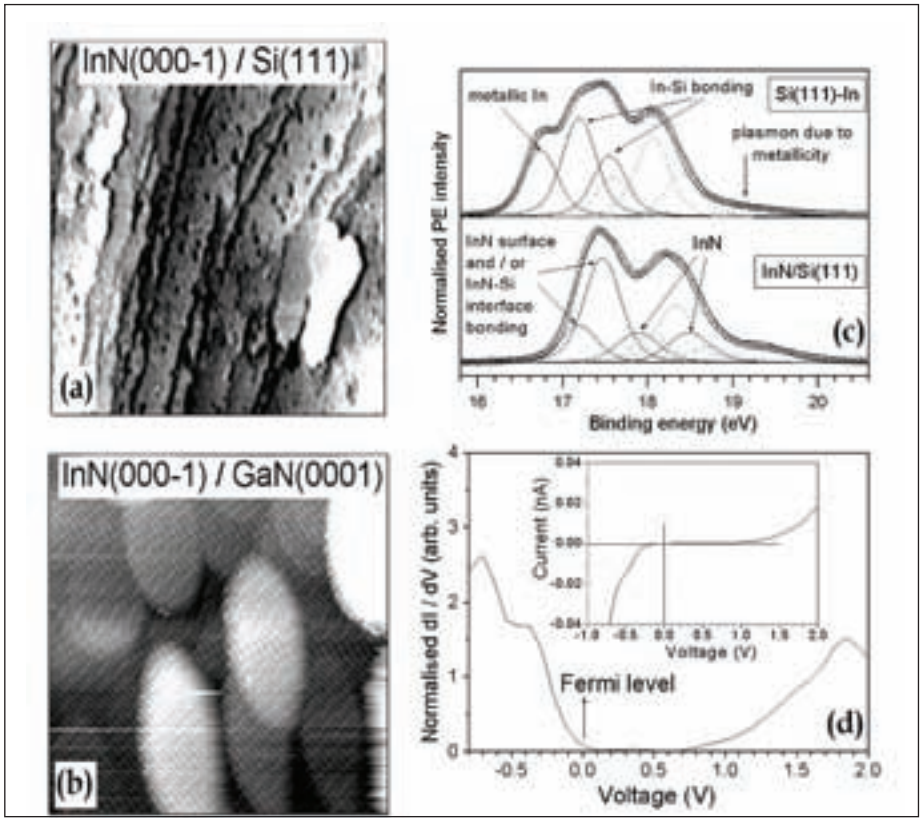
A team from the Institute of Solid State Theory, Friedrich Schiller University and the European Theoretical Spectroscopy Facility, all based in Germany, using *ab initio* calculations, recently predicted the Fermi level position for InN.

Furthermore, researchers at Ritsumeikan University in Japan and Seoul National University, Korea, have shown that the plasma nitridations during growth stop the transformation of even large indium clusters into two-dimensional InN islands, improving InN quality.

Now researchers, led by a team at the University of Turku in Finland, have shown that high electron concentrations can be avoided, which is promising for making *p*-type InN films.

They initially grew InN films on silicon (111) and GaN (0001) substrates by the nitridation of the indium-covered semiconductor surfaces with ammonia (NH_3) or cracked N_2 gas.

Following this treatment, the scientists found it was possible to grow up to 25 nm thick polar InN films with the surface Fermi level close to the valence band maximum. In other words, they avoided the presence of electron accumulation layers.



(a) STM image showing two-dimensional nature of InN (000)/Si (111) sample (~ 800 nm x 800 nm) (b) STM image showing two-dimensional nature of InN (000)/GaN (0001) sample (~450nm x 450nm) (c) Synchrotron-radiation In 4d core-level photoelectron spectra show that the nitridation transforms metallic indium to InN (d) Analysis of current-voltage curves, measured by STS from well-defined surface areas, reveal that the surface Fermi level locates close to the valence-band maximum

The substrate temperature during the nitridation was found to be one of the most crucial parameters in the formation of InN (000$\bar{1}$) films with the Fermi level near the valence-band maximum.

Indium was evaporated from a heated tantalum envelope onto the substrates, which were kept at room temperature before nitridations. The NH_3 pressure was about 5 x 10^{-5} mbar during the nitridation.

Temperature of indium-covered silicon (111) substrates was 400 - 450 °C during the nitridation, and the temperature for indium-covered GaN (0001) pieces was 530 - 580 °C, just below the decomposition temperature of InN.

The silicon (111) substrates were flash heated at about 1200 °C. Scanning tunnelling microscopy indicates a smooth, well-defined (7x7)-reconstructed surface.

To clean HVPE-grown *n*-type GaN (0001) substrate pieces, they were heated to around 600 °C in the NH_3 atmosphere to get a sharp (1 x 1) diffraction.

J. Dahl et al Phys. Review B **86** 245304 (2012)

Scaling up microwave GaN HEMT fabrication

200 mm (111) silicon provides a platform for high frequency, high-power transistors

A SINGAPORE RESEARCH TEAM has demonstrated the direct current and microwave performances of 0.3-μm-gate-length AlGaN/GaN HEMTs grown on a 200 mm silicon substrate. The researchers say this is the first demonstration of sub-micron gate GaN HEMTs on 200 mm silicon.

The team was composed of scientists from Nanyang Technological University (NTU), A*STAR Institute of Microelectronics (IME) and A*STAR Institute of Materials Research and Engineering (IMRE).

HEMTs were grown using the MOCVD Veeco TurboDisk k465i system.

The fabrication and the characterisation of the submicron devices were performed at NTU. The submicron-gate devices on crack-free AlGaN/GaN HEMT structures exhibited good DC and microwave characteristics. According to the team, this work demonstrates the feasibility of achieving good performance AlGaN/GaN HEMTs on 200 mm diameter silicon (111) for low-cost high-frequency and high-power switching device applications.

Currently, many major silicon fabs worldwide are also pursuing the growth and process development of GaN devices on 200 mm silicon substrates. They would utilise their 200 mm line to reduce the chip cost and increase the chip functionalities by combining with CMOS circuitries.

The figure below shows a photograph of crack-free AlGaN/GaN HEMT structures grown on a full 8 inch diameter Silicon (111) substrate, with a starting substrate resistivity of ~100 Ω -cm. The device structure is: i-GaN (2nm)/i-$Al_{0.17}Ga_{0.83}N$ (18 nm)/GaN (1050 nm)/AlN (10 nm)/GaN (870 nm)/AlN (10 nm)/GaN/$Al_{1-x}Ga_xN$ (1000 nm) multiple layers/AlN (100 nm)/8 inch silicon (111).

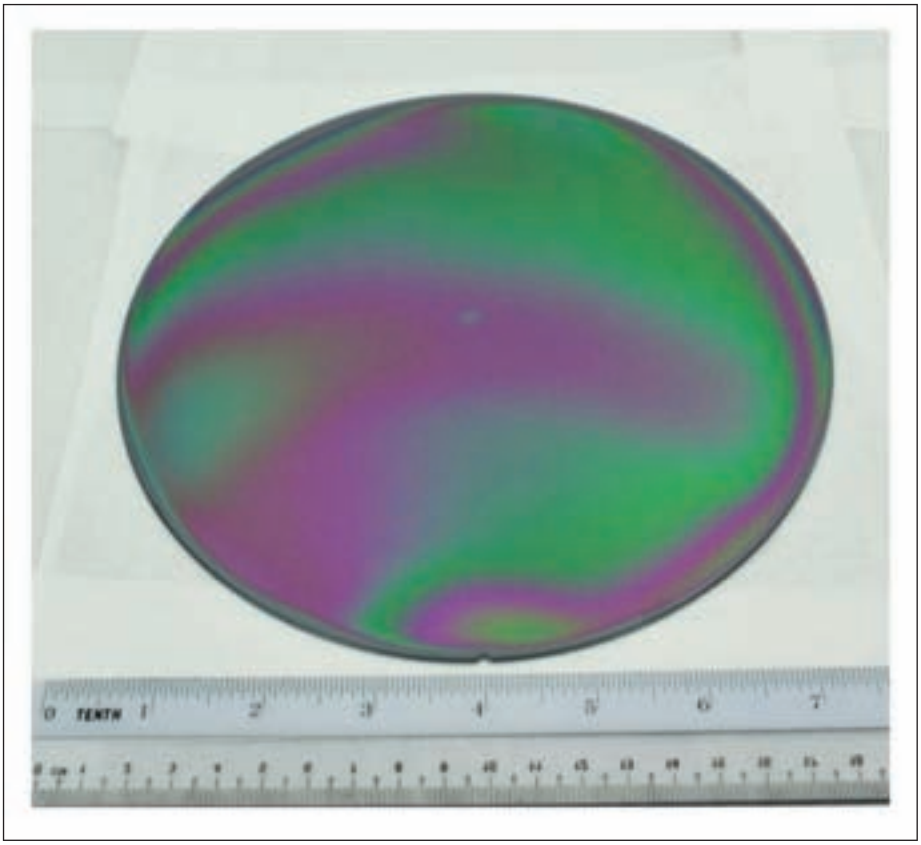


Image of crack-free AlGaN/GaN HEMT structure on 8-inch diameter silicon (111)

The grown GaN HEMT structure exhibited an average two dimensional electron gas (2DEG) mobility of 1550 $cm^2V^{-1}s^{-1}$, sheet carrier concentration of 0.84 x 10^{13} cm^{-2}, and an average sheet resistance of less than 400 Ω /sq. The surface RMS roughness of AlGaN/GaN HEMT structure is 0.25 nm. These figures are equivalent to previously reported data in the literature for AlGaN/GaN heterostructures grown on 4-inch to 6-inch silicon substrates.

The submicron-gate devices were fabricated using a conventional process technique. Device dimensions are: gate length (L_g) = 0.3 μm; gate width (W_g) = (2 x 75) μm; gate-drain spacing (L_{gd}) = 2 μm.

Small-signal microwave characteristics of AlGaN/GaN HEMTs on 200 mm silicon (111) were measaured at V_D = 10 V and V_g = -2.4 V.

The device exhibited good pinch-off characteristics with I_{Dmax} = 853 mA/mm, $g_{m,max}$ = 180mS/mm, threshold voltage = -3.8 V, f_T = 28 GHz and f_{max} = 64 GHz. The $f_T x L_g$ is 8.4 GHzμm, which is comparable to the AlGaN/GaN HEMTs fabricated on smaller diameter silicon substrates.

The observed f_{max}/f_T of greater than 2 to 2.6 is due to the occurence of good quality buffer GaN with low buffer leakage current (4.8 x 10^{-3} mA/mm at 100 V).

The 2-μm-gate HEMT in the same device structure exhibited a BV_{gd} of 188 V which is almost equivalent to the lateral buffer breakdown voltage (B_{VBuff}) of 192 V. The presence of a higher screw- and edge-dislocation density at the hetero-interfaces usually leads to a lower B_{VBuff}.

In the future, the researchers aim to optimise the growth of GaN-on-silicon to improve the buffer quality and reduce the wafer bowing.

S. Arulkumaran *et. al.* Japanese Journal of Applied Physics **51** 111001 (2012)

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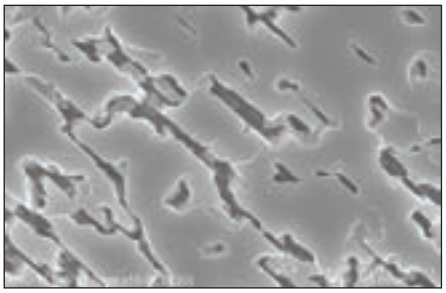
Simplifying the growth of *m*-plane GaN

Growth of non-polar GaN on m-plane sapphire is realized without buffer layers and nitridation processes

RESEARCHERS at Kyung Hee University in Seoul, South Korea, have improved the reproducibility associated with the growth of non-polar GaN films on m-plane sapphire. Deposition of these non-polar films, which can improve LED efficiency thanks to the absence of internal electric fields, has already been reported by a handful of groups. However, according to Chikyo Kim from Kyung Hee University, the pre-treatment conditions used by these groups differ substantially from one another, indicating that it is difficult to grow non-polar GaN films reproducibly with their approaches.

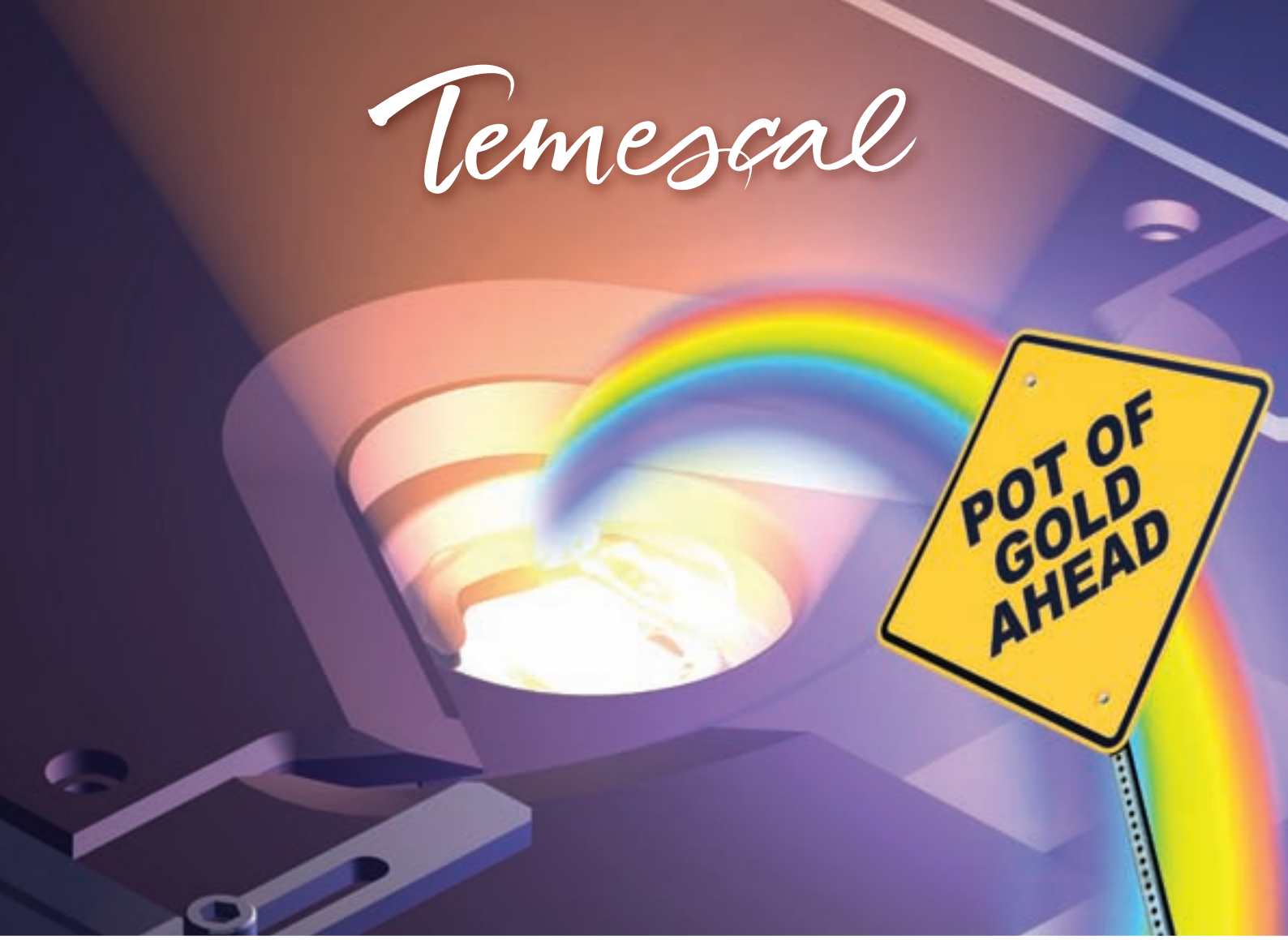
In comparison, Kim and his co-workers don't use buffer layers or a nitridation step – exposure of a heated sapphire substrate to ammonia gas, which cracks on the surface of this wafer. "The main purpose of nitridation is to modify the top surface of a sapphire substrate by producing aluminium-nitrogen bonds, which are known to simplify subsequent growth of gallium nitride," explains Kim.The Korean team's study of its relatively simple growth process began by placing *m*-plane sapphire in a HVPE reactor and depositing GaN at growth temperatures of 950 °C to 1100 °C. Nitrogen was used as the carrier gas. Samples were removed after 10 minutes of growth. None featured coalesced films, and X-ray diffraction analysis revealed domains with three different orientations: $<1\bar{1}00>$, $<1\bar{1}03>$ and $<11\bar{2}2>$. Several growth conditions resulted in just the non-polar, *m*-plane $<1\bar{1}00>$ orientation, including the combination of III-V ratios above 100 and growth temperatures of either 1000 °C or 1050 °C. The researchers scrutinized the samples with transmission electron microscopy, finding that in interfacial region, the density of extended defects is higher than that for samples formed with nitridation.

However, in the region away from the interface, their material that is grown with the simpler process is free from extended defects. Increasing the growth time to 80 minutes and using flow rates of 6 sccm for HCl and 1600 sccm for ammonia led to the formation of completely merged, m-orientated films. However, in some instances, growth conditions led to films with a small proportion of domains that were not *m*-orientated. The surface of the coalesced films is flat, except from regions with pits that have a density of 1-2 pits μm^{-2}. One way to speed up the growth rate of these non-polar films is to increase the flow rate of HCl. "But an increase in the HCl flow rate could induce unwanted nucleation of other-oriented domains," warns Kim, who says that the growth technology requires further investigation.



Scanning electron microscopy reveals the dimensions of the unmerged, m-plane GaN domains on sapphire

Y. Seo et al. Appl. Phys. Express **5** 121001 (2012)



The end of the rainbow is closer than you think.

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News Digest Contents

LEDs

Sparking up communications with Li-Fi

Minute LED lights could deliver Wi-Fi-like internet communications

The University of Strathclyde says it has made a breakthrough in displaying information and illuminating homes,

The aim of the universities project is to develop the innovative technology to unleash the full potential of "Li-Fi".

This is the transmission of internet communications using visible light, rather than via the radio waves and microwaves currently in use.

Micron LED

Although the potential possibilities offered by Li-Fi are already being explored globally, the EPSRC funded consortium of UK universities (see below) is pursuing a radical, distinctive vision that could deliver big benefits.

Martin Dawson, a professor at Strathclyde, who is leading the four-year initiative, says, "Imagine an LED array beside a motorway helping to light the road, displaying the latest traffic updates and transmitting internet information wirelessly to passengers' laptops, netbooks and smartphones. This is the kind of extraordinary, energy-saving parallelism that we believe our pioneering technology could deliver."

To enable the potential to be realised, the consortium has drawn together a wide branch of Li-Fi research experts.
Dawson, of the University's Institute of Photonics, continues, "The Universities of Cambridge, Edinburgh, Oxford and St Andrews are all working with us, bringing specific expertise in complementary areas that will equip the consortium to tackle the many formidable challenges involved - in electronics, computing and materials, for instance - in making this vision a reality. This is technology that could start to touch every aspect of human life within a decade."

Underpinning Li-Fi is the use of LEDs,a rapidly spreading lighting technology which is expected to become dominant over the next 20 years.

LEDs flicker on and off thousands of times a second. By altering the length of the flickers, it is possible to send digital information to specially-adapted PCs and other electronic devices - making Li-Fi the digital equivalent of Morse Code.

This would make the visible part of the electromagnetic spectrum available for internet communications, easing pressure on the increasingly crowded parts of the spectrum currently being used.

But rather than developing Li-Fi LEDs around 1mm2 in size, which other researchers around the world are concentrating on, the EPSRC-funded team is developing micron-sized LEDs which potentially offer a number of major advantages.

Firstly, the tiny LEDs are able to flicker on and off 1,000 times quicker than the larger LEDs, meaning that they can transmit data more quickly.

Secondly, 1,000 micron-sized LEDs would fit into the space occupied by a single larger 1mm2 LED, with each of these tiny LEDs acting as a separate communication channel. A 1mm2 sized array of micron-sized LEDs could therefore communicate 1,000 x 1,000 - or, in other words, one million - times as much information as one 1mm2 LED.

Each micron-sized LED would also act as a tiny pixel. This means one large LED array display, for example, used to light a living room, a meeting room or the interior of an aircraft, could also be used as a screen displaying information, at exactly the same time as providing internet communications and lighting.

Eventually, it could even be possible for the LEDs to

incorporate sensing capabilities too. For example, a mobile phone could be equipped with a flash that - when pointed at a shop display in which every item has been given an electronic price tag - could display the price of these items.

LED firms Lextar and Wellypower merge

After the merger of the two LED subsidiaries of AU Optronics (AUO), Lextar will have capital values at US $169 million), Lextar will have capital values at US $169 million

This unification hopefully means Lextar can achieve a more complete and vertically integrated business model and further expand its LED lighting and backlighting product lines and customer base.

These developments will take place under the wing of David Su, who will become Chairman and CEO with Allen Huang acting as president.

Lextar is excited about the expected result of the merger. In the past, the company's backlighting products were mostly for monitor and TV applications but now will also be used in notebook and smartphone applications.

What's more, aside from developing mostly on solid-state lighting products such as lamps and board lights, Lextar's new merger will give the company a line of products that also include T5 tube and CCFL lighting applications along with LED bulbs and fixtures.

Also resulting from the merger is an expanded customer portfolio, which gives Lextar OEM businesses in the US and Japan.

Chairman Su notes that Lextar and Wellypowers' product lines, system platforms and personnel have already merged to form a competent team that will be even more well-versed in lighting operations and able to improve Lextar's output value in the market.

Cree's latest LED troffers suit many applications

The company's III-nitride CR Series now delivers up to 130 LPW with a standard efficacy of 100 LPW

With its patented TrueWhite Technology, Cree is launching the CR Series LED architectural high efficacy (HE) troffer with 130 lumens per watt (LPW) and 90 CRI.

Cree is also increasing the efficacy of its standard CR family to 100 lumens per watt.

The firm is also expanding the CR troffer line with the new CR Series High Definition (HD) troffer, featuring over 80 CRI with an enhanced colour spectrum and high R9 values using proprietary colour mixing and tuning technology.

The HD technology delivers higher colour quality than traditional 80 CRI fluorescent troffers.

The new CR Series HD troffer effectively targets applications where a slightly lower quality of light is an acceptable trade-off for a lower initial cost.

Delivering high performance and a low cost per lumen, the Cree CR Series has a ten-year warranty and a lifetime of up to 100,000 hours.

An innovative thermal management system and room-side heat sink enable the LEDs to consistently run cooler, providing significant boosts to lifetime, efficacy and colour consistency.

The new CR Series HE troffer consumes nearly 60 percent less energy than a comparable linear fluorescent 34W T12 system and nearly 50 percent less when compared to an existing 32W T8 system.

"These new troffers deliver a no-compromise alternative to fluorescent lighting," says Greg Merritt, vice president, lighting at Cree. "This is another example of Cree pushing the performance boundaries to improve energy savings and enable faster payback over a broader range of products to accelerate LED lighting adoption."

The CR Series troffer family includes three models, the CR14 1 x 4 troffer, CR22 2 x 2 troffer and CR24 2 x 4 troffer, is available in a wide range of

colour temperatures to match existing fluorescent technologies (3000K, 3500K and 4000K) and now offers new 5000K for all CR Series LED troffers.

CR24 2'x4' Architectural LED Troffer

Dimming control down to five percent and emergency backup features are also available.

The CR Series is sold through Cree lighting sales channels which can be accessed on the company's website.

Rubicon has shipped 400,000 large dimension sapphire wafers

The wafers are building block for LEDs used in HDTVs, laptops, smart phones and tablets and RFICs

Rubicon Technology has shipped a total of 400,000 large diameter sapphire wafers to LED and SoS/ RFIC manufacturers.

Sapphire is a key building block for LEDs used in HDTVs, laptops, smart phones and tablets. Another significant market for sapphire is Silicon-on-Sapphire (SoS) Radio Frequency Integrated Circuits (RFICs).

SoS RFIC chips deliver high RF performance with low power consumption, a small form factor, and significantly reduced crosstalk in antenna applications that are pervasive in smart phones and other consumer devices.

Rubicon claims it was the first firm to develop large diameter sapphire wafers for use in the RFIC market and customise needs for the LED industry.

"This latest milestone demonstrates Rubicon's continuing leadership in the volume delivery of high quality large-diameter sapphire wafers," says Raja M. Parvez, President and CEO of Rubicon Technology.

"Our emphasis on vertical integration - achieving cost efficiencies and control of sapphire production – enables us to scale production and ensures our customers an unparalleled, reliable supply of high quality, large diameter sapphire wafers that meet their unique and exacting specifications. Rubicon's capabilities are increasingly important as LED manufacturers seek to reduce costs throughout the manufacturing process to make LED-based lighting more affordable for consumers and encourage adoption worldwide."

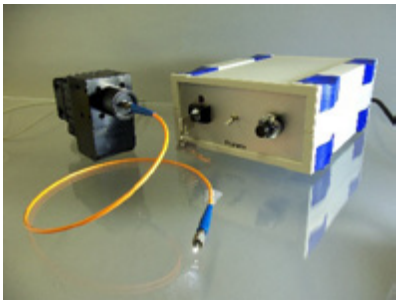
IMS Research estimates that the overall LED market will reach nearly $10.9 billion in 2012 with $2.9 billion in lighting. By 2015, IMS projects that the LED market will reach $13.9 billion with the lighting market nearly doubling to $5.8 billion in three year

Ultra high power LED from Prizmatix

The device has over 4 Watts of collimated white light for scientific and industrial applications. The benefits of fast rise and fall times, no warm up, and long life make this UHP-T attractive

Prizmatix has revealed a new generation of collimated LED light sources, with over 60 percent increase in power over previous versions.

The UHP-T-LED-White has over 4.5 W of collimated light and can be used as a replacement for traditional mercury and xenon lamps in a variety of applications.



UHP-T-LED-White fibre coupled LED light source

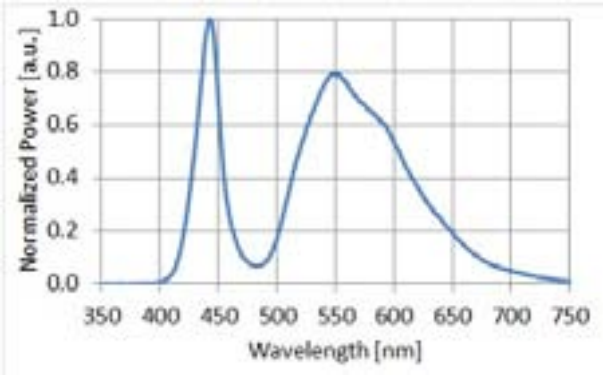
Adapters are available for all major brands of microscopes including Olympus, Nikon, Zeiss, and Leica as well as for fibre optic and liquid light guides.

"We have had a lot of interest for microscope service companies and manufacturers who see the UHP-T as a green alternative to mercury lamps for fluorescent microscopes," says Nathaniel Sperka, North American Sales Manager of Prizmatix USA. "The benefits of fast rise/fall times, no warm up, and long life make this UHP-T very attractive to managers of imaging labs and researchers."

The Prizmatix UHP-T-LED is compatible with the Prizmatix OptiBlock system allowing it to be combined with other LED modules.

These include UV LEDs using beam combiner modules and a range of accessories such as fibre couplers and filter wheels creating complete LED illumination systems in configurations for any application.

This allows OEM customers and researchers alike, the ability to use only the components and features they need. The output can be free space or coupled to optical fibres or liquid light guides.



UHP-T-LED-White spectrum (standard 4500K White)

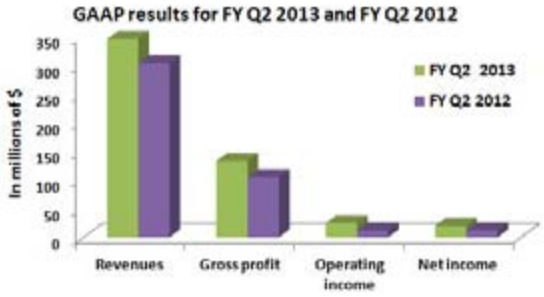
Cree quarterly results shining bright

Revenues increased 14 percent year-over-year to a record $346 million. Net Income increased 69 percent year-over-year to $20.4 million

Cree has announced revenue of $346.3 million for its second quarter of fiscal 2013, ended December 30th, 2012.

This represents a 14 percent increase compared to revenue of $304.1 million reported for the second quarter of fiscal 2012 and a 10 percent increase compared to the first quarter of fiscal 2013.

GAAP net income for the second quarter was $20.4 million, or $0.18 per diluted share, an increase of 69 percent year-over-year compared to GAAP net income of $12.1 million, or $0.10 per diluted share, for the second quarter of fiscal 2012.



"Fiscal Q2 was another strong quarter with record revenue and earnings per share that were higher than our target range due to stronger sales in both LEDs and Lighting combined with improved gross margins," said Chuck Swoboda, Cree Chairman and CEO.

"Overall company backlog is in line with seasonal trends for our fiscal Q3. Longer term, we remain focused on driving adoption through innovation, and with our broad understanding of the technology levers from materials through systems, we see opportunities to move the market even faster than what has been experienced to date."

Q2 2013 (GAAP) Financial Metrics

Gross margin increased 170 basis points from Q1 of fiscal 2013 to 38.5 percent.

Cash and investments increased $69.5 million from Q1 of fiscal 2013 to $885.8 million.

Accounts receivable (net) decreased $17.7 million from Q1 of fiscal 2013 to $144.6 million, with days sales outstanding of 38.

Inventory increased $5.3 million from Q1 of fiscal 2013 to $185 million, with days of inventory declining to 78 days.

GAAP based Business Outlook:

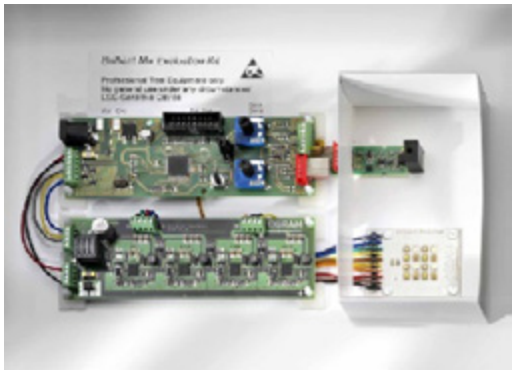
For its third quarter of fiscal 2013 ending March 31st, 2013, Cree targets revenue in a range of $325 million to $345 million with GAAP gross margin targeted to be similar to Q2. The gross margin targets include stock-based compensation expense of approximately $2.4 million.

Operating expenses are targeted to be similar to Q2. The tax rate is targeted at 17.0 percent for fiscal Q3. Net income is targeted at $17 million to $23 million, or $0.15 to $0.20 per diluted share. This target is based on an estimated 116.7 million diluted weighted average shares.

Osram universal controller simplifies electronic control

The company's Brilliant Mix concept gives III-nitride LED luminaire designers greater flexibility as the LED lights can be placed anywhere

The Brilliant Mix LED colour mixing concept from Osram Opto Semiconductors is now even easier to control thanks to the new Brilliant Mix Universal controller from Elec-Con technology.



LLFY Brilliant Mix Controller

The controller is available in a standard version, with or without a sensor and in a customised version. It can be adapted to current building systems standards, such as DALI, KNX and EIB.

The controller concept has been developed as part of the LED Light for many networks.

Warm white light with high efficiency and a high colour rendering index at the top of the wish list for anyone looking for a feel-good factor in general illumination.

Osram says its Brilliant Mix concept can be achieved with semiconductor light sources.

The firm says it provides efficiency of 110 lumen per watt (lm/W) and an excellent colour rendering index of more than 90. The basis for this concept are high-power Oslon LEDs in white and amber and also in bluish white and blue.

The combination of LEDs of different colours results in white light in a spectrum from 2700 Kelvin (warm white) to 6500 Kelvin (cold white). The required luminous flux can be achieved by using an appropriate number of LEDs.

Up to now, application know-how and control know-how have been needed for controlling LEDs. Customers had to develop or modify solutions or controllers themselves in order to control individual channels and maintain the desired color location even as the temperature rises in the module or in the luminaire.

A highly usable standard product is now available in the form of the Universal Controller. The controller has a modular structure, in other words the controller unit, driver and sensor are separate components.

This gives luminaire designers greater flexibility because the components do not have to be arranged next to one another or on top of one another but can be placed anywhere.

The standard driver has channels so that individual LEDs, for example in different colours, can be controlled individually.

Multiple drivers can be connected to a controller to improve performance.

The modularity of the controllers means that different versions can be produced - a standard version without a sensor, one with a sensor, and various customised versions of different shapes and sizes.

The sensor enables the required brightness and colour location to be controlled in accordance with a preset customer-specific value. This ensures, for example, that all the luminaires in a room have the same light colour. It is also possible to adjust the LEDs throughout their lifetime so that different rates of aging among

LEDs of different colours do not have an adverse effect on the overall effect of the light.

Dieter Bauernfeind, Managing Director of Elec-Con technology is extremely pleased with the new product and says, “The modularity of the system make it easy for us to meet specific customer requirements and supply relatively small production runs.”

What all the versions of the controller have in common is that they make it easier to use the Brilliant Mix concept and speed up the implementation of lighting solutions. Thanks to the Universal Controller in combination with the drivers, the light engine and the sensor module it is no longer necessary to have special control know-how.

Brilliant Mix applications can therefore be put into practice quickly, easily and therefore economically with efficient use of resources.

“True to the purpose of our network, namely to offer our customers simple solutions, we have developed the Universal Controller in cooperation with our partners,” adds Sebastian Lyschick, responsible for LED Light for you (LLFY) at Osram Opto Semiconductors.

Also involved in the development, in addition to the LED manufacturer, were Infineon Technologies, Elec-Con technology and MAZeT.

LED lighting market to grow 32 percent

This is according to market research firm Five Star Equities report which focuses on SemiLEDs and Veeco Instruments

A strong driver for growth within the LED Industry in 2013 is expected to be the demand for LED lighting.

Tech newspaper Digitimes has reported that Everlight Chairman Robert Yeh anticipates the LED lighting penetration rate to reach 25 percent in 2013.

Five Star Equities says that by 2020, the global LED lighting market is projected to grow by 32 percent, according to the Taiwan LED Lighting Industry Alliance. Since 2011, LED lighting sales has experienced a growth rate of 17 percent on average, and in 2013 output is likely to reach $15 billion, the Digitimes reported.

“The trend toward LED lighting for energy efficiency will move more quickly this year than anyone expects, driven by cost declines, regulatory incentives and rapidly increasing consumer awareness,” says Jeff Cianci, Green Science Partners’ Chief Investment Officer.

Veeco impresses KaiStar with GaN MOCVD tool

KaiStar, a JV between Epistar and Shenzhen Kaifa Technology will add to its existing fleet of Veeco MOCVD systems as part of its 2013 LED capacity expansion plan

Veeco Instruments has received an order for multi and single-chamber TurboDisc MOCVD systems, including the new MaxBright M, from KaiStar Lighting Co., Ltd.


TurboDisc MaxBright M GaN MOCVD Multi-Reactor System

KaiStar, a joint venture between Epistar and Shenzhen Kaifa Technology Co., Ltd., is based in Xiamen, China and began LED production in 2012.

The systems will be added to KaiStar's existing fleet of Veeco MOCVD systems as part of its 2013 capacity expansion plan.

MJ Jou, President of Epistar Corporation comments, "This latest capacity expansion in Xiamen is in keeping with our goal to maximise our position in the China LED backlighting, automotive and general illumination market."

"Since we originally selected Veeco as our MOCVD equipment supplier for KaiStar a year ago, we have been extremely impressed with the product quality, service and support we have received. A critical deciding factor has been Veeco's quick process transfer which is important as we share know-how across our LED manufacturing sites. In addition, the TurboDisc's low cost-of-ownership made it a straight-forward decision to turn to Veeco as we add more tools for KaiStar in 2013."

Bill Miller, Executive Vice President of Veeco, says, "We are pleased to support Epistar and Kaifa as they continue to expand their leadership position in the China market through KaiStar and their other joint ventures. We will remain focused on helping them to achieve their manufacturing goals."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System platform is an MOCVD system designed to manufacture high quality, high brightness LEDs. The firm says its MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers accommodating layout configurations compared to the original MaxBright.

InfiniLED MicroLEDs are ultra bright

The company says it has developed a light output density of more than 300 W/cm2, the highest recorded for a commercially available LED type device

InfiniLED claims its latest MicroLEDs (μLEDs) have produced record optical beam intensity.

The firm's newest device is capable of producing up to 1mW of light from a single 20μm pixel at 405nm.

The MicroLED combines the benefits of a laser and a LED to produce ultra-high light output. The MicroLED provides the wavelength flexibility, drive characteristics and simplicity of a LED as well as the power and collimated beam of a laser.

The ability to produce such light intensity and control directly from the chip enables the light to be efficiently used in a range of applications.

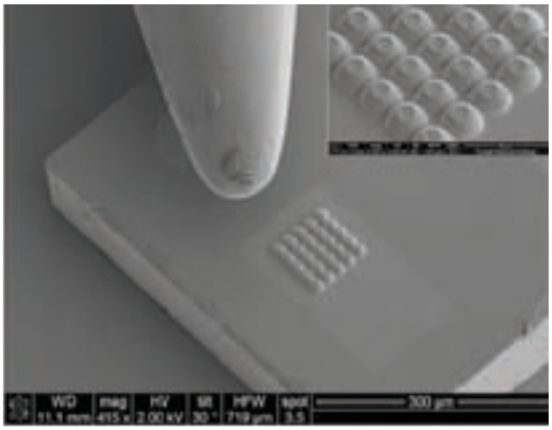
InfiniLED has achieved this performance using its patented MicroLED structure.

A parabolic reflector is etched into the semiconductor material during the fabrication process. This places an optical component directly at the site of light generation and at the most effective position for control of the light produced.

Not only has the light been shown to be extracted in ultra-high intensity but also at high efficiencies. By directing all the generated light through a single surface of the semiconductor it can be efficiently collected and used in the wider system.

The MicroLED is currently being used in a range of applications included life sciences, consumer electronics and OEM equipment. The device can be fabricated as a single pixel, large clusters of pixels or as addressable arrays where each pixel is individually switchable. The single pixels can be used to produce high intensity, collimated light over a small area or to produce useable light at ultra-low currents. The single pixels produce light with a few

nanoamps of current. To produce larger amounts of light, clusters of tightly packed MicroLEDs are available.



A cluster of 25 MicroLEDs beside the tip of a needle. The parabolic reflector shape can be seen in the inset close-up

This results in high light density and collimated emission over a wider area. MicroLEDs are also available as addressable arrays of pixels. The collimation from each pixel results in high packing densities and minimal crosstalk between the devices.

What's more, the high current densities achievable and low capacitance allows the MicroLEDs to be switched at very high speeds. Experimental work is on-going with the Tyndall National Institute and the results will be announced shortly.

Commenting on the announcement Chief Commercial Officer of InfiniLED, Bill Henry says, "These results highlight the capabilities of the MicroLED (μLEDs). This device can be seen as a cross-over between the power and collimation of a laser and the simplicity of an LED. The unique devices enable a range of applications. InfiniLED are proud to have achieved the landmark performance of optical density greater than 300 W/cm2. This was achieved without the need for external optics indicating the potential for further improvement of the performance."

"The applications for the MicroLED are many and varied," adds Henry. "InfiniLED is developing light sources for use in areas such as diagnostics, printing and battery powered consumer electronics. We are particularly focused on applications where the efficient use and control of light is of greatest importance. The first products with MicroLEDs incorporated will be on the market shortly and we look forward to new releases in the near future."

Cree increases LED street light lumens by 35 percent

The company says its III-nitride XSP2L LED is the ideal replacement for outdated high-pressure sodium and metal-halide fixtures up to 400 watts

Cree has extended its XSP Series LED Street Light portfolio to deliver municipalities improved performance at even more affordable price points.

The firm says its new XSP2L LED street light increases lumen output over 35 percent compared to the original XSP luminaire.

Delivering better performance and lower cost per lumen, the Cree XSP Series LED Street Light has a ten year warranty and a calculated L70 lifetime of more than 100,000 hours and features a thermal management system to improve overall performance. The result is a high-performance luminaire that delivers up to 30 percent more lumens per dollar.

"Cree is committed to helping communities significantly lower their energy costs and maintenance expenses," says Greg Merritt, vice president, lighting at Cree. "The latest Cree innovation makes LED street lighting available for higher performance applications with compelling payback."

Seoul Semiconductor & Verbatim reveal new LED lamps

The halogen replacement lamps use gallium nitride (GaN) chip technology

Since 2010, Verbatim has been introducing a growing portfolio of high performance LED lamps to the lighting market.

To address market requirements for LED lamps that more closely approximate the characteristics of halogen lighting, Verbatim will launch a new range of LED products based on Seoul Semiconductor SSC's "nPola" technology.

MR16 'nPola' inside

"nPola" utililises GaN substrates from Verbatim's parent company Mitsubishi Chemical Corporation for GaN epitaxial growth, replacing sapphire or SiC substrates.

Seoul Semiconductor's patented nPola minimises defects in the active layer and allows LED chip current densities 5 to 10 times higher than conventional chips. As a result, 5 to 10 times brighter light output can be realised from the same chip size.

Verbatim's initial launch of nPola halogen LED lamps will focus on the MR16 form factors, with a primary target of 50W MR16 halogen equivalency. The combination of high light output and beam characteristics that closely resemble halogen lamps will allow lighting designers and contractors to adequately replace halogen lighting with high performance, energy efficient LED products in both new design and retrofit environments.

SSC and Verbatim will continue to work together to develop innovative LED lighting products.

Mass production is expected to start in March 2013.

Edwards abatement system for LEDs wins award

Plant Engineering China has recognised the Spectra-G 3000 in the "Environmental Health" category for its role in LED production

Edwards Group Limited has announced that its Spectra-G 3000 abatement system has won Plant Engineering China magazine's 2012 Best Product of the Year award in the Environmental Health category for its role in reducing pollution and costs of LED manufacturing.

Spectra-G300 system

"We are very pleased to be selected for this prestigious award," says Shao Wei, Global Market Sector Manager - LED at Edwards. "The Spectra-G 3000 allows global LED manufacturers to reduce the impact of their operations on the environment and, at the same time, lower their operating costs. It is great to see Edwards being recognised for its commitment to offering state-of-the-art technology with an environmental responsibility."

China's 12th Five-Year Plan focuses on reducing energy consumption and improving the environment. It provides preferential treatment for developing energy-efficient technology and also includes mandatory targets for carbon emissions, nitride pollution in water supplies and nitrogen oxide pollution in air.

The adoption of energy-efficient LEDs for general lighting and specialty applications, such as backlit flat panel displays for computers and televisions, is expected to contribute significantly to reductions in energy consumption and (indirectly) carbon emissions. However, large-scale LED manufacturing has the potential to generate nitride and NOx emissions that must be abated.

Edwards' Spectra-G 3000 system is an advanced gas abatement system specifically designed to

handle the large flows of ammonia (NH3) and hydrogen (H2) found in the MOCVD processes used to manufacture LEDs. Using a combustion process, it converts these gases to harmless nitrogen (N2) and water vapour (H2O). Since the process uses no external water it completely eliminates nitride contamination of the water supply, and careful control of the combustion process keeps NOx emissions well below permitted levels. Combustion of hydrogen eliminates the risk of fire or explosion downstream in the manufacturing facility.

Edwards says the system also offers significant reductions in total cost of ownership as most of the energy is supplied by burning the ammonia and hydrogen from the MOCVD process. This greatly reduces the cost of fuel and the release of carbon from hydrocarbon fuels.

Air is used rather than water for post-combustion cooling, so the hot air can be passed through a heat-exchanger to capture and re-use the heat, further reducing the energy consumption and carbon footprint of the manufacturing facility. Finally, the system's robust design and the simplicity of the combustion process minimise maintenance costs.

SemiLEDs revenues still suffering with weak market

Revenue for FYQ1 2013 was $6.2 million, an 8 percent decrease compared to $6.7 million in FYQ1 2012

SemiLEDs Corporation has announced its financial results for the first quarter of fiscal year 2013, ended November 30th, 2012.

Revenue for the first quarter of fiscal 2013 was $6.2 million, an 8% decrease compared to $6.7 million in the first quarter of fiscal 2012.

GAAP net loss attributable to SemiLEDs stockholders for the first quarter of fiscal 2013 was $8.9 million, or a net loss of $0.32 per diluted share, compared to GAAP net loss attributable to SemiLEDs' stockholders of $7.7 million, or a net loss of $0.28 per diluted share, for the first quarter of fiscal 2012.

"As more of our customers have qualified our EV products, the demand of our LED chips and LED components has increased. We are seeing pockets of demands while the overall LED market is still weak; we continue to manage cost, inventory and spending with a focus on profitable LED sectors to achieve our positive cash flow goal," said Trung Doan, Chairman and CEO of SemiLEDs.

GAAP gross margin for the first quarter of fiscal 2013 was negative 53%, compared with negative gross margin for the first quarter of fiscal 2012 of 12%.

Operating margin for the first quarter of fiscal 2013 was negative 131% compared with negative 95% in the first quarter of fiscal 2012.

Gross margin was negatively impacted in the first quarter of fiscal 2013 primarily due to a decrease in average selling prices and excess capacity charges for our LED chips.

The company's cash and cash equivalents were $39.3 million at the end of the first quarter of fiscal 2013, compared to the fourth quarter fiscal 2012 ending balance of $47.2 million.

The company also had short-term investments consisting of time deposits with initial maturities of greater than three months but less than one year of $8.3 million at the end of the first quarter of fiscal 2013, compared to the fourth quarter fiscal 2012 ending balance of $8.8 million. Cash used in operating activities was $3.3 million in the first quarter of fiscal 2013.

A replay of a webcast discussing the results is accessible on the investors section of the company's website for approximately 90 calendar days.

SemiLEDs develops and manufactures LED chips and LED components primarily for general lighting applications, including street lights and commercial, industrial and residential lighting, along with specialty industrial applications such as ultraviolet (UV) curing, medical/cosmetic, counterfeit detection, and horticulture. SemiLEDs sells blue, green and UV LED chips.

PhotonStar LED and CSR Bluetooth technology enables flexible dimming

The low energy wireless technology can enable smartphones, tablets and other connected devices to control systems such as lighting in the home

PhotonStar LED Group plc, a British designer and manufacturer of smart LED lighting solutions, continues to work with CSR plc (CSR) in the development of its Bluetooth Smart home lighting products.

These demonstrations are shown on the CSR booth at CES International 2013 in Las Vegas, a major global consumer electronics show.

The firms worked closely to create a joint LED lighting demonstration at CES 2013, showing how Bluetooth low energy wireless technology can enable smartphones, tablets and other connected devices to control systems such as lighting throughout the home.

Photonstar's existing LED lighting system is fully colour tuneable and dimmable, and the addition of CSR's Bluetooth low energy technology increases its flexibility and intelligence. Lights can be controlled individually or in groups using an app creating one-touch buttons to adjust the lighting in a room for different uses such as reading, dining or watching movies.

James Mckenzie, CEO of PhotonStar LED Group PLC, comments, "Our work with CSR on the wireless connectivity for our lighting systems has produced some exciting results, as demonstrated at CES 2013. There is great potential for our lighting solutions to work with everyday technology, creating optimal lighting for the connected home or business as part of the future 'internet of things' vision."

SemiLEDs CFO David Young resigns

The III-nitride LED manufacturer has appointed Timothy Lin to serve as Chief Financial Officer on an interim basis while it searches for a permanent replacement

According to a SEC filing, on January 2nd, 2013, David Young resigned as the Chief Financial Officer of Taiwanese firm, SemiLEDs Corporation.

On January 4th, 2013, the Board of Directors of the company appointed Timothy Lin to serve as Chief Financial Officer on an interim basis while it conducts a search for a permanent Chief Financial Officer.

Lin, 36, has served as the Company's Deputy Controller since joining the Company in October 2010. Prior to joining the Company, he was a Senior Manager at Ernst & Young (Taiwan) from October 2009 to October 2010 and a Manager at Deloitte & Touche (Taiwan) from June 2006 to October 2009.

Timothy Lin's monthly base salary is 200,000 New Taiwan dollars (approximately $6,900). Lin is also eligible for a year-end bonus equivalent to two months of his then average base salary, subject to the achievement of performance targets as determined by SemiLEDs' Chief Executive Officer.

Young will provide transition assistance to the company for a period of time.

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

This is according to Strategy Analytics' GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review July - September 2012: Microelectronics."

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling

in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth.

The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

"The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

This viewpoint summarises financial, product, contract and employment developments from leading semiconductor device suppliers from July - September of 2012. These announcements address a variety of commercial and military applications products and companies that use GaAs, GaN, SiC, SiGe and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

Fireflies inspire brighter LEDs

By depositing a layer of light-sensitive material on top of a GaN (gallium nitride) LED and creating a triangular factory-roof profile with a laser increases LED efficiency by 55 percent

The night-time twinkling of fireflies has inspired scientists to modify a LED so it is more than one and a half times as efficient as the original.

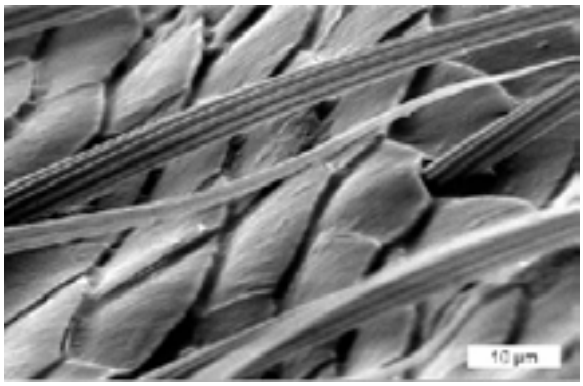
Researchers from Belgium, France, and Canada studied the internal structure of firefly lanterns, the organs on the bioluminescent insects' abdomens that flash to attract mates. The scientists identified an unexpected pattern of jagged scales that enhanced the lanterns' glow, and applied that knowledge to LED design to create an LED overlayer that mimicked the natural structure.

The overlayer, which increased LED light extraction by up to 55 percent, could be easily tailored to existing diode designs to help humans light up the night while using less energy.

"The most important aspect of this work is that it shows how much we can learn by carefully observing nature," says Annick Bay, a Ph.D. student at the University of Namur in Belgium who studies natural photonic structures, including beetle scales and butterfly wings. When her advisor, Jean Pol Vigneron, visited Central America to conduct field work, he noticed clouds of twinkling fireflies and brought some specimens back to the lab to examine in more detail.

Fireflies create light through a chemical reaction that takes place in specialised cells called photocytes. The light is emitted through a part of the insect's exoskeleton called the cuticle. Light travels through the cuticle more slowly than it travels through air, and the mismatch means a proportion of the light is reflected back into the lantern, dimming the glow. The unique surface geometry of some fireflies' cuticles, however, can help minimise internal reflections, meaning more light escapes to reach the eyes of potential firefly suitors.

Bay, Vigneron, and colleagues looked at the intricate structures of firefly lanterns and then investigated how these features could enhance LED design. Using scanning electron microscopes, the researchers identified structures such as nanoscale ribs and larger, misfit scales, on the fireflies' cuticles.



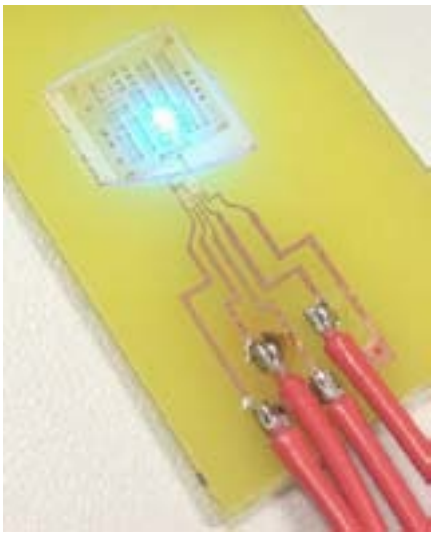
SEM micrograph showing the misfit scales found on the lantern of the Photuris firefly. Researchers found that the sharp edges of the scales let out the most light. (Credit: Optics Express)

When the researchers used computer simulations to model how the structures affected light transmission they found that the sharp edges of the jagged, misfit scales let out the most light. The finding was confirmed experimentally when the researchers observed the edges glowing the brightest when the cuticle was illuminated from below.

"We refer to the edge structures as having a factory roof shape," says Bay. "The tips of the scales protrude and have a tilted slope, like a factory roof." The protrusions repeat approximately every 10 micrometers, with a height of approximately 3 µm. "In the beginning we thought smaller nanoscale structures would be most important, but surprisingly in the end we found the structure that was the most effective in improving light extraction was this big-scale structure," says Bay.

LEDs face the same internal reflection problems as fireflies' lanterns and Bay and her colleagues thought a factory roof-shaped coating could make LEDs brighter.

Nicolas André, a postdoctoral researcher at the University of Sherbrooke in Canada, deposited a layer of light-sensitive material on top of the LEDs and then exposed sections with a laser to create the triangular factory-roof profile. Since the LEDs were made from a material that slowed light even more than the fireflies' cuticle, the scientists adjusted the dimensions of the protrusions to a height and width of 5 µm to maximise the light extraction.



A GaN LED, coated with a "factory-roof" pattern modelled off the fireflies' scales. The bio-inspired LED coating increased light extraction by more than 50 percent. (Credit: Nicolas André)

"What's nice about our technique is that it's an easy process and we don't have to create new LEDs," says Bay. "With a few more steps we can coat and laser pattern an existing LED."

Other research groups have studied the photonic structures in firefly lanterns as well, and have even mimicked some of the structures to enhance light extraction in LEDs, but their work focused on nanoscale features. The Belgium-led team believes it is the first to identify micrometre-scale photonic features, which are larger than the wavelength of visible light, but which surprisingly improved light extraction better than the smaller nanoscale features.

The factory roof coating that the researchers tested increased light extraction by more than 50 percent, a significantly higher percentage than other biomimicry approaches have achieved to date. The researchers speculate that, with achievable modifications to current manufacturing techniques, it should be possible to apply these novel design enhancements to current LED production within the next few years.

The firefly specimens that served as the inspiration for the effective new LED coating came from the genus Photuris, which is commonly found in Latin America and the United States. Bay says she has also examined the lanterns of a particularly hardy species of firefly found on the Caribbean island

of Guadeloupe that did not have the factory roof structure on the outer layer.

A firefly specimen from the genus Photuris, which is commonly found in Latin America and the United States and served as the inspiration for the effective new LED coating. (Credit: Optics Express)

She say that she and her colleagues will continue to explore the great diversity of the natural world, searching for new sources of knowledge and inspiration. "The Photuris fireflies are very effective light emitters, but I am quite sure that there are other species that are even more effective," says Bay. "This work is not over."

This work is further described in the papers;

"Improved light extraction in the bioluminescent lantern of a Photuris firefly (Lampyridae)," by Bay *et al* in *Optics Express*, Vol. 21, Issue 1, pp. 764-780 (2013). http://dx.doi.org/10.1364/OE.21.000764

and

"An optimal light-extracting overlayer, inspired by the lantern of a Photuris firefly, to improve the external efficiency of existing light-emitting diode," by Bay *et al* in *Optics Express*, Vol. 21, Issue S1, pp. A179-A189 (2013). http://dx.doi.org/10.1364/OE.21.00A179

Optical market still facing tough times

Firms in the LED and equipment market are still facing rapidly declining prices and waning demand and are finding it difficult to increase revenue and income. However, it's not all bad news - product development remains a bright spot

Rapidly declining pricing, softening demand and the continuing uncertainty of the global economy are creating challenges for manufacturers at all stages of the optical industry supply chain.

Most of the companies that manufacture equipment, material and devices for LEDs, optoelectronic devices and photovoltaic devices are seeing declining revenue and income, or outright losses.

This is according to the Strategy Analytics report, "Compound Semiconductor Industry Review July – September 2012: Optoelectronics, Materials and Equipment" It captures financial announcements from companies such as Soitec, Aixtron, AXT, Hitachi Cable, JDSU, Finisar, Oclaro, Emcore, GigOptix, IQE, Kopin, Cree, OpNext, First Solar and Spire.

Despite declining financials at many of these companies, the report concludes that product development activities remain strong with the announcement of several new LED and higher data rate optical components.

"With a few notable exceptions like Dowa, First Solar and Cree, most of the other companies in this report struggled to increase revenue and income," observes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "Companies in the LED and equipment market are trying to address rapidly declining prices in conjunction with declining demand and they are finding it difficult to increase revenue and income in this environment."

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Companies in the optical component segment of the supply chain are developing products for higher data rate networks, but most of the equipment orders at the front-end of the optical supply chain are going to research institutions rather than production expansions.

Shenzhen General Technology employs Osram LED technology

The Oslon LEDs will be used to reduce energy, maintenance and accidents

Osram's versatile Oslon SSL series are applied in Xishan Duerping coal mine lighting in Shanxi Province, the so-called "home of coal" in China.

The 19,500 LEDs are installed in 975 lamps, replacing the traditional fluorescent lamps, to light up the 63.1 square km high wattage coal mine.

They enable energy savings of 61 percent (from 427050 kilo Watt hour down to 170820 kilo Watt hour annually). They also reduce maintenance requirements and accident rate significantly, resulting in an annual saving of more than RMB220,000 (around €28,000).

The underground coal mine is one of the most difficult lighting applications. It is a low reflectivity, low contrast, high temperature, and high corrosive environment. With the use of LEDs in place of traditional incandescent lamps, coal mine lighting application has become less challenging.

The 20W LED lamps come in two designs; the round shape ones are for general lighting in the underground coal mine while the square ones are for long distance lighting inside the tunnels. Because of the low reflectivity in coal mines, the output of light sources needs to be much higher. With luminous flux of 104 lm warm white to 130 lm cool white, Osram says its Oslon SSL is the ideal choice for this application.

"We have chosen Osram's Oslon SSL LEDs for their high reliability and efficiency," says Zhong-hua Li, Chairman of the Board of Shenzhen General Technology Co. Ltd., the company which builds these coal mine lamps. "More importantly, the light output of these LEDs is high enough for good designs. The average luminance is 82Lx, compared to 45Lx of the previous incandescent lamps. With the use of advance optics, we are able to reduce glare to a minimum in this low contrast environment."

Apart from high efficiency, these Oslon SSL LEDs excel in all the stringent tests for applications in the coal mine environment. They include the coal mine safety certification, explosion-proof certification, salt spray, waterproof testing, impact test and the 1000-hour burning test.

"The use of LEDs in coal mine lighting is definitely taking off," adds Kai-chong Cheng, Senior Marketing Director APAC of Osram Opto Semiconductors Asia Ltd.. "We are very pleased that our Oslon SSL LEDs are being chosen to be used in the coal province of China. These are the most compact 1 W LEDs on the market. As LEDs do not use any glass envelope and cannot break, we hope the use of these LED lamps will reduce hazards for the people who work underground."

LEDs are robust because they do not have a glass envelope or filament that can break. Besides, they can provide useful light in excess of 50,000 hours of operation as compared to about up to 3,000 hours for an incandescent bulb. The maintenance interval will be reduced from once in every three months to once a year.

According to a study by the National Institute for Occupational Safety and Health (NIOSH) in the USA, the greatest percentage of accidents (53 percent) happened during the maintenance and repair work of light bulbs or light fixtures. The longer life and packaging (no glass envelope) of LEDs would decrease the exposure to these hazards.

QuantumClean acquires Advent Cleaning Technology

The provider of high-purity outsourced process tool parts, cleaning and surface treatment to the solar and LED industries has added quartz fabrication to its portfolio

QuantumClean, has acquired Advent Cleaning Technology, Inc. (Advent) semiconductor parts cleaning business located in Carrollton, Texas.

The acquisition of Advent enhances QuantumClean's regional cleaning capabilities and adds quartz fabrication and repair to QuantumClean's already extensive portfolio of semiconductor parts refurbishment services.

"We are pleased to acquire Advent Cleaning Technology, long-recognised in the industry for their strong customer orientation and quality focus. Advent is a perfect fit with QuantumClean's strategy to continually increase its value to its semiconductor wafer fabrication, OEM and OPM customers through the offering of greater capabilities and convenience," comments Scott Nicholas , CEO & President of Quantum Global Technologies, LLC.

"With the Advent acquisition, QuantumClean now operates fifteen Advanced Technology Cleaning Centers and three world class ChemTrace microcontamination analytical laboratories in seven countries employing nearly 1,000 employees dedicated to providing the industry's most technologically advanced high-purity semiconductor parts cleaning and analytical services," Nicholas continues.

ChemTrace is a reference analytical testing laboratory primarily serving the semiconductor, solar and related industries by providing answers and solutions to its customers' micro-contamination related issues. Founded in 1993, ChemTrace also provides independent analytical verification of process tool part cleaning effectiveness for many of QuantumClean's semiconductor fab, OEM and OPM customers which have critical cleaning requirements.

VTT and Lumichip invest in LED firm LightTherm

The firms will unite to simplify and develop more cost-effective methods in LED lamp manufacture

VTT Ventures and Lumichip are jointly investing in Finnish LED technology company LightTherm.

LightTherm uses its innovative materials and heat management solutions to introduce novel design and manufacturing capabilities for LEDs.

LightTherm's electro-thermo-mechanical technologies provide higher light output, leaner sizing and lighter weight in its products for the LED replacement lamp and luminaire industry.

The estimated global market for LED lamps is over US$20 billion, with more than 1 billion units due for manufacture in 2013. LED technology still faces some challenges, particularly where high light output is required from small compact light units.

The major difficulty with LEDs is the heat sensitivity of used components and materials. Overheating can shorten the lifespan and efficiency of the LED, while light output falls below product optimal specification as temperatures rise.

VTT Technical Research Centre of Finland produces high-level technology solutions and innovation services for its customers. VTT Ventures Ltd supports companies exploiting new technology, from business plan through to funding.

LightTherm Ltd is VTT's new spin-off company, whose innovative LED interconnection solution can yield better thermal characteristics and cooler semiconductor junction temperatures. This capacity for better thermal efficiency management will have a major impact on the lifetime of LEDs. Combined with new materials for lamp body production, substantial cost savings can be achieved through reduced materials, manufacturing simplicity and total production automation.

"The high thermal management efficiency of this technology enables significantly higher light output – for example from replacement spots – than is currently available anywhere in the LED market," says Juha Rantala, Chairman of Lumichip Ltd.

"LightTherm materials, device construction and manufacturing processes give flexibility in design, and will enable the manufacture of entirely new lighting applications for both consumer and industrial luminaires. We believe this will change completely the way in which LED products are manufactured in the future," adds Rantala.

LightTherm's technologies are based on years of development, characterisation and lifetime tests carried out at VTT Technology Research Centre of Finland, which provides high-end technology solutions and innovation services. "We are pleased to co-operate with a partner such as Lumichip to take this very innovative and promising technology to the industrialisation and commercialisation phase," says Antti Sinisalo, CEO of VTT Ventures Ltd.

LightTherm's founding team consists of Petri

Nyman, Ville Moilanen and Kimmo Jokelainen. CEO and co-founder Petri Nyman has extensive experience in start-ups, as well as in the management of growth companies. Co-founders Ville Moilanen and Kimmo Jokelainen have a research background with VTT and have been instrumental in developing the core innovations behind this new technology.

VTT Technical Research Centre of Finland is the largest multi-technological applied research organisation in Northern Europe. VTT provides high-end technology solutions and innovation services. The mission of VTT Ventures Ltd is to extract value from VTT technology by developing the international growth potential of VTT-based high-tech companies.

VTT Ventures, together with its public and private innovation partners, provides entrepreneurs with professional business development support to facilitate the spin-off process, from business planning through to funding. VTT Ventures co-invests in its spin-offs with private investors. The goal of VTT Ventures is to stimulate innovation in Finland and to receive a return on its pre-seed and seed capital investments.

Lumichip is a provider of customised LED lighting components. Lumichip designs, manufactures and markets proprietary LED components and specialised COB devices, and offers custom designs and manufacturing services for high power LED light engines, special luminaires and multi-wavelength modules for lighting and industrial applications. The development and manufacturing operations in Asia and Europe provide customisation and service support for its worldwide client base.

LightTherm is an ODM designer and manufacturer of thermally highly efficient LED structures, components and designs. LightTherm's patent pending technologies enable the use of new materials in LED luminaires and LED engine components, resulting in greater design and manufacturing freedom and high quality light and lumen output from all its designs. LightTherm operates with customers and partners globally.

Rubicon secures $25 million revolving credit facility

The financing to the sapphire substrate manufacturer strengthens its liquidity position

Rubicon Technology, Inc. has announced the closing of a three year $25 million secured revolving credit facility with Silicon Valley Bank.

"This undrawn credit facility bolsters Rubicon's strong liquidity position," says William Weissman, Chief Financial Officer of Rubicon Technology. "We believe it is prudent to establish this additional financial flexibility for the future."

Rubicon currently has no debt.

The terms and conditions of the credit facility will be described in the company's filings with the Securities and Exchange Commission.

GE Lighting takes on new CEO in EMEA region

Agostino Renna has been named president and CEO of GE Lighting Europe, Middle East & Africa

The appointment of Renna is effective immediately.

Agostino Renna, President and CEO of GE Lighting, EMEA region

Renna, who will report to GE Lighting president & CEO Maryrose Sylvester, succeeds Phil Marshall who has led GE Lighting Europe, Middle East & Africa, since 2008. Marshall has left GE Lighting to pursue a position outside of the company.

"Agostino Renna's experience, leadership and significant sales and marketing background make him an outstanding person to continue the transformation of the Lighting business in the region," says GE Lighting president & CEO Maryrose Sylvester. "Agostino has demonstrated outstanding management qualities and has the ability to sharpen our strategic focus to lead GE Lighting Europe, Middle East & Africa to achieve strong, sustained growth in 2013 and beyond.

Renna most recently was Vice President, Growth & Market Strategy for GE-Canada with responsibility for the long term growth and market positioning of all GE's businesses in Canada.

Prior to joining GE, Renna spent 14 years at Johnson Controls Inc., where he worked in Canada, the US and Europe. He held leadership roles in sales, marketing, strategy and general management culminating with a position leading Johnson Controls' Energy Solutions division for Europe, the Middle East and Africa based in Brussels, Belgium.

Renna was born in Montreal, Quebec and holds a degree in Mechanical Engineering from McGill University. He speaks 4 languages fluently.

He is a regular speaker at conferences and roundtables that focus on addressing global energy challenges. While in Belgium, Renna was an Executive in Residence at the Vlerick Leuven Gent Management School, where, in his lectures, he brought a strong practioner's perspective to the topics of sales, marketing, strategy and leadership.

Seoul Semiconductor LED patents in IEEE`s Top 10

The Korean firm was the only LED manufacturer who registered more than 10,000 patents, and was considered to be at the highest level in the industry in Patent Power

Seoul Semiconductor was ranked the number 10 by IEEE Spectrum from 20 of the most valuable patent portfolios in the semiconductor manufacturing field.

Seoul Semi says it was the only LED manufacturer which has registered more than 10,000 patents, and was considered to be at the highest level in the industry in the "Patent Power" category. Factors taken into account included the pipeline growth index, pipeline impact and adjusted pipeline impact.

RANK	COMPANY/ORGANISATION, COUNTRY (PARENT ORGANISATION)	2010 U.S. PATENTS	PIPELINE GROWTH INDEX	PIPELINE IMPACT	SELF-CITATIONS	ADJUSTED PIPELINE IMPACT	PIPELINE GENERALITY	PIPELINE ORIGINALITY	PIPELINE POWER
1	Samsung Electronics Co., South Korea	4977	1.1	0.9	16%	0.9	0.9	1.0	3976.5
2	SanDisk Corp., U.S.	352	1.2	2.8	29%	2.9	2.7	1.0	2968.9
3	Semiconductor Energy Laboratory Co., Japan	764	1.0	1.8	75%	1.0	2.4	1.1	2072.0
4	Broadcom Corp., U.S.	1246	1.2	1.1	35%	1.0	1.3	1.0	1949.5
5	Micron Technology Inc., U.S.	950	1.0	1.2	46%	1.0	1.3	1.0	1900.7
6	STATS ChipPac Ltd., Singapore	232	1.4	2.3	50%	1.9	2.5	0.9	1595.0
7	Intermolecular Inc., U.S.	37	3.0	3.0	60%	2.3	5.0	1.1	1342.5
8	Magic Corp., Taiwan	65	3.0	5.0	80%	2.5	2.5	1.1	1322.3
9	Marvell Technology Group Ltd., Bermuda	685	1.3	1.3	43%	1.9	1.2	1.0	1203.1
10	Seoul Semiconductor Co., South Korea	67	1.9	3.0	34%	2.9	2.5	1.0	890.7
11	Tela Innovations Inc., U.S.	31	3.0	4.9	59%	3.5	2.2	1.1	833.4
12	Intel Corp., U.S.	1313	0.8	0.8	15%	0.8	1.0	1.0	830.1
13	Rambus Inc., U.S.	137	1.3	1.4	27%	1.4	2.3	1.1	667.3
14	Unity Semiconductor Corp., U.S. *	45	2.0	2.2	37%	2.0	3.6	1.0	625.1
15	Renesas Electronics Corp., Japan	1040	1.1	0.8	15%	0.8	0.8	0.9	585.2
16	Marvell Inc., U.S.	23	0.9	4.1	26%	4.1	5.0	1.4	559.4
17	RF Micro Devices Inc., U.S.	62	1.9	1.8	23%	1.8	2.5	1.1	566.0
18	NetLogic Microsystems Inc., U.S. *	71	1.2	2.3	63%	1.5	3.6	1.2	545.2
19	Nvidia Corp., U.S.	277	1.1	1.4	21%	1.4	1.2	0.9	519.6
20	Global Oled Technology LLC, U.S. (LG Electronics)	72	1.5	1.9	59%	1.4	3.2	1.1	499.5

Seoul Semiconductor has developed LED technology for over 20 years, and has built up competitive strength with a variety of proprietary information.

The advancements made by the firm enhance the emission of light when electricity flows through an LED chip. These include "Black Hole Lens" technology for direct backlight TVs and "Acrich" technology, which operates directly from AC power without any converter, which the company claims was the first in the world.

Black Hole lens technology, in particular, is now being applied to all types of direct backlight TV monitors, along with this year's release of nPola, which increases brightness levels by 5 to 10 times.

The IEEE's analysis is based on objective, quantitative benchmarking of the patent portfolios of more than 5000 commercial enterprises, academic institutions, non profit organisations and government agencies.

According to the LED market reports issued by Strategies Unlimited in the U.S., Seoul Semiconductor is the world's fifth largest LED supplier.

Could silicon substrates eclipse sapphire?

Maybe in the LED market. But opportunities for power amplifiers and tuneable capacitors and competing technologies may bring new volume applications to sapphire wafer manufacturers

Significant overcapacity and low LED substrate prices will affect the profitability and viability of many sapphire players in 2013 and beyond, but emerging applications could transform the industry.

According to the latest report by ReportsnReports.com, “Sapphire Substrates 2013”, the sapphire material shortage experienced from 2010 to early 2011 created a window of opportunity for new entrants.

In the last two years, more than 80 companies announced their intention to enter the industry, bringing the potential number of players to over 130 with more than 50 of these potential new entrants located in China.

Coupled with slow demand from LED makers in 2012, this has created a very challenging environment with cores and wafers often selling at prices at or below manufacturing cost.

Revenues increased 15 percent in 2011 but are expected to drop 9 percent in 2012 due to lower Average Selling Prices. This will be despite volume increase and a favourableproduct mix with the percentage of PSS wafers increasing dramatically.

These difficult market conditions will trigger an industry rationalisation through consolidation and attrition that should take place in 2013 and 2014; activities that the Yole Finance business unit is monitoring closely.

In the long-term, as the environment remains extremely competitive, it is expected that the industry will evolve towards a more vertically integrated model in order to limit margin stacking. A handful of tier-1 worldwide leaders should emerge from this rationalisation, along with smaller tier-2 regional players.

LED-on-Silicon is a major threat for sapphire makers

All major LED makers are currently exploring opportunities for transitioning from a sapphire-based technology platform to a silicon-based one (“LED-on-silicon”). This interest is driven by a potential cost savings of up to 60 percent at the die level.

But while significant progress has been made, the technology still faces hurdles.

It remains to be seen whether the leading proponents of LED-on-silicon, like Bridgelux/Toshiba and Lattice Power, will be able to tackle all of the remaining challenges and transition to mass manufacturing in a cost-effective manner. Another new player in the market is Plessey Semiconductor who have not yet begun mass production, but this should hopefully come in the next year.

For most other LED companies, LED-on-silicon is often an important development axis, but not a necessary milestone on their manufacturing roadmap. The jury is still out, but in the meantime, investments in the large-diameter sapphire platform are often postponed pending the outcome of LED-on-silicon.

GaN could capture some niche markets thanks to higher performance and competitive system-level cost of ownership.

What’s more, the Silicon on Sapphire (SoS) application could represent a nice upside for the happy few that enter the supply chain. Demand more than doubled in 2012 and could well do the same in 2013.

Major SoS company Peregrine has developed an Antenna Switch technology that has already achieved vast success in smart phones. The company benefits from strong macro trends in the cell phone market and is developing new components that could further increase not only SoS content per phone, but also wafer demand.

Opportunities for these new components (Power Amplifiers and tuneable capacitors), as well as for competing technologies developed by companies like Paratek (now part of cell phone maker RIM), may bring new volume applications to sapphire wafer manufacturers.

LG Innotek and Future Lighting Solutions unite

The two companies have signed a strategic worldwide distribution agreement that will introduce LG Innotek's entire portfolio of LED lighting solutions to the market

LG Innotek's portfolio features one of the industry's broadest selection of LED products to fit virtually any lighting application, from LED packages to integrated solutions.

Future Lighting Solutions' LED expertise, from design support services to supply chain and business solutions, creates a synergistic partnership that will allow both companies to further their positions within the rapidly growing LED lighting market.

Future Lighting Solutions' believes its expertise, combined with LG Innotek's capabilities, the 4th ranking global LED producer, will deliver unprecedented value to the lighting OEMs.

"We are excited about LG Innotek's exceptionally strong portfolio of LED products, aggressive technology road map, and unparalleled quality manufacturing capabilities for the general illumination market," says Gerry Duggan, Executive Vice-President of Future Electronics. "This will further strengthen our proficiency in serving our customers' growing demand for best-in-class LED lighting solutions."

"This agreement will significantly increase the availability of our products around the world as well as help us continually broaden our product line to offer the right solution for different lighting scenarios," adds Harry Kang, Vice-President of the LED Business Division at LG Innotek. "By joining forces with Future Lighting Solutions, we will be better able to equip lighting OEMs with the products and tools they need to put more LED-based lighting products on store shelves."

Ultratech acquires assets of Cambridge Nanotech

The firm is expanding its nanotechnology and IP portfolio with atomic layer deposition to enhance capability in new market opportunities such as semiconductors

Ultratech, Inc., a supplier of laser-processing systems used to manufacture semiconductor devices has acquired the assets of Cambridge Nanotech, Inc. (Cambridge).

Based in Cambridge, *Massachusetts,* Cambridge was an innovator in atomic layer deposition (ALD) solutions with hundreds of system installations in research and manufacturing settings worldwide.

Financial terms of the transaction were not disclosed.

With this acquisition, Ultratech expands its nanotechnology and intellectual property (IP) portfolio with ALD technology to provide solutions for new layers within the electronics industry and entry into new markets, such as biomedical and energy.

Due to the increasing interest in nanoscience, ALD has emerged as a critical technology for depositing precise nanometre-thin films. Typical applications of ALD require the manufacture of very precise nanometre - thin, pinhole - free and conformal thin films on many shapes and geometries.

As a result, this technology will be in high demand in volume manufacturing environments and in particular for micro-electro-mechanical systems (MEMs), implantable devices in the biomedical sector and batteries and fuel cells in the energy arena.

ALD is an enabling technology and provides coatings and material features with significant advantages to other existing techniques.

Ultratech Chairman and Chief Executive Officer Arthur W. Zafiropoulo says, «As a global leader in experimental ALD solutions, Cambridge has developed a portfolio of valuable technology and systems. We plan to integrate the intellectual property acquired from Cambridge Nanotech into

Ultratech and include the ALD systems in our nanotechnology product group. By increasing our IP and expanding our nanotechnology portfolio to new levels, we expect to generate a new revenue stream in existing and new markets. We have focused on technology solutions and support our global customer operations. We expect that this acquisition will enhance our short-term as well as our long-term growth expectations.»

Ultratech, Inc. designs, manufactures and markets photolithography and laser processing equipment. Founded in 1979, the company›s lithography products deliver high throughput and production yields at a low, overall cost of ownership for bump packaging of integrated circuits and HB-LEDs.

A pioneer of laser processing, Ultratech developed laser spike anneal technology, which increases device yield, improves transistor performance and enables the progression of Moore›s Law for 32 nm and below production of state-of-the-art consumer electronics.

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Cambridge Centre for GaN orders tool to purify hydrogen in MOCVD reactor

The centre will use the tool to remove oxygen, moisture and carbon contamination to ensure a stable process regardless of source gas quality or flow rate in gallium nitride products

Power & Energy Inc. (P+E) , has received an order for a PE9000C Series purifier from The Cambridge Centre for Gallium Nitride at the University of Cambridge.

The micro-channel palladium purifier will be used to purify hydrogen for use in a new Aixtron MOCVD reactor. The research team is focused on the cutting edge of GaN research via collaboration with universities and industries throughout the world.

The compact 9000C Series removes oxygen, moisture and carbon contamination to parts-per-trillion levels to assure a stable process regardless of source gas quality or flow rate.

PE9000C Series Hydrogen Purifier

According to Colin Humphreys, the Director of The Cambridge Centre for Gallium Nitride, "We require the highest purity gases for our advanced GaN research, which is why we have chosen the palladium membrane technology in the 9000C Series purifier."

This compact mass spectrometer uses a patent-pending method to concentrate impurities for analysis.

HEMS Hydrogen Analyser

HEMS has a 10 minute analysis cycle time and is self-calibrating.

Three models are available for applications such as semiconductor process control and bulk gas production.

Rubicon granted patent for ultra-flat high-throughput wafer lapping

The provider of sapphire substrates has secured a patent to ensure the platens facing the wafers are continuously self-conditioned and self-optimised

Rubicon Technology has had its patent application entitled, "Ultra-Flat, High-Throughput Wafer Lapping Process" accepted by the United States Patent and Trademark Office (USPTO).

The patent covers Rubicon's process developed to perform grinding and polishing to achieve consistent, ultra-flat and defect-free surface quality for the high-volume production of large diameter sapphire wafers.

Rubicon's customers in the LED and SoS/RFIC markets have very demanding requirements for the quality of sapphire wafers used in their applications. The patent addresses the quality and flatness challenges inherent in the production of sapphire wafers at larger diameters.

The patented ultra-flat, high-throughput lapping process enables Rubicon to achieve high levels of flatness and quality while maintaining the highest levels of throughput in the production of large diameter sapphire wafers.

As wafers are lapped and polished, the platens facing the wafers become worn and deformed, leading to the deterioration of wafer quality. In the patented process, the platens are continuously self-conditioned and self-optimised to maintain high performance.

"Rubicon continues to build its patent portfolio and increase its technological leadership throughout the sapphire wafer manufacturing process," says Raja M. Parvez, President and CEO of Rubicon Technology. "This patent underscores our dedication to improving the large-diameter sapphire manufacturing process and improving the leading technology platform for the high-throughput production of high-quality large diameter sapphire wafers for our customers."

Agilent unveils platform for GaN device analysis

The firm's latest software includes the industry's standard gallium nitride device-modelling program. It delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes

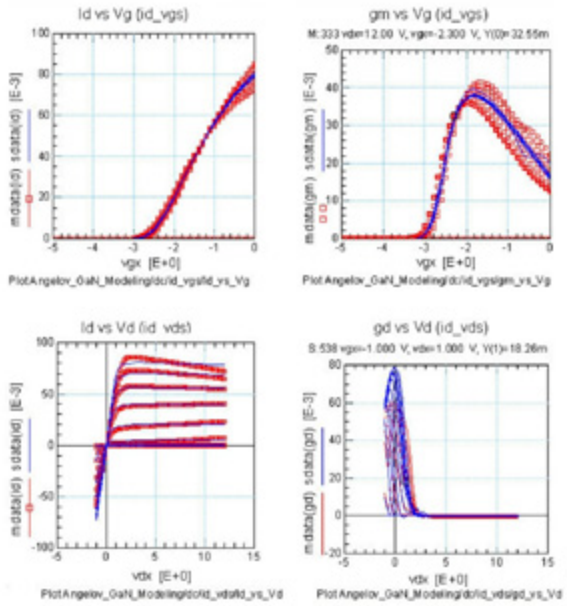
Agilent Technologies has launched a new release of its device modelling software platform, the Integrated Circuit Characterisation and Analysis Program (IC-CAP).

With IC-CAP 2013.01, Agilent introduces major improvements to its flagship product for high-frequency device modelling. One key improvement is turnkey extraction of the Angelov-GaN model, the industry standard compact device model for GaN semiconductor devices.

GaN technology is becoming commonplace in today's high-power RF communication circuits and automotive electronic components. Modelling these devices is challenging due to the impact of trapping and thermal effects on the device electrical characteristics.

Existing GaAs models have been used as a first attempt to model GaN devices, but they are not accurate enough. The Angelov-GaN model, developed by Professor Iltcho Angelov at Chalmers University of Technology, is quickly establishing itself as the industry solution to this dilemma.

Agilent's W8533 Angelov-GaN extraction package, which is part of the IC-CAP platform, was developed in conjunction with industry partners and validated on real GaN processes. It provides a dedicated software environment that allows users to perform the necessary measurements and extraction of the Angelov-GaN model.



Example of graphs from IC-CAP Angelov-GaN Extraction Package

Typical DC and network analysers are supported for making DC and S-parameter measurements and de-embedding. A convenient interface lets users execute a step-by-step extraction flow to obtain the model parameters. A turnkey flow provides quick start modeling of GaN devices. The package also enables complete customisation to optimise the flow to different technology flavours of GaN processes. Simulations are performed using Agilent's Advanced Design System.

IC-CAP 2013.01 also features a new Python programming environment that is up to 100 times faster for typical tasks such as parameter extraction, data analysis, instrument control and interface responsiveness. It enables better code organisation and provides an extensive set of libraries for calculations, instrument control and statistical analysis. With IC-CAP Python, users gain major efficiency when developing their programs. Python programs are interoperable with existing programs, ensuring compatibility with ongoing IC-CAP projects.

"As the leading provider of RF device characterisation and modelling, Agilent continues to make bold improvements to our IC-CAP product," says Roberto Tinti, device modelling product manager with Agilent EEsof EDA. "This release represents a major milestone, as Python greatly improves an engineer's ability to learn and get the

most out of IC-CAP. We continue to lead the way in high-frequency modelling with our Angelov-GaN extraction package."

Other new features in IC-CAP 2013 .01 include support of Smartspice simulations and support for gain compression and two-tone intermodulation distortion measurements with Agilent's PNA-X network analyser.

The firm says this is a critical capability since nonlinear device characterisation is essential in verifying model accuracy in real applications. Another part of the platform, IC-CAP WaferPro (a powerful automated on-wafer measurement solution), now features usability and user interface enhancements to facilitate test-plan development.

Agilent IC-CAP software is a device-modelling program that delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes. Providing efficient and accurate extraction of active device and circuit model parameters, IC-CAP performs numerous modelling tasks, including instrument control, data acquisition, graphical analysis, simulation and optimisation. It is used by semiconductor foundries and design houses to characterise foundry processes.

IC-CAP 2013.01 can be downloaded from the link: www.agilent.com/find/eesof-iccap-downloads-and-trials

Plessey`s GaN-on-Si MAGIC LEDs win Elektra award

The firm's gallium nitride on silicon LEDs have been honoured in the SSL category

Plessey's new innovative MAGIC (MAnufactured on GaN ICs) High Brightness LED (HBLED) products have won the Solid-State Lighting Application Category of the Elektra Awards 2012.

The winners were revealed last week at the European Electronics Industry Awards ceremony in London. The awards were hosted by TV impressionist and comedian Rory Bremner,

Barry Dennington, Plessey's COO, said, "LEDs are the next key phase of the drive to reduce carbon usage but widespread adoption has been held back by the high product costs and the low level of the light output. Our MAGIC technology solves both these problems opening the way for LED lighting to become widespread and help cut energy bills. We have invested millions of pounds in our MAGIC manufacturing lines in Plymouth that are ramping up to volume production this year."

MAGIC HBLEDs are manufactured using industry standard, silicon foundries at a much lower cost than current LED technologies based on sapphire or SiC. Plessey's technology uses GaN on 6-inch silicon substrates. It requires a much thinner GaN layer at only 2.5µm compared to 6 to 8µm in other GaN on silicon technologies. This means less deposition time so that Plessey can do multiple production cycles in 24 hours to achieve higher throughputs and lower costs.

For the next generation products, Plessey intends to integrate its MAGIC HBLED products with its range of sensor and power technologies to provide smart lighting solutions for even greater energy savings and carbon footprint reductions.

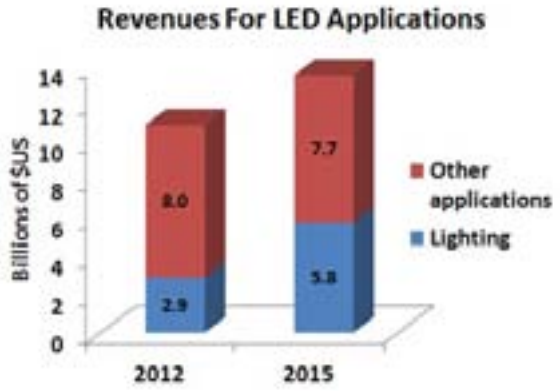
IHS: LED lighting revenues to double by 2015

The market will peak at $13.5 billion in 2015 but will remain relatively flat after that. This is mainly due to fewer LED replacements being required each year due to longer lifetimes

IMS Research, now part of IHS, is forecasting world packaged LED revenue to decline in the second half of the decade according to its latest "Packaged

LED – World – 2012 Report".

With many LED end markets already saturated, the lighting sector is the main driver of growth this decade.



The 2012 market size is projected to be about $10.9 billion, with $2.9 billion in lighting and $8.0 billion in all other applications. By 2015 the market is forecast to reach $13.5 billion in 2015, with $5.8 billion in lighting (doubling in three years) and $7.7 billion in other areas (almost unchanged, and actually slightly less).

But there has been a much more important development within the lighting market itself. IMS expects shipments of LED lamps to remain relatively flat from 2015 onwards. IMS Research Analyst Stewart Shinkwin explains, "This is mainly due to fewer replacements being required each year due to the longer-lifetime of CFL and LED lamps reducing the overall market."

With price erosion set to remain in double digit figures, the LED lighting sector, as component packaged LED revenue, is forecast to contract towards the end of the decade. With no other markets expected to grow significantly, IMS expects the total packaged LED market to fall towards the end of the decade, in terms of revenue, once the general lighting market has peaked.

There are, however, a number of factors that could change the outlook, notably if adoption is slower than predicted over the next three or four years. In this alternative scenario, growth would be slower initially but could be maintained for a longer period throughout the decade.

The TV sector is the second largest market for packaged LEDs. This market is forecast to grow slightly from 2012 ($2.0 billion) to 2016 ($2.4 billion), as LED adoption rates increase throughout the time period just enough to overcome price erosion and the reduction of LEDs required for a given area.

LCD panel shipments are also forecast to increase slightly, while there is also the trend towards larger screens, one which has been ongoing for a number of years. However the number of LEDs required for a given sized screen has also been decreasing more rapidly than had been previously expected.

For example, in the first quarter of 2012, the low cost TVs which were introduced used half the number of LEDs for a given area, and although overall LED TV penetration increased as a result, average LEDs per LCD TV actually fell from 175 in the fourth quarter of 2011 to 137 in the first quarter of 2012.

This trend cannot continue at the same rate forever and innovations may cause more LEDs to be used in some cases. However the overall trend is for a slow decline.

Ex Amazon.com & NBC CFO jumps on Board at Intematix

The innovator of patented phosphors and phosphor components used in LED lighting has taken on Warren C Jenson. He has been involved in scaling some of the most important success stories of the last two decades.

Intematix, an innovator of patented phosphors, has appointed Warren C. Jenson to its Board of Directors, effective December 11th, 2012.

Jenson is currently CFO and Executive Vice President of Acxiom, a marketing services and technology company.

Warren C. Jenson

Having been named twice as one of the "Best CFOs in America" by Institutional Investor magazine, Jenson has a successful track record guiding corporations at important inflection points in their evolution.

Before joining Acxiom, Jenson was COO at Silver Spring Networks, a provider of smart grid networking technology. He has also served as CFO at Electronic Arts, Amazon.com and NBC. Jenson received both an undergraduate degree in accounting and a Master of Accountancy from Brigham Young University.

"Intematix is helping to define the future of an industry with the advantages phosphors and remote phosphors bring to LED lighting," Warren C. Jenson said. "There is a massive need for energy efficiency and energy saving, and Intematix provides critical capabilities and products for making that happen."

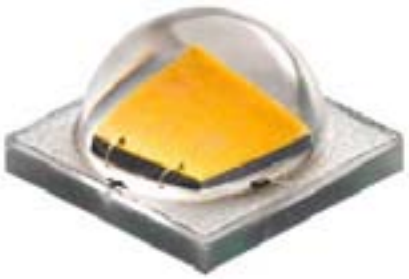
Intematix Chief Executive Officer Mark Swoboda added, "Warren is a distinguished and welcome addition to our board. He has been involved in scaling some of the most important success stories of the last two decades. That experience gives him valuable perspective for where Intematix is today and where it will go tomorrow."

Cree claims its single-die LEDs are industry's brightest

The XLamp XM-L2 LEDs, based on the firm's SiC (silicon carbide) technology, deliver 186 lumens-per-Watt

Cree says it has once again set an LED industry performance milestone with the commercial availability of its XLamp XM-L2 LEDs.

The new XM-L2 LED delivers up to 186 lumens-per-watt at 350 mA, 25°C, a level of performance available only in a lab setting just three years prior.



XM-L2 LED

Built on Cree's proprietary revolutionary SC³ Technology next-generation LED platform, the new XM-L2 LEDs double the lumens-per-dollar and deliver 20 percent more lumens-per-watt over the original XM-L LED. This enables lighting manufacturers to use fewer LEDs to deliver a better lighting system for lower cost.

The new XM-L2 LEDs are designed for very-high-lumen applications such as indoor, high-bay and outdoor lighting. The high-performance XM-L2 LEDs are compatible with existing XM-L LED designs and leverage the 5 mm x 5 mm XM footprint . This allows customers to easily incorporate the XM-L2 LEDs into existing XM LED designs to shorten the fixture design cycle and improve time-to-market.

"We're excited that Cree has improved the performance of the XM package with the XLamp XM-L2 LED," says Jeff Rogers, vice president of sales and marketing, Musco Sports Lighting. "XM-L2 allows us to boost the performance of our existing XM-L designs without changing optics or drivers."

The XM-L2 LED offers the unique combination of very high efficacy and high drive currents, delivering an unprecedented 1198 lumens at 116 lumens-per-watt efficacy at 3 A, 25°C. The XM-L2 is the eighth product built on Cree's SC³ Technology platform.

The platform leverages Cree's advanced silicon-carbide technology and features advancements in LED chip architecture and phosphor. It boasts a new package design to deliver the most-advanced LED components in the industry.

"The XM-L2 LED efficiently delivers hundreds of lumens per LED, allowing us to significantly reduce the number of LEDs in our designs," comments Steve Walczak, director of engineering, Sternberg Lighting. "By using fewer LEDs, we can simplify design and production, ultimately reducing cost without sacrificing light output or quality for our end customers."

Characterised at 85°C, the XM-L2 LED is available in 2700K to 6200K colour temperatures and offers minimum CRI options of 80, 85 and 90. What's more, since the XM-L2 LED is a successor product to XM-L LEDs, the application of ENERGY STAR qualification requires only 3000 hours of XM-L2 LED LM-80 data, instead of the normal 6000 hours. The XM-L2 LED is also UL-recognised and features a level-4 rating.

Cree XLamp XM-L2 LED samples are available now, and production quantities are available with standard lead times.

PhotonStar LED to provide IP to major LED chip manufacturer

The patents of the British designer and manufacturer of smart LED lighting solutions are now mostly granted in Europe and are moving to the Chinese market

PhotonStar LED Group plc. has signed its first licensing agreement for its next generation chip design patents and an associated design services supply agreement, with a leading LED chip manufacturer.

The financial terms of the non-exclusive patent license agreement have not been disclosed, but are expected to start to have an impact on PhotonStar's revenues in 2014. This is when the resulting LED chips are anticipated to brought to market by the manufacturer.

PhotonStar has a substantial IP platform, comprising a total of 15 patent families covering advanced LED chip design, optimal low cost packaging, advanced colour mixing and control. The LED chip patents dating back to 2008/9 are now mostly granted in Europe and progressing through the international phase. The firm recently received its first Chinese patents and continues to further develop its chip IP.

James Mckenzie, CEO of PhotonStar LED Group PLC, comments, "Licensing our LED chip design IP to third parties will be a key part of our business going forward, and will be a clear demonstration of the substantial value in our IP."

"This agreement is a major validation of our LED chip design approach and is expected to produce LED chips with extremely high levels of chip light extraction, making them some of the lowest cost and most efficient chips available on the market," adds McKenzie.

Luminus Devices UV slim LED packages now shipping

There are two variations available, and have been designed to enable tight linear high power UV LED arrays

Luminus Devices, the innovator of Big Chip LEDs, has announced that its new UV Slim LED packages, which began sampling in May, have begun shipping as production units.

Designed specifically for high-density linear arrays, the firm says its UV Slim LED devices provide the maximum UV energy of any single-die UV LED available.

In addition to their superior performance, higher reliability, and greater energy efficiency over traditional UV mercury lamp technology, these devices also improve workplace safety and lower environmental impact by eliminating harmful byproducts such as ozone and mercury.

"The UV Slim LED represents our dedication in providing customers with the best UV LED technology available," says Mike Lim, Director of Global Industrial and New Business at Luminus. "Customers can tightly align the UV Slim LEDs together in order to generate the highest power-density UV LED line source available, which is especially useful for line-curing applications."

Designed with graphic arts printing in mind, the UV Slim devices also provide all of the traditional advantages of Luminus' Big Chip LED technology, including improved thermal power density and simpler support system architecture, along with delivering greater wall-plug efficiency than traditionally-sized LED dies.

These new UV Slim LEDs, with a product designation of CBT-120-UV-C14, are Big Chip LEDs that feature a single monolithic 12mm2 die that emits directly into air. They are available in a NIST-traceable power range output of 11W to 13.3W.

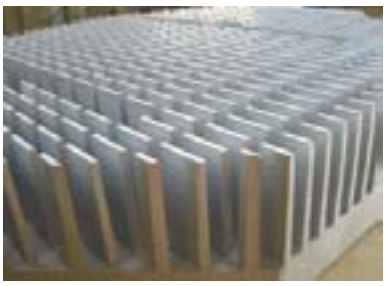
Luminus' UV Slim LEDs are available across the globe through Avnet, Digi-Key, EBV Elektronik, Marubun, and Mouser distribution partners.

LED Waves extends LED lamp lifetime with new heat sink

The company's in-house engineers reveal the process behind longer-lasting LED replacement lamps

LED Waves, a supplier and manufacturer of LED lights in the USA has unveiled a line of replacement lamps.

Launched only last year, it is easily distinguished by the highly intricate heat sinks that surround and protect each light source.



A close up of the extruded LED high bay heat sink body

This month the company announced an update to their LED high bay light, originally introduced in May 2012. Designed for clients in the commercial, industrial, and transportation sectors, the Andromeda replaces the high pressure sodium and metal halide lamps typically used in facilities with high ceilings.

In following LED Waves' philosophy of thermal distribution, the firm's LED high bay features a unique heat sink that maximises surface area. This component, which makes up the body of the lamp, underwent the most development since the beta release of the product.

Now, after months of research and tweaking, the final heat sink design is primed for extrusion. The company's LED OEM team is proud to announce that as of December 2012, the Andromeda LED high bay has the only extruded heat sink of its kind on the market.

Typical LED high bay manufacturers use a die casting process to create heat sinks. This limits the potential surface area of the heat sink to that of the mould on which it is formed. These moulds must be lined with thick walls to withstand the high temperatures of the metals poured therein.

As a result, the heat sinks produced from die casting feature fewer open spaces. However, this is still the most commonly used process in the LED lamp manufacturing industry as it is inexpensive.

Extrusion refers to the process of pushing or pulling a material through a die to achieve a desired cross section. As the material undergoes no outside pressure as it is extruded, very fine details may be rendered through the cavities in the die. This process is therefore capable of creating more distinct surfaces within a cross section.

This increased potential is LED Waves' reason for extruding the heat sink on their LED high bay, even though the process is more costly. Maximising surface area within a form in turn maximises channels through which hot air can flow away.

As heat is the leading contributor to premature failure in electronics, effective dissipation significantly lengthens the lifespan of an LED light. This supports the extended 5 warranty LED Waves places on the Andromeda LED High Bay.

This guiding principle of maximising surface area to increase heat dissipation is evident in the other exclusive LED replacement lamps made in the USA

by LED Waves. Its high-performance heat sinks on the firm's LED MR16s as well as their series of PAR LED light bulbs are all covered by a 5 year warranty.

Bridgelux unveils novel platform for SSL design

The US firm's new packaging system broadens array performance at the same time as reducing the cost of LED lighting

Bridgelux is launching the Vero LED array, a lighting platform that simplifies design integration and manufacturing and gives designers more flexible LED lighting solutions.

The Vero packaged array technology offers future opportunities to integrate smart sensors and wireless communication technology for smart building control systems and other applications.

Vero advancements revolve around three primary innovations: a new, higher flux density LED array, an increase in lumens per watt by up to 20 percent over existing Bridgelux LED arrays and a simplified assembly process that streamlines manufacturing and improves overall system reliability.

Bridgelux says the Vero platform will allow manufacturers to dramatically reduce electronic and optical component inventories while broad input current ranges allow designers to optimise products on efficiency, cost, and light output.

"The Vero platform is a major advancement in LED array packaging technology," says Jim Miller, chief sales and marketing officer of Bridgelux.

"The Vero product is manufactured using highly automated processes to reduce cost and can be easily upgraded for the smart applications of the future. The Vero array offers our customers the manufacturing and design capabilities they need to open up new design possibilities, while ultimately driving faster adoption of LED lighting."

Vero Platform Technical Details

The Vero platform provides complete application coverage from four form factors, delivering the light output and colour temperatures required for retail, hospitality, commercial, industrial, residential and outdoor lighting applications.

The arrays will initially be available with performance ranging from 800 lumens in warm white (3000K) up to 20,000 lumens in cool white (5000K) with multiple CCT and CRI options, including the 97 CRI Decor product option.

With significant advancements in luminaire design flexibility, the Vero product offers a light emitting surface (LES) area with higher flux densities than earlier Bridgelux array designs. The Vero LED array has been engineered to be driven reliably at much higher drive currents than previous offerings to further increase performance and reduce cost.

These new features allow luminaire designers to develop smaller, sleeker designs and to deliver narrow beam angles for spot and track applications facilitating high contrast ratio lighting designs.

The Vero arrays are compatible with a wide variety of standard drivers and optical components, providing manufacturers with greater flexibility and more options than normal. This shortens product development times, lowering inventory requirements and reducing costs.

The new Vero array series will also delight many luminaire manufacturers with enhanced interface and connection options. The electrical connection may be established via user friendly solder pads or by using a solderless on-board connector provided by Molex. The Vero line combines the advanced light source with innovative connector options into a single, easy to integrate package.

The Vero platform is currently being evaluated by Bridgelux customers and will be commercially available in the first quarter of 2013.

Luminus LEDs honoured for being green

The company has been recognised for creating technology innovations in green technology

Luminus Devices has been chosen by AlwaysOn as one of the GoingGreen Silicon Valley Global 200

winners.

Inclusion in the GoingGreen Silicon Valley Global 200 signifies leadership amongst its peers and game -changing approaches and green technologies that are likely to disrupt existing and entrenched players in traditional technology.

Luminus was selected by the AlwaysOn editorial team and industry experts based on a set of five criteria: innovation, market potential, commercialisation, stakeholder value, and media buzz.

The LED firm and the GoingGreen Silicon Valley Global 200 companies were honoured at AlwaysOn's seventh annual GoingGreen Silicon Valley, November 27th and 28th, 2012, at the Golden Gate Club in San Francisco, California.

"Luminus Deivices is proud to accept this award from AlwaysOn," says Keith T.S. Ward, CEO of Luminus Devices. "GoingGreen highlights the importance of green technology and the positive impact that LEDs can have on our energy usage and our environment, and through this our company plans to encourage the widespread use of LEDs to save energy, reduce costs, provide better lighting solutions, and create a cleaner global environment."

The GoingGreen Global 200 winners were selected from thousands of domestic and international technology companies nominated by investors, bankers, journalists, and green technology industry insiders.

The AlwaysOn editorial team conducted a rigorous three-month selection process to finalise the 2012 list.

"This year's GoingGoing Global 200 displays a maturity in the green technology industry that makes it very attractive to both investors and innovators," says Tony Perkins, founder and editor of AlwaysOn. "This year's GoingGreen Global 200 winners are pushing the bounds of how technology can bring about change in the war on our planet's waning resources. The strength of these companies lies in their ability to nurture innovative ideas and see them through to successful, sustainable, and profitable businesses."

Deli Optoelectronics opts for Veeco MOCVD tools

The newly formed firm will use the reactors to manufacture III-nitride HB-LED wafers

Guangdong Deli Optoelectronics Co., Ltd, has ordered multiple TurboDisc K465i MOCVD systems to support its high brightness LED manufacturing ramp.

Guangdong Deli Optoelectronics is a privately held company located in Jiangmen.

Mai Qinghua, President of Deli Optoelectronics, comments, "We are excited to select Veeco's K465i systems for our new production facility which will open in the spring of 2013. We chose Veeco over its competitors because of the company's demonstrated market leadership in MOCVD and production-proven technology. Veeco's systems will provide us the lowest cost of ownership to help us achieve great success in the LED market."

Jeff Hawthorne, Veeco's Senior Vice President, MOCVD, adds, "It is gratifying to be chosen by Deli Optoelectronics as they make their first foray into the LED industry. Our tools have supported many of China's LED leaders, so we look forward to providing this new customer with state-of-the-art equipment, engineer training and excellent support and service."

Deli Optoelectronics (a sub-company of DELIXI), headquartered in Wenzhou, specialises in the manufacturing of electric power transmission and distribution appliances. DELIXI produces a broad range of high and low voltage switchgear sets and components.

Osram infrared chip exhibits 72 percent efficiency

At 930mW the 850nm chip, from an operating current of 1A, has a light output (under lab conditions) 25 percent higher than that of many of the chips currently available

Osram's infrared chip prototype has achieved a new record with an efficiency of up to 72 percent.

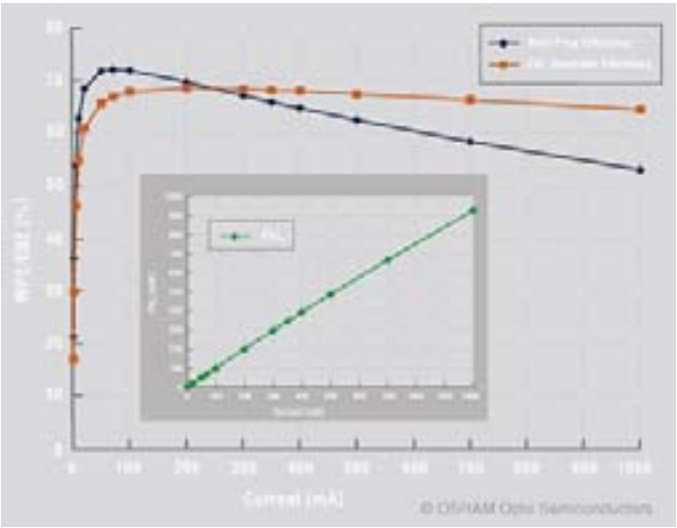
This means that future infrared LEDs can be made even more energy-efficient.

The efficiency was measured at room temperature and at a DC current up to 1 A. With a wavelength of 850nm, the chip has been designed for infrared illumination applications.

Osram says the results from the R&D laboratory in Regensburg have created a new milestone.

The prototype of a 1mm2 chip in infrared thin-film chip technology has achieved an efficiency of 72 percent from an operating current of 100mA. This efficiency, known as wall plug efficiency, indicates the ration of the radiated power to the electrical input power.

The external quantum efficiency, in other words the probability of creating a photon and its emission from the LED chip per electron, is 67 percent. It also remains above 64 percent up to an operating current of 1A.



The new 1mm2 infrared chip also has a high quantum efficiency which remains around 65 percent up to 1A

The wavelength of the chip prototype of 850nm is perfect for infrared illumination, particularly for surveillance tasks and use with CCTV cameras. There are also potential safety applications in the automotive sector, such as precrash sensors and illumination sources for night vision systems.

"The way in which the efficiency and brightness have been increased can be transferred from 850 nanometres to other wavelengths," says Markus Bröll, Project Manager for the development of IRED chips at Osram Opto Semiconductors in Regensburg. "This means that it will be possible to create highly energy-efficient solutions for infrared lighting in the future".

Fewer components will be needed in multichip applications, saving both money and energy.

The results of this development work are now being implemented stage by stage. The new chip is expected to go into series production between the start and middle of next year.

KLA-Tencor unveils LED wafer inspector

The ICOS WI-2280 system is designed to provide manufacturers with greater flexibility, reduced cost of ownership and improved efficiency

KLA-Tencor Corporation has revealed its next-generation LED patterned wafer inspection tool, the ICOS WI-2280.

ICOS WI-2280

The tool is designed specifically for defect inspection and 2D metrology for LED applications.

But the ICOS WI-2280 also provides enhanced inspection capabilities and increased flexibility for power semiconductor wafers spanning two inches to eight inches in size.

The ICOS WI-2280 is KLA' fourth generation LED wafer inspection system and is built on its WI-22xx platform, delivering sensitivity with increased throughput.

What's more, the tool supports handling of whole wafers in carriers and diced wafers in hoop ring or film frame carriers to accommodate multiple media with minimal equipment changeover time.

The WI-2280 also features an enhanced rule-based binning defect classification and recipe qualification engine, enabling manufacturers to achieve faster yield learning during production ramps, as well as improve process control and process tool monitoring strategies in their manufacturing process.

"Increasingly, LED manufacturers are demanding improved detection and classification of yield relevant defects of interest, which enables them to take faster corrective actions to improve their yields at higher inspection throughput. There is also a growing need to boost productivity by enabling faster production recipe creation," says Jeff Donnelly, group vice president, Growth and Emerging Markets (GEM) at KLA-Tencor.

"The ICOS WI-2280 addresses critical market requirements, ultimately enabling LED manufacturers to achieve better lumens per watt and lumens per dollar performance. We remain committed to advancing our industry-leading ICOS product line to meet the LED community's emerging needs," continues Donnelly.

The ICOS WI-2280 includes flexible advanced optical modes with dedicated image processing. This enables a high defect capture rate and recipe robustness against varying process backgrounds.

The tool can also classify defects uniquely and has an advanced recipe tuning engine and enhanced metrology capability.

Front-end to back-end-of-line connectivity analysis is also possible, delivering a single platform for defect source analysis. KLA says the system has an easy-to-use inline or offline reclassification engine. This enables post-inspection yield improvements for enhanced productivity

In addition to LED application environments, compound semiconductor and power device markets can leverage the ICOS WI-2280 tool for back-end-of-line and post-dicing outgoing quality control or binning; front-end-of-line patterned wafer inspection for baseline yield improvement, rework, excursion control or overlay; and 2D surface inspection and metrology.

The ICOS WI-2280 also works in conjunction with KLA-Tencor's Candela LED unpatterned wafer inspection system and Klarity LED automated analysis and defect data management system to provide manufacturers with end-to-end inspection coverage.

Telecoms

III-Vs improve integrated circuit battery life tenfold

Early results using compound semiconductors and processes achieve a milestone towards low-power tunnel transistor electronics

Researchers have demonstrated that using new methods and materials for building integrated circuits can reduce power.

This extends battery life to 10 times longer for mobile applications compared to conventional transistors.

The consortium of researchers was composed of scientists from Rochester Institute of Technology (RIT), SEMATECH and Texas State University.

The key to the breakthrough is a tunnelling Field Effect Transistor (FET). The FET includes GaAs, In0.53Ga0.47As, InAs, InAs0.9Sb0.1/Al0.4Ga0.6Sb and InAs/GaSb.

Transistors are switches that control the movement of electrons through material to conduct the electrical currents needed to run circuits. Unlike standard transistors, which are like driving a car over a hill, the tunnelling FET is more like tunnelling through a hill, says Sean Rommel, associate professor of electrical and microelectronic engineering.

Sean Rommel

"The tunnelling field effect transistors have not yet demonstrated a sufficiently large drive current to make it a practical replacement for current transistor technology," Rommel adds, "but this work conclusively established the largest tunnelling current ever experimentally demonstrated, answering a key question about the viability of tunnelling field effect transistor technology."

Rommel worked with David Pawlik, Brian Romanczyk and Paul Thomas, three graduate students in the microelectronic engineering and microsystems engineering programs at RIT. Along with colleagues from SEMATECH and Texas State University, the team presented the breakthrough findings at the International Electron Devices Meeting in San Francisco this past December.

In order to accurately observe and quantify these current levels, a fabrication and testing procedure was performed at RIT. Pawlik developed a process to build and test vertical Esaki tunnel diodes smaller than 120 nanometres in diameter, Rommel explains.

This procedure allowed the researchers to measure hundreds of diodes per sample. Because of the nanometre-scale devices tested, the researchers were able to experimentally observe currents substantially larger than any previously reported tunnelling currents.

Esaki tunnel diodes, discovered in 1957 and the first quantum devices, were used to create a map showing output tunnel currents for a given set of material systems and parameters. For the first time, researchers have a single reference to which they can compare results from the micro- to the mega-ampere range, Rommel adds.

"This work may be used by others in designing higher performance tunnelling field effect transistors which may enable future low power integrated circuits for your mobile device," he says.

The National Science Foundation, SEMATECH and RIT's Office of the Vice President of Research sponsor the team's work.

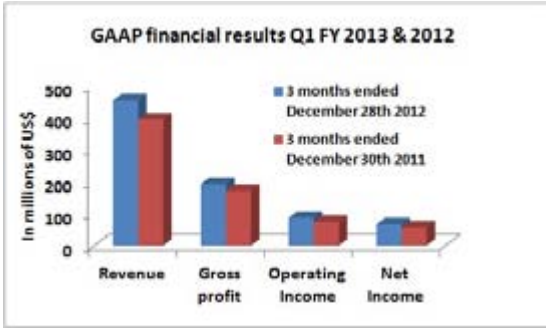
"SEMATECH, RIT and Texas State have made a significant breakthrough in the basic materials for the sub 10 nm node with this work," comments Paul Kirsch, director of SEMATECH's Front End Processes. "The research that was presented at the International Electron Devices Meeting on III-V Esaki tunnel diode performance resolves fundamental questions on the viability of tunnelling field effect transistors and provides a practical basis for low-voltage transistor technologies."

The team's findings in the area of developing high performance, low-power electronic devices are also detailed in the paper, "Benchmarking and Improving III-V Esaki Diode Performance with a Record 2.2 MA cm2 Current Density to Enhance Tunnelling Field-Effect Transistor Drive Current."

Skyworks smashes Q1 FY 2013 forecast

The company delivered revenue of $454 million, up 15 percent Year-Over-Year

Skyworks Solutions, Inc., an innovator of III-V analogue semiconductors, has reported first fiscal quarter 2013 results for the period ending December 28th, 2012.



Revenue for the quarter was $453.7 million, up 15 percent when compared to $393.7 million in the first fiscal quarter of 2012 and exceeding the company's guidance of $450 million.

On a GAAP basis, operating income for the first fiscal quarter of 2013 was $86.6 million and diluted earnings per share was $0.34, up from $0.30 for the same quarter last year. Basic earnings per share was $0.35 as opposed to $0.31 for FY Q1 2012.

"As our results and guidance reflect, Skyworks is enabling anytime, anywhere communications across a diverse set of end markets and applications," said David J. Aldrich, president and chief executive officer of Skyworks.

"We're capitalising on growing consumer and enterprise demand for ubiquitous connectivity spanning all modes of wireline and wireless communications. In fact, our analogue semiconductor solutions are increasingly at the heart of everything from smartphones to smart appliances to home security systems to satellites to medical sensors to hybrid vehicles. This market diversity coupled with Skyworks' leadership scale, product breadth and system IP is setting the stage for continued market outperformance and shareholder value creation."

Second Fiscal Quarter 2013 Outlook

"Given order visibility and specific product launches, we expect to continue to gain market share and capture additional content per platform in the seasonally low March quarter," said Donald W. Palette, vice president and chief financial officer of Skyworks. "Specifically, for the second fiscal quarter of 2013, we anticipate revenue to be up 15 percent year-over-year with better than normal seasonality to approximately $420 million with non-GAAP diluted earnings per share of $0.47."

Skyworks hosted a conference call with analysts to discuss its first fiscal quarter 2013 results and business outlook. A replay of the conference call can be accessed on Skyworks' website by calling 800-475-6701 (domestic) or 320-365-3844 (international), access code: 275282.

TriQuint introduces PA GaAs HBT module for mobile devices

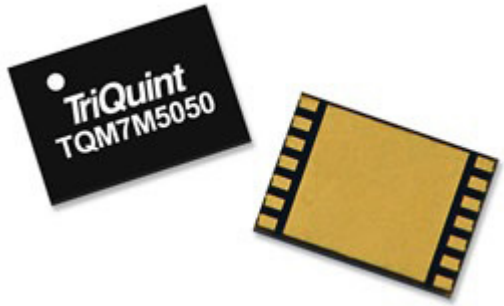
The compact gallium arsenide power amplifier saves board space and enables high levels of integration

TriQuint has released a new quad-band GSM / EDGE power amplifier module with power-added-efficiency (PAE).

Included on a leading chipset supplier's multi-mode reference design for linear EDGE applications, it is ideal for smartphones, tablets and other mobile devices.

The 5 x 3.5mm module is 30 percent smaller than previous generation products, saving board space and allowing for high levels of integration.

TriQuint says its GaAs HBT / CuFlip PA technology offers reliability, temperature stability and ruggedness.



TQM7M5050

The 14-pin 5 x 3.5 x 0.9mm module is claimed to have excellent Rx band noise sensitivity. It also has an input power controlled GMSK and 8PSK (pre-distortion required in EDGE mode)

The low band and high band operation features

two modes – BM and LBM. The PA output power is controlled by the input power coming from the transceiver in both GMSK and 8PSK modes.

The device's built-in CMOS controller is optimised for 50Ω operation.

The TQM7M5050 is in production, and samples are available from the firm's website.

GAO unveils Identifier with detachable InGaAs detector

The indium gallium arsenide device is suited to identifying dark or live fibre and excessive losses due to misalignment of mechanical splices or poor connections

GAO Instruments has launched a compact fibre optic identifier which provides transmission direction, multiple signal frequency identification and a detachable InGaAs detector.

The model C0230001, employs safe and reliable macro bending technology to avoid the disruption of network communications that would normally be caused due to the need to disconnect or cut the fibre optic cable for identification and testing.

GAO C0230001

With a very small signal loss, normal communications can be maintained while identifying the transmission direction, speed and relative signal strength on its 5-level display.

The portable device offers a wavelength range of 800 to 1700 nm. It identifies signal frequencies of CW, 270 Hz, 1 kHz, and 2 kHz. The identifier is compatible with multiple adapters including Φ250 μm bare fibre, Φ900 μm tight tube fibre and Φ3 mm pigtail fibre.

It provides communication signal indications, comparison light indication and has 5 LED for signal intensity indication. The identifier has a low-voltage indicator and an automatic shutdown function when not in use. Its rechargeable lithium battery allows for more than 4 hours of continuous operation.

The fibre optic identifier belongs to GAO's family of Optical Fibre Identifiers. Another similar product in this line is the Portable Optical Fibre Identifier which features core power display of the fibres, low bending loss and highly efficient output and serves as a tool in the installation and maintenance of telecommunication and CATV systems and other fibre networks.

The two handheld identifiers are simple, rugged, easy-to-use test instruments to detect the presence of network traffic, test tones and multiple signals and determine the direction of signal flow.

Gigoptix lawsuit against M/A-COM set for trial In August

The provider of gallium arsenide (GaAs) and indium phosphide (InP) products is suing for misappropriation of trade secrets

GigOptix has provided an update on its lawsuit against M/A-COM Technology Solutions, Inc. its subsidiary Optomai, Inc., and three former GigOptix employees.

The firm last year conducted forensic and other discovery to support its lawsuit for misappropriation of trade secrets.

The firm brought a motion for preliminary injunction, which the Court heard on September 13th, 2012. It is not necessary that such motions be filed in trade secret misappropriation cases, and the Court's denial of the request for an injunction does not have any impact on the strength of GigOptix' case against the defendants.

On January 29th 2013, the Superior Court of

Santa Clara County, California held a trial setting conference. Here, the Superior Court scheduled the lawsuit for a two-week jury trial starting Monday, August 26th, 2013.

GigOptix is a fabless supplier of semiconductor and optical components that enable high-speed end-to-end information streaming over the network and address emerging high-growth opportunities in the communications, industrial, defence and avionics industries.

Rubicon has shipped 400,000 large dimension sapphire wafers

The wafers are building block for LEDs used in HDTVs, laptops, smart phones and tablets and RFICs

Rubicon Technology has shipped a total of 400,000 large diameter sapphire wafers to LED and SoS/RFIC manufacturers.

Sapphire is a key building block for LEDs used in HDTVs, laptops, smart phones and tablets. Another significant market for sapphire is Silicon-on-Sapphire (SoS) Radio Frequency Integrated Circuits (RFICs).

SoS RFIC chips deliver high RF performance with low power consumption, a small form factor, and significantly reduced crosstalk in antenna applications that are pervasive in smart phones and other consumer devices.

Rubicon claims it was the first firm to develop large diameter sapphire wafers for use in the RFIC market and customise needs for the LED industry.

“This latest milestone demonstrates Rubicon’s continuing leadership in the volume delivery of high quality large-diameter sapphire wafers,” says Raja M. Parvez, President and CEO of Rubicon Technology.

“Our emphasis on vertical integration - achieving cost efficiencies and control of sapphire production – enables us to scale production and ensures our customers an unparalleled, reliable supply of high quality, large diameter sapphire wafers that meet their unique and exacting specifications. Rubicon’s capabilities are increasingly important as LED manufacturers seek to reduce costs throughout the manufacturing process to make LED-based lighting more affordable for consumers and encourage adoption worldwide.”

IMS Research estimates that the overall LED market will reach nearly $10.9 billion in 2012 with $2.9 billion in lighting. By 2015, IMS projects that the LED market will reach $13.9 billion with the lighting market nearly doubling to $5.8 billion in three year.

OVH uses Infinera PICs for European cloud network

The InP (indium phosphide) based devices will be used by the largest web hosting company in Europe

OVH will deploy the Infinera DTN-X platform for its Pan-European Network, featuring 500 Gigabit per second (Gb/s) super-channels.

OVH is the largest web hosting company in Europe supporting both public and private cloud services.

The DTN-X platform will enable OVH to increase its network capacity by potentially up to 10 times than what was previously offered, connecting data centres throughout 10 major European cities in seven countries.

With the Infinera DTN-X platform, OVH will deploy multi-terabit optical transmission capacity across its optical network to support the growing and dynamic capacity demands of cloud services.

Infinera claims its DTN-X delivers the industry’s first commercially available 500 Gb/s long-haul optical super-channels, which OVH will deploy to provide services to its consumers and enterprise customers with its data centres, across 10,000 kms of optical fibre.

OVH’s customers require large amounts of bandwidth very quickly, and a key factor in its selection of the DTN-X was the combination of integrated OTN switching with the delivery of 500 G/bs long-haul super-channels based on Infinera’s

500 Gb/s Photonic Integrated Circuit (PIC) and second generation FlexCoherent Processor.

Integrated OTN switching enables efficient utilisation of long-haul capacity while at the same time enabling OVH to rapidly deploy large amounts of optical bandwidth for customer services. The Infinera DTN-X platform will be deployed across routes on OVH's network, such as the 1,200 kms Roubaix-Paris-Strasbourg-Frankfurt route, scaling the capacity of the network while lowering operational costs.

"We've chosen an innovative technology leader, offering the best solution on the market to meet our capacity, flexibility and service lead time requirements," says Octave Klaba, CEO at OVH. "We continue to be impressed by Infinera's PIC technology and the DTN-X platform, from significantly simplifying our operations and reducing the time to deploy bandwidth to fundamentally lowering our total cost of ownership."

"After a rigorous and competitive bid process, OVH's selection of the DTN-X demonstrates that Infinera's solution for multi-terabit optical networks proves valuable to markets above and beyond traditional network operators," adds Chris Champion, VP EMEA Sales for Infinera. "We are pleased that Infinera continues to grow within OVH's optical footprint as they aggressively deploy cutting edge cloud and web hosting services."

OVH first selected Infinera's Digital Optical Network in 2007, deploying the DTN platform for an international expansion across Europe.

Telstra and Infinera go over a mile for Hawaii-California submarines

Infinera's indium phosphide (InP) PICs have crossed 4,200 km across the Pacific

Infinera has successfully demonstrated a 100 Gigabit per second (Gb/s) optical signal enhanced with Soft Decision Forward Error Correction (SD-FEC) across Telstra Global's dedicated fibre pair within Segment S5 of AAG Hawaii to California submarine cable.

Infinera says this D-FEC technology has the potential to double the transmission capacity of existing submarine cables. This trial demonstrates the power of SD-FEC in concert with Infinera's long haul FlexCoherent super-channel technology and how it can optimise both reach and capacity on submarine cables worldwide.

The subsea trial was performed over Telstra Global's fibre pair within Segment 5 of the AAG cable, connecting San Luis Obispo in Southern California to the island of Oahu in Hawaii and spanning 4,200 km across the Pacific.

The trial was staged using Infinera's DTN-X platform and a prototype super-channel line card enabled with Infinera's 3rd generation FlexCoherent Processor for real time SD-FEC processing combined with the InP based 500 Gb/s Photonic Integrated Circuits (PICs).

Using the additional error recovery capability enabled by the SD-FEC, multiple Infinera FlexCoherent modulation formats were able to close this link with no bit errors detected. The SD-FEC enabled higher order modulation formats to be used which could allow Telstra to increase the available capacity on this link increasing the commercial life of the cable in the face of aggressive increases in internet demand.

A key characteristic of Infinera's FlexCoherent technology is that the line card can be configured for a specific modulation format via simple software controls, increasing flexibility and maximising capacity and reach while lowering operational and inventory sparing costs.

Telstra Global is a part of Telstra Corporation Limited, one of Australia's leading telecommunications and media services company and owner of one of the most technologically advanced IP backbone networks in the world.

Telstra's dedicated fibre pair within Segment S5 of the AAG submarine cable is part of a system of cables linking the powerhouse economies of Australia and the Far East to the West Coast of the United States. Telstra Global forecasts more than 60 percent annual growth in its trans-Pacific submarine cable traffic over the next three years.

Telstra Global Managing Director, Martijn Blanken

says, “We are delighted by the results of this field trial and this shows further increased capacity potential for Telstra Global’s leading submarine cable plant. Our continuing focus on cutting edge technologies will enable us to continue to deliver new services to our customers and meet their future capacity needs with a long term, reliable offering.”

Infinera co-founder and Chief Strategy Officer, David Welch adds, “We are pleased to see that our 3rd generation FlexCoherent Processor along with 500 Gb/s PICs, is performing exceptionally in real world environments.”

“Over the past few months we’ve shown that a PIC-based long haul super-channel implementation can deal with record-breaking levels of PMD impairments in fibre; deliver a full 8Tb/s of capacity on Dispersion Shifted Fibre that service providers might have written off as useless, and now with Telstra’s help we’ve shown that with the addition of SD-FEC, this technology is capable of being deployed on some of the longest and most challenging cable routes in the world.”

NeoPhotonics to acquire telecom division of Lapis

This will add to the firm’s capabilities for over 100G deployment and strengthen the firm for high speed telecom and datacom applications

PIC manufacturer NeoPhotonics Corporation has entered into a definitive agreement to acquire the semiconductor optical components business unit (OCU) of Lapis Semiconductor Co., Ltd.

Lapis Semiconductor is a wholly-owned subsidiary of Rohm Co. Ltd.

OCU is to be acquired by NeoPhotonics Semiconductor GK, a Japanese subsidiary of NeoPhotonics.

Today’s rapidly accelerating demand for bandwidth is driving increasing needs for capable, scalable telecommunication networks. These advanced network systems are increasingly relying upon photonic integration technologies based on advanced components and scalable device integration approaches.

This aquisition should accelerate the development of NeoPhotonics Photonic Integrated Circuit (PIC) technology by coupling complex optical devices and analogue semiconductor ICs within the same platform.

Also, the NeoPhotonics technology portfolio would expand to include high speed semiconductor devices for signal generation and amplification, which are designed to enable advanced modulation methodologies, enhanced performance, and reduced power consumption in communications networks.

“We are excited about signing this definitive acquisition agreement as Lapis Semiconductor OCU is a leading provider of high speed devices for communications,” says Tim Jenks, NeoPhotonics Chairman and CEO.

“Lapis Semiconductor OCU provides a broad range of lasers, drivers, and detectors for high speed 100G applications. We believe the company’s technologies are well-suited for data rates in optical networks beyond 100G as well. We also believe this acquisition can enhance our ability to provide customers with innovative and technologically advanced optical communication products, which can benefit our customers as they strive to accelerate the delivery of scalable high speed and high bandwidth connectivity.”

“The transaction is a natural step in the relationship between NeoPhotonics and Lapis Semiconductor OCU, as the businesses have been collaborating closely on high speed coherent technology development for the past four years. Further we plan to leverage our existing sales channels after the acquisition, as the two businesses serve many common customers. The transaction will provide NeoPhotonics with revenue from OCU’s advanced lasers and drivers used in many of today’s 100G client-side data transmission modules,” concludes Jenks.

NeoPhotonics Semiconductor GK, an indirect wholly-owned subsidiary of NeoPhotonics Corporation, has agreed to pay approximately $36.8 million in cash, which is comprised of approximately $21.2 million in cash, before adjustments for the business unit and an additional $15.6 million over three years for the associated real estate.

The acquisition agreements provide for the purchase of the Lapis Semiconductor OCU business, together with a portfolio of more than 150 patents and patents applications, its campus and high speed semiconductor and laser and detector fabrication facility.

Payments will be made in Japanese Yen. Following completion of the transaction, NeoPhotonics intends to combine and operate the business as NeoPhotonics Semiconductor GK in its current location near Tokyo, Japan.

The Lapis Semiconductor OCU business is a high speed semiconductor and high speed laser and photodetector devices for communications networks.

OCU was an early innovator in high speed optoelectronics and the business today is among the leading producers of both analog electronic ICs and photonic solutions for the current generation of 100G modules used in accelerating deployments.

The Lapis Semiconductor OCU business unit is not a standalone company. Lapis says OCU had a revenue of approximately $45 million for the first nine months ended September 30th, 2012. For the same period, approximately 30 percent of revenue attributable to OCU was from network equipment manufacturers that are also customers of NeoPhotonics. This is approximately 6 percent of revenue attributable to OCU from NeoPhotonics, and the remainder attributable to OCU was from other optical module manufacturers and test and measurement customers.

The board of directors of each company has approved the transaction. The parties expect the transaction to close in the second quarter or sooner. Completion of the transaction is subject to various customary closing conditions.

JDSU executives restructure

The firm has promoted Rex Jackson as executive VP and CFO and appointed Susan Spradley as SVP and GM of the Communications Test and Measurement Business segment

JDSU has appointed Rex Jackson as executive vice president and chief financial officer, and Susan Spradley as senior vice president.

Spradley will have the responsibility of developing and managing of the company's communications test and measurement product portfolio.

Jackson reports to Tom Waechter, JDSU's president and chief executive officer, and has served as acting CFO since September 2012.

He joined JDSU two years ago as senior vice president, Business Services, with responsibility for several corporate functions, including Information Technology, where he has driven significant operational improvements. Jackson brings strong financial management experience to the company.

Prior to JDSU, Jackson served as executive vice president and chief financial officer at Symyx Technologies, where he led the company's acquisition of MDL Information Systems and subsequent merger with Accelrys. Jackson also served as acting CFO at Synopsys and held executive positions with Avago, AdForce and Read-Rite.

"Rex's strong performance as acting CFO and his deep knowledge of the company's strategy to drive profitable growth - combined with his prior experience as a public company CFO - make him an excellent choice for this key leadership position," said Waechter.

Susan Spradley joins JDSU as senior vice president and general manager of the Communications Test and Measurement (CommTest) business segment. Reporting to David Heard, CommTest's president, she is responsible for the development and management of the communications test product portfolio, including instruments, probes, software applications and service assurance solutions.

Spradley brings more than 20 years of telecommunications industry experience to JDSU, serving in executive positions at Nokia Siemens Networks and Nortel. Spradley was appointed by the President of the United States to serve on the National Security Telecommunications Advisory Committee and is chair of a White House and National Science Foundation initiative, called U.S. Ignite, to promote U.S. leadership in developing applications and services for broadband and

software - defined networks.

“Sue brings unique experience and strong relationships with the world’s leading network equipment manufacturers and service providers to JDSU,” said Heard. “She is ideally suited to advance our communications test growth strategy as we transition from traditional test and measurement to providing an integrated portfolio of instruments and software for the enablement of networks, services and applications.”

Mid-Atlantic/Chesapeake rep offers Firecomms FOTs

Firecomms’ new fibre optic transceivers are suited to industrial automation, transportation and medical markets

Firecomms has signed a representative agreement with Colrud-Lowery to better serve key industrial automation, transportation, and medical businesses in the Mid-Atlantic/Chesapeake region.

A representative of electro-mechanical and passive components in the Mid-Atlantic/Chesapeake region, Colrud-Lowery is known among its customers and distribution partners as a team of technical sales professionals with a commitment to exceed expectations.

“We are very excited about the opportunity to help Firecomms expand its footprint in the plastic optical fibre market ,” says Colrud-Lowery Vice President Jeb Bartle. “Firecomms is an energetic company with new products that should dovetail nicely with our marketplace.”

“As our fibre optical transceivers are ideal for industrial automation, transportation, and medical applications, we have sought a representative in the Mid-Atlantic/Chesapeake region that will effectively serve large businesses in these markets,” adds Lawrence Thorne, Firecomms Vice President of Sales and Marketing, North America. “Due its excellent reputation among both its customers and partners, we have chosen Colrud-Lowery to offer our OptoLock, LC, and new RedLink fibre optical transceivers to key customers in that region.”

Firecomms recently announced a significant expansion of its line of fibre optical transceivers, which now includes:

RedLink, a series of DC-capable transmitters and receivers for industrial command and control applications that are drop-in compatible with the Versatile Link range of products. Firecomms RedLink range is perfect for low-speed and DC-capable applications, such as IGBT/thyristor control and fault feedback or field I/O, in areas where immunity from harmful EMI or high voltage signals is required.

The first LC connectors designed for use with plastic optical fibre (POF) and other large core glass fibres such as HCS. Known for its compact form factor, the LC connector is widely used in the optical networking industry. The company specifically developed the LC product range due to its recognised durability and reliability for industrial automation applications.

Firecomms innovative OptoLock plugless fibre optic transceivers, which along with the LC connectors are ideal for Ethernet- or TCP/IP-based applications as well as for proprietary optical link solutions.

In addition to its industrial fibre optic transceivers, Firecomms now offers an accompanying line of cable assembly solutions to enable quick field installations without extensive training.

PhotonStar LED and CSR Bluetooth technology enables flexible dimming

The low energy wireless technology can enable smartphones, tablets and other connected devices to control systems such as lighting in the home

PhotonStar LED Group plc, a British designer and manufacturer of smart LED lighting solutions, continues to work with CSR plc (CSR) in the development of its Bluetooth Smart home lighting products.

These demonstrations are shown on the CSR booth at CES International 2013 in Las Vegas, a major global consumer electronics show.

The firms worked closely to create a joint LED lighting demonstration at CES 2013, showing how Bluetooth low energy wireless technology can enable smartphones, tablets and other connected devices to control systems such as lighting throughout the home.

Photonstar's existing LED lighting system is fully colour tuneable and dimmable, and the addition of CSR's Bluetooth low energy technology increases its flexibility and intelligence. Lights can be controlled individually or in groups using an app creating one-touch buttons to adjust the lighting in a room for different uses such as reading, dining or watching movies.

James Mckenzie, CEO of PhotonStar LED Group PLC, comments, "Our work with CSR on the wireless connectivity for our lighting systems has produced some exciting results, as demonstrated at CES 2013. There is great potential for our lighting solutions to work with everyday technology, creating optimal lighting for the connected home or business as part of the future 'internet of things' vision.

GigOptix poor revenues prompt 10 percent slash in workforce

The firm was affected by weaker demand and a push-out into the first half of 2013 of some anticipated deployments within the company's optical product line

GigOptix, announced preliminary revenues of approximately $8 million, including recognition of approximately $0.9 million of previously unrecognised government contract revenue, for its fourth quarter of fiscal 2012, ended December 31st, 2012.

This compares with the previous outlook provided on October 30th, 2012, that fourth quarter fiscal 2012 revenues would be roughly in-line with third quarter fiscal 2012 revenues of $10.1 million.

The firm is a fabless supplier of semiconductor and optical components that enable end-to-end high speed information streaming over the network.

Revenues for fiscal 2012 are expected to be approximately $37 million. This compares with $32.3 million in fiscal 2011, representing a year-over-year increase of approximately 14 percent. The annual increase resulted solely from organic growth as the company did not enter into any mergers or acquisitions in 2012.

Factors that contributed to the lower than expected revenues in FYQ4 2012 included weaker demand in the markets the company currently serves, challenging macroeconomic conditions, and a push-out into the first half of 2013 of some anticipated deployments within the company's optical product line.

The company has also taken immediate actions to adjust overall spending as it continues to focus on its adjusted EBITDA performance. Selected actions, which became effective on January 9th, 2013. These include reducing the company's global workforce by about 10 percent, primarily in the company's support and administrative functions, and company-wide salary reductions ranging between 5 to 25 percent based on an individual's salary level.

These actions are expected to result in approximately $450,000 of quarterly cost savings once the plan is fully implemented.

"After 12 consecutive quarters of increasing revenues we are clearly disappointed that revenues for the fourth quarter of fiscal 2012 are below expectations. We view the revenue performance of the fourth quarter of 2012 as a temporary setback and not indicative of our future prospects," said Avi Katz, Chairman and Chief Executive Officer of GigOptix, Inc.

"We will use this opportunity to further sharpen our business model and cost structure, enhance our operating efficiency, and deploy a leaner and more structured organization. We are confident these changes will deliver improved Adjusted EBITDA in 2013," said Katz.

"While we are not in a position to provide specific financial guidance for fiscal 2013 at this time, our current outlook for the year is positive based on customer feedback and the prospect for better conditions in the areas within the optical components market we currently serve, and

new product deployments targeting the telecom, datacom, and consumer electronics markets."

GigOptix cautions that its anticipated revenue results, and the cost reduction savings, are preliminary and based on the best information currently available. The revenue results are subject to completion of the audited financial statements for fiscal 2012.

The company will hold a conference call to discuss its fourth quarter and full year fiscal 2012 financial results and current business outlook in February. The conference call date and participation information will be distributed through a press release at a later date.

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

This is according to Strategy Analytics' GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review July - September 2012: Microelectronics."

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth.

The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

"The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

This viewpoint summarises financial, product, contract and employment developments from leading semiconductor device suppliers from July - September of 2012. These announcements address a variety of commercial and military applications products and companies that use GaAs, GaN, SiC, SiGe and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

RFMD introduces integrated InGaP PA modules for WiFi

The devices are built using the firm's advanced indium gallium phosphide HBT process

RFMD's new RFPA520x series of three-stage WiFi PA modules are designed for 802.11b/g/n applications.

Other uses include consumer premise equipment, picocells, femtocells, data cards and terminals and ISM band transmitter applications. They can also be used in wireless access points, gateways, routers and set top box appliances.

Each is a high-performance, highly integrated solution with minimal external components, eliminating the need for any external matching components and greatly reducing layout area, bill of materials and manufacturing costs for the customer application.

These PAs have high linear output power while maintaining excellent power added efficiency (PAE). RFPA5200 comes in a 4mm x 4mm x 1mm, 10-pin laminate package, while RFPA5201 comes in a 14-pin, 7mm x 7mm Multi-Chip Module (MCM).

Features include:

POUT: RFPA5200: 27dBm, 5V < 3% Dynamic EVM RFPA5201: 29dBm, EVM = 3%; 11n MCS7 HT40

High PAE: RFPA5200: 21% RFPA5201: 18.5%

High gain: RFPA5200: 33dB RFPA5201: 33.5dB

Input and output matched to 50Ω

Integrated power detector, biasing, harmonic filtering, and enable pin

Both parts are available now in production quantities. Pricing for 5000 pieces begins at $1.26 each for RFPA5200 and $2.64 each for RFPA5201.

Aegis Lightwave & Photop Technologies merge

Following Oclaro selling off its Santa Rosa thin film filter business to Photop Technologies, the two II-VI subsidiaries have merged

Aegis Lightwave and Photop Technologies, both subsidiary companies of II-VI Incorporated, have merged under the Photop brand identity.

Aegis Lightwave, Inc., based in Woburn, MA, U.S.A. will now operate as Photop Aegis Inc. Its subsidiary AOFR Pty Limited, based in Canberra, Australia has been renamed Photop AOFR Pty Limited.

The merger will allow the affiliates to better serve an expanding and global customer base with coordinated sales, marketing, applications engineering and product development activities using the companies' combined resources and complementary expertise.

The joint product portfolio of the combined companies will be presented as one Photop product portfolio with each product carrying the same brand identity.

"We are excited about the ability to leverage Photop's strong brand identity to accelerate the sales of our market leading optical channel monitors and fused fiber devices in the global market," says Chris Koeppen, General Manager, Photop Aegis.

"We look forward to partnering with Aegis and AOFR to further develop our product portfolios and market penetration worldwide where Photop is rapidly becoming a leading player of Optical Components & Photonic Products dedicated to the markets of Communications, Industrial Applications and Life Sciences", adds John Ling, CEO of Photop Technologies.

Photop Technologies became a subsidiary of II-VI in 2010, and Aegis Lightwave became a subsidiary of II-VI in 2011. Photop Aegis and Photop AOFR have transferred their main manufacturing operations to Photop Technologies at the extensive facilities in Fuzhou, China.

Based on the joint manufacturing and integrated operations, the companies were able to complete a full merger efficiently and with less impact to its customer base. As a consolidated brand, Photop will be able to provide its customers a seamless experience across a broad portfolio of products, with increasing levels of customer service and responsiveness to enable the business development and sales growth.

RFMD reveals 5GHz WiFi module for 802.11ac

The RFFM4501E is based on the firm's InGaP HBT and GaAs pHEMT technologies and is designed for notebook and mobile equipment devices

RF Micro Devices has introduced the highly-integrated RFFM4501E front end module (FEM) for 802.11ac notebook and mobile equipment applications.

The firm's latest WiFi FEM meets or exceeds the system requirements for 802.11ac connectivity in the 5.150GHz - 5.850GHz frequency band and is

optimised to support multiple applications. These include notebooks, mobile routers, and low-power customer premises systems.

The RFFM4501E integrates a +17.5dBm (80MHz MCS9) PA at 3.3V, a low insertion loss/high isolation single pole two throw (SP2T) switch, harmonic filtering, and a low noise amplifier (LNA) with bypass mode, for equipment manufacturers seeking to adjust receive sensitivity.

The receive chain provides 12.5dB of typical gain with only 12mA of current and an excellent noise figure of 2.5dB. Separate Rx/Tx 50 Ohm ports simplify matching and provide input and output signals for both the transmit and receive paths.

The RFFM4501E is optimised to mate with the 802.11ac chipset of a leading semiconductor company.

The ultra-small form factor (3mm x 3mm x 1.1mm) and high level of integration of the RFFM4501E shrink the product footprint, reduce external component count, minimise assembly costs, speed time-to-market.

SiC could eclipse diamond in quantum computers

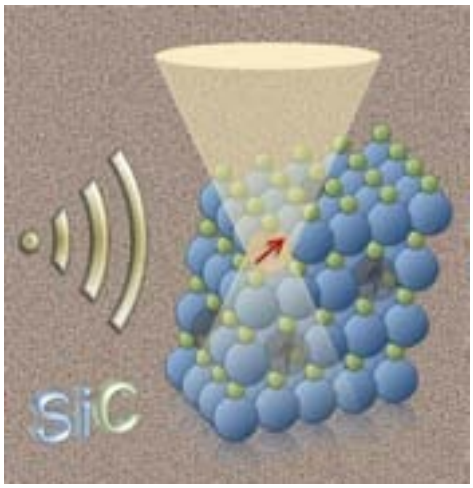
By creating a silicon vacancy defect in silicon carbide, scientists have generated additional energy levels in the so band gap for use in supercomputers

Researchers from the University of Würzburg have modified SiC crystals to exhibit new and surprising properties.

This makes them interesting with regard to the design of high-performance computers or data transmission.

SiC crystals consist of a regular lattice formed by silicon and carbon atoms. At present, these semiconductors are extensively used in micro and optoelectronics. They are particularly suited for used in high temperature applications in power semiconductors.

Now physicists from Saint Petersburg and the University of Würzburg have succeeded in manipulating SiC in a way so it can be used in novel, super-fast quantum computers.



A combination of light and radio waves can be used to store and retrieve information in silicon vacancy defects. (Graphics: Georgy Astakhov)

A defect in the crystal

“We have removed a silicon atom from the crystal lattice, thus creating a silicon vacancy defect,” Georgy Astakhov says, explaining the method applied by the physicists. Astakhov is a research fellow at the Department for Experimental Physics VI of the University of Würzburg.

To the researchers’ surprise, this crystallographic defect gives the material interesting new properties. In order for the semiconductor to emit light, its electrons must be raised to a higher energy level by means of energy-rich light, for instance. The silicon vacancy defect leads to the generation of additional energy levels in the so-called band gap.

Stepladder for electrons

Vladimir Dyakonov, chair of the Department for Experimental Physics VI, explains the process with a simple analogy; “In a regular, perfectly structured silicon carbide crystal, the electron must overcome a big hurdle with only one step. This requires a lot of energy. Due to the defect, the electron is provided with a ladder. It can clear the hurdle with two steps, requiring less energy.”

When the electrons “fall back” from the higher energy level to the lower one, this type of silicon carbide emits infrared rather than ultraviolet light.

According to Astakhov, such light is better suited to transfer information in an optical fibre. “This requires wavelengths in the infrared range,” the physicist says.

Application in a quantum computer

The modified SiC is particularly promising for another application – as a semiconductor and storage medium in novel quantum computers. “Since their invention, transistors have shrunk from several tens of micrometers to approximately 10nm, i.e. about one thousandth of their original size,” Astakhov notes.

If the miniaturisation continues at this speed, transistors would have to consist of one individual atom in ten years’ time. At this scale, however, special physical laws apply, namely the laws of quantum mechanics.

The computers of today process information with the binary system (0/1): Electricity flows or it does not. A quantum computer processes information in the form of so-called qubits. These can be based on the spin of electrons. In simplified terms, the spin represents their angular momentum. It can point in several directions, for which reason it can represent much more information than a classical bit.

The information lies in the defect

“In this field of research, a lot of attention has been paid to the colour centres in diamond, which exhibit defects that are similar to those of our silicon carbide,” says Astakhov.

Their qubits can be easily addressed, changed or read even at room temperature. However, the diamond production technology is not nearly as advanced as that of silicon semiconductors. “For this reason, there is a worldwide hunt for quantum systems that combine the advantages of diamond and silicon within one material,” Astakhov explains.

The Würzburg physicists believe SiC with a vacancy defect to be a suitable candidate for this purpose. “The missing atom also has as a consequence that the crystal lattice lacks an electron, which in turn is equivalent to the spin that can be used as information carrier in a quantum computer,” Dyakonov explains. What’s more, the SiC technology is fairly well developed. LEDs, transistors, micro-electro-mechanical components or sensors made from this material are already on the market.

Exposing the material to light and radio waves

The Würzburg physicists conducted their experiments in collaboration with researchers from Saint Petersburg. By “hitting” the silicon crystals simultaneously with light and radio waves, they were able to manipulate the spins in a targeted way, enabling them to store and retrieve information at will.

What the physicists are particularly enthusiastic about is the fact that the silicon vacancy qubits in a densely packed crystal behave almost like atoms with well-defined, very sharp optical resonances. “This is very unusual,” Astakhov adds.

“This is a new research field where experimental data of other study groups are still scarce at the moment. However, the reviewers looked favourably on our experiments and immediately recommended our manuscript for publication. We are very curious to know how the scientific community will react to our study,” Astakhov reveals. The first reaction has already materialised; Astakhov has been invited to present his results at the Quantum Science Symposium in Cambridge.

Spin quantum computers not only require the ability to process information, but also to store the information for as long as possible. This is still a problem at this point, since the stray field of adjacent nuclei can gradually erase the information stored in the defects.

Therefore, the researchers from Würzburg and Saint Petersburg plan as a next step to produce SiC crystals that are formed from a silicon isotope without a magnetic moment. “We know that spin-free isotopes of silicon and carbon atoms exist,”concludes Astakhov. A SiC crystal exclusively consisting of such isotopes should therefore be capable of storing the information over a long period of time.

Further details of this work have been published in the paper, “Resonant addressing and manipulation of silicon vacancy qubits in silicon carbide”, by D. Riedel, *et al* in *Physical Review Letters*, 109, 226402 (2012). DOI:10.1103/

PhysRevLett.109.226402

RFMD`s Kobayashi awarded 2013 IEEE Fellow

Kobayashi has been acknowledged for his work in gallium arsenide (GaAs) MMIC and indium phosphide (InP) technology

RFMD Fellow Kevin W. Kobayashi has been named a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) by the IEEE Board of Directors.

The IEEE grade of Fellow was conferred on Kobayashi in recognition for his contributions to monolithic microwave integrated circuits (MMICs).

The IEEE is one of the world's largest professional associations for the advancement of technology.

Less than one-tenth of one percent of the total IEEE voting membership is recognised each year by the IEEE Board of Directors for elevation to IEEE Fellow.

Bob Bruggeworth, CEO and president of RFMD, says, "Kevin is an outstanding engineer with an extraordinary record of accomplishments. His extensive industry knowledge and deep expertise across multiple technologies are valuable assets to RFMD and to our customers. We stand with the IEEE in congratulating Kevin for his industry achievements and for his recognition as IEEE Fellow."

Kobayashi is the principle author of 130 technical publications and the inventor of 48 U.S. patents. Noteworthy are his inventions improving the broadband linearity and dynamic range of fundamental MMICs such as the Darlington pair, Gilbert cell, Doherty, cascode, and distributed amplifier topologies.

His early work on GaAs MMIC technology established the foundation for many of the first HBT, HEMT, and MESFET MMIC insertions in national space satellite systems and for the first commercial GaAs HBT MMIC products for the wireless industry. He was early to recognize the benefits of GaAs HBT for RF and microwave applications, and he was first to design a microwave GaAs HBT Darlington feedback amplifier, later helping to commercialise it into a high volume product.

Kobayashi's contributions to MMICs span multiple compound semiconductor and silicon technologies. He helped prove the viability of monolithic GaAs BiFET-type solutions in challenging microwave designs. He also demonstrated the advantages of InP HBT for millimetre-wave and fibre optic applications, later inventing a wide dynamic range transimpedance amplifier currently deployed in an industry-leading 40 Gbps InP receive optical subassembly (ROSA).

More recently, Kobayashi has been engaged in the development of GaN MMICs, having achieved record low noise and wideband linearity expected to enable future radio architectures. One of his HEMT-HBT MMIC demonstrations (the world's first) is displayed in the MTT historical exhibit, along with a GaAs HBT MMIC he developed.

Kevin Kobayashi serves on several IEEE conference committees and has served as an associate editor of the Journal of Solid-State Circuits, applying his extensive RF and microwave experience in technical reviews of emerging silicon RF, millimetre-wave and fibre optic ICs.

IIVI buys LightWorks Optics for $31 million

IIVI has acquired the manufacturer of optical systems and components, including visible, infrared, and laser based systems

IIVI Incorporated has bought all of the outstanding shares of LightWorks Optics, Inc. (LightWorks). The initial consideration consisted of cash of approximately $31 million.

In addition, the agreement provides for approximately $4 million of cash earn out opportunities based upon LightWorks achieving certain future financial targets and is subject to customary closing adjustments including a working capital adjustment.

Founded in 1997, LightWorks is a privately held company headquartered in Tustin, California with manufacturing locations in both Tustin and Vista,

California. LightWorks manufactures precision optical systems and components, including visible, infrared, and laser based systems and subassemblies addressing the Defence, Aerospace, Industrial and Life Science markets.

For the 12 months ended September 30th, 2012, LightWorks generated approximately $22 million in revenues.

For the quarter ending December 31st, 2012 and for the fiscal year ending June 30th, 2013, IIVI does not expect this purchase to have a material impact on its previously issued guidance for revenues and earnings per share. LightWorks will be included in the company's Military & Materials segment for financial reporting purposes.

Francis J. Kramer, president and chief executive officer of IIVI Incorporated, says, "We are excited about the acquisition of LightWorks and anticipate a unique partnership with our Exotic Electro Optics (EEO) business unit which is also based in California. LightWorks is a premier supplier of a wide array of advanced optical systems currently deployed across a host of critical defence, aerospace, and commercial applications, and will further strengthen our relationships with customers by broadening our portfolio and expanding our product offering. We are eager to work cooperatively with the talented team of employees from LightWorks and welcome them to IIVI.

Daniel Barber, president of LightWorks, comments, "LightWorks' expertise in the engineering design and manufacturing of complete optical subsystems is a logical market extension for EEO. The optical system designs we create involve engineering and manufacturing expertise similar to those possessed by EEO, and will extend the range of solutions the combined companies offer to the marketplace."

"Not only do our companies offer complementary technology and a shared vision, we both have cultures committed to customer closeness, technical excellence and high levels of employee involvement and participation. We believe that together we can provide substantial value to our current customers as well as to the growing commercial markets for precision optical assemblies," adds Barber.

US company orders Riber MBE system

The reactor will be used for the developing II-VI semiconductors

Reactor manufacturer Riber has sold an MBE 412 system to a leading company in IR imaging sensors materials for ground and space based astronomy.

Benefiting from a very high performance level, the MBE412 system is designed for the development of II-VI semiconductors. The system was selected as this platform is optimised for top performances when complex semiconductor heterostructures layers are needed.

The system 412 order is a repeat busiess and will enable Riber's customer to further increase its activities on new IR sensor material and structures.

TriQuint's GaAs amplifiers are oh so quiet

The gallium arsenide based devices are suited for use as first-stage LNAs in base station receivers, tower-mounted amplifiers and repeaters

TriQuint Semiconductor has released two new dual matched low noise amplifiers that are ideally suited for balanced high performance RF design configurations.

These integrated LNAs are highly linear and offer very low noise figures, high output and include automatic shut-down capability for use in Time Division Duplex (TDD) and Frequency-Domain Duplex (FDD) applications. They are suited for use as first-stage LNAs in base station receivers, tower-mounted amplifiers and repeaters.

TQP3M9039

700-1000 MHz GaAs pHEMT low-noise amplifier: 0.5dB noise figure; 38.8dB OIP3; 21dBm P1dB RF output power; single positive supply (4.35V at 57mA).

TQP3M9040

1500-2300 GHz GaAs pHEMT low-noise amplifier: 0.62dB noise figure; 39.8dB OIP3, 21dBm P1dB RF output power; single positive supply (4.4V at 57mA).

Both devices come in a dual-amplifier structure which enables balanced operation. They provide adjustable bias (drain current and voltage) and integrated bias shut-down capability for FDD and TDD operation. Both come in a 4 x 4mm QFN package.

The TQP3M9039 and TQP3M9040 are in full production and samples are available.

InP-Si sandwich chips combine the best of both worlds

The integration of an indium phosphide chip with a silicon chip could be the key to faster and more powerful terahertz devices for high resolution and mobile applications

Two Leibniz institutes have broken new technological ground; they have successfully combined their up to now, separate technologies.

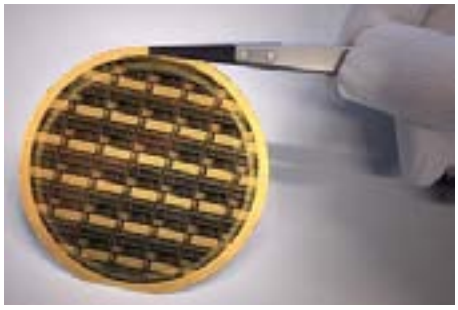
Due to their high performance, the novel chips developed within the HiTeK project promise to open the door to new applications.

Wolfgang Heinrich and Bernd Tillack are convinced of holding the key to faster and more powerful terahertz (THz) chips. The two scientists and their teams come from the Berlin-based Ferdinand-Braun-Institut (FBH) and from the IHP-Leibniz-Institut für innovative Mikroelektronik in Frankfurt/Oder.

FBH is one of the leading institutes in developing III-V semiconductors, while IHP is specialised in silicon-based systems and circuits. Both Leibniz institutes joined forces within the HiTeK project to combine the advantages of silicon-based CMOS (Complementary Metal Oxide Semiconductor) circuits from the IHP with those of InP circuits from the FBH.

The partners have taken an important step within the project by successfully integrating both circuits onto a semiconductor wafer, with experimental results demonstrating their high performance.

With the integration on one chip, new ambitious applications in the THz range are within reach. These include high-resolution imaging systems for medical and security technology as well as ultra-broadband mobile communication applications.



InP / Silicon sandwich wafer

For such applications, high output powers along with faster computer processors are needed, offering enhanced computer operation per second. In order to achieve this, circuits on the chips need to become smaller to boost miniaturisation in the semiconductor industry.

If the frequency range around 100 gigahertz (GHz) and beyond is to be covered, however, the breakdown voltage in the CMOS switching circuits decreases significantly. As a consequence, the available output power of the chips declines. This implies that the capability of generating sufficiently strong signals to establish a radio link and to detect material defects becomes insufficient.

To find a solution to this problem, IHP conducted research on bipolar CMOS based on SiGe, enhancing the breakdown voltages at high speed

compared to pure CMOS. By combining a standard CMOS circuit with a second InP circuit promised further improvement.

Both circuits are realised in a "sandwich-like" structure and lie one on top of another. Where the traditional silicon-based CMOS technology reaches its limits, this novel material combination delivers the desired properties; high output powers at high frequencies. The sandwich chips enable a high level of production and integration of CMOS circuits - particularly regarding the fact that 95 percent of all digital and analogue-digital circuits are based on this technology.

"It was particularly challenging to make both technologies compatible at the interfaces", underlines Wolfgang Heinrich from the FBH. To achieve this, the whole development environment of both processes as, for example, the software for the circuit layout had to be merged in a first step.

Subsequently, both layers had to be dimensioned so that they reach the essential good transmission properties for frequencies around 200 GHz. Precision work was also highly demanded to adjust the circuits precisely to each other with an accuracy of less than 10µm.

Heinrich is especially proud of the friction-less cooperation, "We managed to align both technology worlds so smoothly that the circuits deliver fully the specified high-frequency performance. This also demonstrates what added value can be created by bundling the competencies of two institutes like IHP and FBH".

The next steps are to further stabilise the process and to optimise the circuits. A follow-up project has already been granted. In this way, the potential of the hybrid chips will be exploited fully to reach the borders of what is feasible. This will set the stage for the novel sandwich circuits to be integrated in sophisticated applications in the near future.

Terabit interconnect project combines III-Vs with silicon

The three year project announced by imec, will combine III-V high speed VCSELs with various silicon components to allow new functionalities such as wavelength multiplexing

MIRAGE, a new EU FP7 project, was recently launched with the goal to develop next-generation optical interconnect technology for terabit data links.

The project that focuses on optical rack-to-rack and board-to-board interconnects is scheduled to run for three years and brings together seven leading academic and industrial partners in the optical value chain.

Along with imec, the project participants are the National Technical University of Athens (Greece), Austriamicrosystems AG (Austria), OptoScribe Ltd. (UK), Technische Universität München (Germany), Aristotle University of Thessaloniki (Greece) and AMO GmbH (Germany).

Today the internet is morphing into a content-centric network with billions of users demanding ubiquitous, instant access to vast amounts of data. In this new networking paradigm, the hot spots are the data centres, where the bulk of the information is residing.

These data centres may consist of hundreds or even thousands of servers interconnected with each other. The content providers are in a constant race to increase this interconnection speed to improve the delivery of the data to the end user.

It is MIRAGE's ambition to increase the optical interconnect speed, which currently tops at around 140Gb/s per link, and bring it to the terabit realm. To do so, the program will tackle the issues that still have to be solved to develop technology suitable for commercial adoption.

The project will look into a number of things. These include high speed III-V VCSELs, low-energy electronic drivers and a flexible motherboard technology that allow new functionalities such as wavelength multiplexing. MIRAGE will also explore multi-level modulation and multicore fibre coupling, and ways to introduce new degrees of

parallelisation into the optical interconnects.

What's more, the project partners will develop new assembly processes based on 3D-integration of electronic and optical components to effectively blend silicon, glass and III-V photonic elements with CMOS electronic drivers.

In this project, imec's associated lab at Ghent University will develop the dedicated high-speed low-power VCSEL driver array and the transimpedance amplifier array. In these IC designs, imec will focus on the close integration and matching of the drivers with the corresponding VCSEL/photodiode arrays. The team will co-optimise the electronic circuits, parasitic elements, interconnects and optical-electronic-optical component parameters to take advantage of the various new technologies developed by the MIRAGE consortium.

Imec will also develop an innovative methodology to simplify bonding the MIRAGE active add-ons to the silicon platform. For VCSEL and photodiode bonding, in particular, tight alignment tolerances usually require costly equipment whereas the large distance between VCSELs and waveguides necessitates the use of microlenses to account for the beam divergence.

MIRAGE will confront these costs with a self-alignment assembly process based on microbumps.

Emcore unveils 1550nm fibre optic transmitters and receivers

The III-V based devices support multiple format frequency transport in a single platform for C, X, Ku, and Ka-band applications

Emcore is launching Optiva Satcom Band Microwave fibre optic transmitters and receivers for satellite communications, RF antenna remoting and other high-dynamic range microwave applications.

These new products supplement the existing Emcore Optiva Ultra-Wideband RF Fibre Optic Transport System by adding band-specific C, X, Ku, or Ka transmitter and receiver modules compatible with Emcore's modular or flange-mount Optiva Platform configurations.

Optiva Microwave Fibre Optic Transport System

The Optiva Satcom Band RF Fibre Optic Transport System expands on the existing Optiva Platform that already supports 50 MHz to 18, 22 or 40 GHz broadband microwave transport, reference oscillators, IRIG, IF, L & S-band, plus audio, video, data and Ethernet. Emcore says this makes it one of the most universal platforms in the industry.

"The Optiva Satcom Band RF Fibre Optic Transport System represents a significant breakthrough in microwave transmission technology from Emcore," says Frank Weiss, Vice President of Emcore's Advanced Systems Division. "By leveraging our existing ultra-wideband 50 MHz – 40 GHz Optiva products as building blocks, Emcore is able to provide high-performance externally modulated RF-banded technology at directly modulated technology price points. Additionally, these new products support multiple format frequency transport in a single flexible platform for C, X, Ku, and Ka-band applications."

Utilizing Emcore's high-performance ultra-low Relative Intensity Noise (RIN) source laser technology and high optical input power capable photodiodes, the Optiva Satcom Band RF Fibre Optic Transport System provides a high-dynamic range of over 110 dB-Hz2/3. The system features microprocessor-based transmitter and receiver control for laser and modulator bias and variable RF link gain which provides consistent high-performance and constant gain operation.

The standard Optiva transmitter provides a high power optical output and operates at a nominal wavelength of 1550 nm. Wavelength selected

lasers on the ITU grid are also available to support multichannel DWDM applications.

Additional advanced capabilities include Simple Network Management Protocol (SNMP) V.1, optical and RF amplification options, and RS-232 monitor & control with flexible user interface options.

Anadigics wins supplier award from ZTE

The provider of 3G and 4G PAs using indium gallium phosphide (InGaP) HBT technology, was recognised for its excellent technology, quality and service

Anadigics, an innovator in radio frequency (RF) solutions, has received the 2012 Best Comprehensive Performance Award from ZTE Corporation.

This award was presented to Anadigics for the company's technology, quality and service at ZTE's recent Supplier Day event in Shenzhen China.

"We are very honoured to be recognised by ZTE by receiving the Best Comprehensive Performance Award in both 2011 and 2012," says Michael Canonico, senior vice president of worldwide sales at Anadigics. "These awards not only validate the tremendous performance, technology, and quality advantages that we offer, but also exemplify the strength of the relationship forged between Anadigics and ZTE."

ZTE Corporation is a provider of telecommunications equipment and network solutions. The company's products connect global customers via voice, data, multimedia and WLAN.

Microsemi launches SiGe power amplifier for Wi-fi applications

A new silicon germanium device is the second in a series of devices aimed at accelerating the propagation of the next-generation Wi-Fi standard

Microsemi Corporation has introduced a 5 gigahertz (GHz) LX5509 power amplifier (PA) for IEEE 802.11ac, also known as fifth generation Wi-Fi, wireless access points and media devices.
The firm says its LX5509 is the first commercially available PA that can transmit at similar power levels in both IEEE 802.11n and IEEE 802.11ac networks. This allows optimum system performance by extending the high data rate range.

"Our new PA is the second in a series of devices we are introducing to accelerate the proliferation of the next-generation Wi-Fi standard," says Amir Asvadi, vice president and general manager of Microsemi's Analogue and Mixed Signal group. "We will continue to focus on strengthening our 802.11ac portfolio with industry-leading solutions and partnering with world-class WLAN manufacturers to deliver circuits that provide the highest system performance."

Apart from its power capabilities, the LX5509 features a standardised pin out. This enables customers to, without layout changes, later upgrade the performance level in their systems with higher power 5 GHz PAs that are currently in development at Microsemi.

Microsemi's 802.11ac solution offerings include the LX5586, what the firm says is the world's first monolithic SiGe RF front-end device. The company recently announced that this innovative solution works in conjunction with Broadcom's BCM4335 combo chip for mobile platforms.

The LX5509 is packaged in a 4 mm x 4 mm quad flat no-lead package and is available now for sampling.

Sofradir wins first contract with Indian space agency

The mercury cadmium telluride (MCT) detector manufacturer has secured a high value contract which covers new innovations for longer-life infrared detectors

Sofradir has announced that ISRO/SAC, the Indian Space Research Organisation's Space Applications Centre in Ahmedabad has awarded Sofradir a 2.5 year infrared detector contract.

Sofradir will develop large format infrared detector prototypes for testing and will deliver numerous flight models. The value of the contract is undisclosed.

"We are proud to become a supplier to the Indian Space Research Organisation, a major player in the space community," says Philippe Bensussan, chairman and CEO at Sofradir. "This is Sofradir's first contract for flight models with the Space Applications Centre. Foremost, it is the outcome of several years' close cooperation with the IR team at SAC that included delivering IR detectors for ground testing. It is also a result of our growing reputation as a reliable supplier of technically innovative IR detectors that have proven robust performance in space."

ISRO/SAC will receive flight models of Sofradir's IR detector for space applications, the large format 1000x256 Saturn SWIR (ShortWave InfraRed). In the last four years, Sofradir has delivered as many as ten Saturn SWIR flight models to aerospace companies. ISRO/SAC will use Saturn SWIR for future projects within the scope of India's hyperspectral earth observation satellite developments.

Sofradir Saturn SWIR detector

Compared to Sofradir's Saturn SWIR detectors currently deployed in space instruments, such as PRISMA and TROPOMI, Sofradir will integrate two new features on top of Saturn SWIR's space configuration. The innovations will meet ISRO/SAC's requirements for added performance.

The first innovation consists of a new long-life high-power active cooler. This longer-life cooler has been designed to extend the operating lifetime of Saturn SWIR from one to four years, as a single robust element.

The second innovation involves an integrated custom optical filter that significantly reduces the complexity of optics located in front of the detector.

"With this new contract, we'll be expanding our offer in space applications to include longer-life cooled IR detectors optimised for size, weight and power," adds Bensussan. "Our customers will benefit greatly from this development."

Qualcomm & Sharp To Invigorate LCD Displays

The displays will incorporate Sharp's IGZO (Indium Gallium Zinc Oxide) technology and be built utilising existing LCD manufacturing infrastructure, and Qualcomm's equity investment in Sharp.

Qualcomm is expanding its display technology agreement between its subsidiary Pixtronix, Inc. and Sharp Corporation to develop and commercialise high-quality colour, low-power MEMS displays.

As a result of the equity investment, Qualcomm will become a minority shareholder in Sharp.

Qualcomm's equity investment in Sharp and the expanded joint development agreement build upon the existing work between Sharp and Pixtronix; the two companies have been engaged in development activities for the last year and a half.

The goal of this joint effort is to accelerate commercialisation of Pixtronix's low power MEMS displays utilising Sharp's IGZO technology.

The equity investment by Qualcomm will take place in stages and the consummation of the transaction is subject to certain contingencies.

"As one of the leading electronics companies in the world, Sharp has an established industry brand and is a recognised leader in the development and commercialisation of new innovative display technologies," says Derek Aberle, executive vice president and group president of Qualcomm.

"Expanding our existing relationship with Sharp to jointly commercialize new MEMS display technologies will help both companies realise their shared goal of driving high performance, lower

power displays for a variety of devices, including smartphones and tablets."

"Sharp has brought many innovations to the display industry, including the world's first commercialisation of IGZO technology in LCD displays this year," adds Yoshisuke Hasegawa, executive managing officer of Sharp Corporation. "Sharp is targeting to accelerate the commercialisation of MEMS displays by combining Sharp's cutting-edge IGZO technology and Pixtronix's MEMS display technology."

OneChip takes on Jonathan Boocock to develop InP PICs

Boocock will lead the company's efforts to extend its indium phosphide PIC technology into the next-generation data centre interconnect market

OneChip Photonics has named Jonathan Boocock its Vice President of Product Development.

Jonathan Boocock, VP of Product Development

Boocock is responsible for the development of OneChip's Photonic Integrated Circuit (PIC)-based Passive Optical Network (PON) transceivers and Bi-directional Optical Sub-Assemblies (BOSAs).

He will lead the company's efforts to extend this breakthrough technology into the next-generation data centre interconnect (NG DCI) market.

"Jonathan knows what it takes to succeed in the very cost-sensitive, high-volume broadband access arena," says Jim Hjartarson, CEO of OneChip Photonics. "His experience in developing innovative optical communications solutions, from the ground up, will be crucial as we look to extend our unique PIC technology to the fast-growing data communications market."

Boocock, 49, has more than 25 years of industry experience and most recently was Executive Vice President of Engineering at BTI Systems Inc., where he managed development of the BTI 7000 Series Service Edge and Aggregation Packet Optical Platform from its inception to its volume delivery to carriers worldwide.

Previously, he was a co-founder and member of the senior management team at Catena Networks, an Ottawa-based broadband access start-up, which was sold in May 2004 for U.S. $487 million to Ciena Corporation. Boocock was also a senior manager at Nortel Networks, where he led development of its World Line Card access product, which shipped in volumes of more than 12 million lines per year and has a deployed base of greater than 200 million lines.

"I am excited to join a company that was the first to develop fully integrated optical modules for the PON market," Boocock says. "I look forward to leading our product development efforts in this and the exploding data communications market, where our technology can greatly reduce the cost and footprint of optical modules and boost optical interconnect speeds to 40G, 100G and beyond."

OneChip, on May 21st, 2012, announced that it will make available, in the second half of this year, engineering samples of its PIC-based 40GBASE-LR4 and 100GBASE-LR4 receiver chips for partner testing. The company also expects to make engineering samples of its 40GBASE-LR4 transmitter optical components and 100GBASE-LR4 single-chip transmitter PICs available, after the release of its PIC-based receiver chips.

According to Boocock, OneChip will use the feedback that it receives from these initial 40G and 100G engineering sample designs to develop PIC-based optical modules – such as Transmitter Optical Sub-Assemblies (TOSAs) and Receiver Optical Sub-Assemblies (ROSAs) – which can be used to lower costs, boost performance and improve reliability in high-speed optical interconnect applications. These solutions would help remove traffic bottlenecks in data centers and in campus and enterprise networks.

Meanwhile, the company will continue to grow the Engineering team that is focused on this effort.

"We have an opportunity, with our PIC technology, to make a significant impact in the PON market and the Next-Generation Data Centre Interconnect market, and we want to bring in additional Engineering talent to supplement the strong team that we have in place," Boocock adds.

InGaAs MOSFETs could beat Moore's Law

Indium gallium arsenide transistors could snatch silicon's crown

Silicon's crown could be under threat. The semiconductor's days as the king of microchips for computers and smart devices could be numbered, thanks to the development of the smallest transistor ever to be built from III-V semiconductor InGaAs.

Last week, researchers at Purdue University announced a new type of transistor shaped like a Christmas tree, where each transistor contains three tiny nanowires made of InGaAs.

So III-Vs replacing silicon seems to be a hot research topic, with InGaAs being one of the main contenders.

Now scientists at MIT's Microsystems Technology Laboratories, have also created a compound transistor, which performs well despite being just 22nm length. This makes it a promising candidate to eventually replace silicon in computing devices, says co-developer Jesús del Alamo, the Donner Professor of Science in MIT's Department of Electrical Engineering and Computer Science (EECS), who built the transistor with EECS graduate student Jianqian Lin and Dimitri Antoniadis, the Ray and Maria Stata Professor of Electrical Engineering.

To keep pace with our demand for ever-faster and smarter computing devices, the size of transistors is continually shrinking, allowing increasing numbers of them to be squeezed onto microchips. "The more transistors you can pack on a chip, the more powerful the chip is going to be, and the more functions the chip is going to perform," del Alamo says.

But as silicon transistors are reduced to the nanometre scale, the amount of current that can be produced by the devices is also shrinking, limiting their speed of operation. This has led to fears that Moore's Law - the prediction by Intel founder Gordon Moore that the number of transistors on microchips will double every two years - could be about to come to an end, del Alamo says.

To keep Moore's Law alive, researchers have for some time been investigating alternatives to silicon, which could potentially produce a larger current even when operating at these smaller scales. One such material is the compound InGaAs, which is already used in fibre-optic communication and radar technologies, and is known to have extremely good electrical properties, del Alamo says.

But despite recent advances in treating the material to allow it to be formed into a transistor in a similar way to silicon, nobody has yet been able to produce devices small enough to be packed in ever-greater numbers into tomorrow's microchips.

Now del Alamo, Antoniadis and Lin have shown it is possible to build a nanometre-sized metal-oxide semiconductor field-effect transistor (MOSFET) - the type most commonly used in logic applications such as microprocessors - using the material. "We have shown that you can make extremely small indium gallium arsenide MOSFETs with excellent logic characteristics, which promises to take Moore's Law beyond the reach of silicon," del Alamo says.

Transistors consist of three electrodes: the gate, the source and the drain, with the gate controlling the flow of electrons between the other two. Since space in these tiny transistors is so tight, the three electrodes must be placed in extremely close proximity to each other, a level of precision that would be impossible for even sophisticated tools to achieve. Instead, the team allows the gate to "self-align" itself between the other two electrodes.

A cross-section transmission electron micrograph of the fabricated transistor. The central inverted V is the gate. The two molybdenum contacts on either side are the source and drain of the transistor. The channel is the InGaAs light colour layer under the source, drain, and gate. (Image courtesy of the researchers)

The researchers first grow a thin layer of the material using MBE, a process widely used in the semiconductor industry in which evaporated atoms of indium, gallium and arsenic react with each other within a vacuum to form a single-crystal compound.

The team then deposits a layer of molybdenum as the source and drain contact metal. They then "draw" an extremely fine pattern onto this substrate using a focused beam of electrons - another well-established fabrication technique known as electron beam lithography.

Unwanted areas of material are then etched away and the gate oxide is deposited onto the tiny gap. Finally, evaporated molybdenum is fired at the surface, where it forms the gate, tightly squeezed between the two other electrodes, del Alamo says. "Through a combination of etching and deposition we can get the gate nestled [between the electrodes] with tiny gaps around it," he says.

Although many of the techniques applied by the MIT team are already used in silicon fabrication, they have only rarely been used to make compound semiconductor transistors. This is partly because in applications such as fibre-optic communication, space is less of an issue.

"But when you are talking about integrating billions of tiny transistors onto a chip, then we need to completely reformulate the fabrication technology of compound semiconductor transistors to look much more like that of silicon transistors," del Alamo says.

The team presents its work this week at the International Electron Devices Meeting in San Francisco.

Their next step will be to work on further improving the electrical performance, and hence the speed of the transistor by eliminating unwanted resistance within the device. Once they have achieved this, they will attempt to further shrink the device, with the ultimate aim of reducing the size of their transistor to below 10nm in gate length.

Matthias Passlack, of Taiwanese semiconductor manufacturer TSMC, says del Alamo's work has been a milestone in semiconductor research. "He and his team have experimentally proven that indium arsenide channels outperform silicon at small-device dimensions," he says. "This pioneering work has stimulated and facilitated the development of CMOS-compatible, III-V-based-technology research and development worldwide."

The research was funded by DARPA and the Semiconductor Research Corporation.

Henniker multi-tasking deposition systems take off

The company says its latest multi-deposition systems are ideal for both small scale production and R&D prototyping for nanomaterials research

Henniker Scientific has released a new range of multi-technique deposition systems for nanomaterials research.

The family of systems offer the flexibility of several techniques in a single chamber. One of these is pictured below.

HSP 370 deposition system

The company says its latest multi-deposition systems are ideal for both small scale production and R&D prototyping for nanomaterials research

All systems in the range feature a universal 'quick-change' source flange which can be configured for specific deposition techniques or combination of techniques including magnetron, thermal, e-beam or combination sources.

Henniker says the systems provide a multi-technique and deposition system suited for both small scale production and R&D prototyping.

Also, each system configuration has many viewports and equipment ports for ancillary instruments such as ion sources for sample cleaning, thickness monitors and load lock entry.

PC control and data acquisition on system is available as an option and also allows ancillary techniques and devices to be fully integrated.

Efficient water cooling and differentially pumped seals guarantee a base pressure of E-9 mbar which, together with sample manipulator options, provide the widest possible access to substrate conditions, including full 360 degree rotation with stage heating and cooling.

CenturyLink chooses Infinera InP DTN-X for 100G telecoms

The indium phosphide platform based on PIC technology features 500 gigabit per second (Gb/s) long haul super-channels on its nationwide fibre optic al network

CenturyLink, Inc. has deployed the Infinera InP DTN-X platform,

The Infinera DTN-X platform has enhanced CenturyLink's nationwide transport network to support video, mobile, and cloud IP services, and extend its ability to deliver up to 100 Gigabit Ethernet services (GbE) to the company's data centres and customer facilities around the country.

The Infinera DTN-X platform provides CenturyLink a scalable, efficient, and reliable long haul optical transport solution for its network.

The DTN-X platform delivers 500 Gb/s FlexCoherent super-channels and integrates 5 Terabits per second (Tb/s) of OTN switching per chassis. This results in lower latency for mission critical services while lowering the total cost of ownership of the transport network.

"We evaluated the available 100G solutions for long haul optical transport and the DTN-X platform stood out," says Matt Beal, CenturyLink senior vice president - corporate strategy, product development and chief technology officer.

"Our experience with the Infinera DTN platform has demonstrated a system based on quality, ease of use, proven technology and reliability. As a customer since 2004, we look forward to including the DTN-X as part of our next generation network and achieving the same positive results as we have in the past," continues Beal.

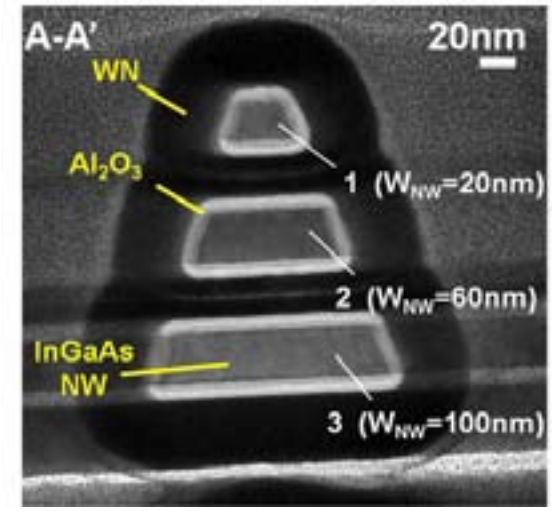
"I am delighted to announce the continuation of the long-term relationship between CenturyLink and Infinera," adds Tom Fallon, Infinera CEO. "CenturyLink's selection of the DTN-X platform underscores the value of our optical transport solution for Tier-1 operators around the world. As operators upgrade existing networks to 100G or deploy new 100G networks, the DTN-X uniquely delivers the scale and efficiency required at the core of the world's largest optical networks."

CenturyLink first deployed Infinera's Digital Optical Network architecture in 2004 with the DTN platform, the industry's first optical transport solution powered by photonic integrated circuits (PICs).

InGaAs `4-D` transistor could be the future for computers

Indium gallium arsenide is one of the several promising semiconductors being studied to replace silicon

A new type of transistor shaped like a Christmas tree has arrived just in time for the holidays, but the prototype won't be nestled under the tree along with the other gifts.



This image taken with a transmission electron microscope shows the cross section of a new type of transistor shaped like a Christmas tree that was created by researchers at Purdue and Harvard universities. The transistor is made from tiny nanowires of a material called InGaAs, which could replace silicon within a decade. (Purdue University image)

"It's a preview of things to come in the semiconductor industry," says Peide "Peter" Ye, a professor of electrical and computer engineering at Purdue University.

Researchers from the universities of Purdue and Harvard created the transistor, which is made from a material that could replace silicon within a decade.

Each transistor contains three tiny nanowires made not of silicon, but from InGaAs. The three nanowires are progressively smaller, yielding a tapered cross section resembling a Christmas tree.

The research builds on previous work in which the team created a 3-D structure instead of conventional flat transistors. The approach could enable engineers to build faster, more compact and efficient integrated circuits and lighter laptops that generate less heat than today's.

New findings show how to improve the device performance by linking the transistors vertically in parallel.

"A one-story house can hold so many people, but more floors, more people, and it's the same thing with transistors," Ye comments. "Stacking them results in more current and much faster operation for high-speed computing. This adds a whole new dimension, so I call them 4-D."

The findings will be detailed in two papers to be presented during the International Electron Devices Meeting taking place between Dec 8th and 12th in San Francisco. One of the papers has been highlighted by conference organisers as among "the most newsworthy topics and papers to be presented."

The newest generation of silicon computer chips, introduced this year, contain transistors having a vertical 3-D structure instead of a conventional flat design. However, because silicon has a limited "electron mobility" - how fast electrons flow - other materials will likely be needed soon to continue advancing transistors with this 3-D approach, Ye adds.

Transistors contain critical components called gates, which enable the devices to switch on and off and to direct the flow of electrical current. Smaller gates make faster operation possible. In today's 3-D silicon transistors, the length of these gates is about 22 nanometres (nm), or billionths of a metre.

The 3-D design is critical because gate lengths of 22 nm and smaller do not work well in a flat transistor architecture. Engineers are working to develop transistors that use even smaller gate lengths; 14 nm are expected by 2015, and 10 nm by 2018.

However, size reductions beyond 10 nm and additional performance improvements may not be possible using silicon, meaning new materials will be needed to continue progress, Ye says.

Creating smaller transistors also will require finding a new type of insulating, or "dielectric" layer that allows the gate to switch off. As gate lengths shrink smaller than 14 nm, the dielectric used in conventional transistors fails to perform properly and is said to "leak" electrical charge when the transistor is turned off.

"Nanowires in the new transistors are coated with a different type of composite insulator, a 4 nm thick layer of lanthanum aluminate with an ultrathin, half-nanometre layer of aluminium oxide. The new ultrathin dielectric allowed researchers to create transistors made of InGaAs with 20 nm gates, which is a milestone," Ye points out.

The work, based at the Birck Nanotechnology Centre in Purdue's Discovery Park, was funded by the National Science Foundation and the Semiconductor Research Corporation.

Sagem & Thales strengthen Sofradir's IR technology

Sagem will transfer to Sofradir its indium antimonide (InSb) and indium gallium arsenide (InGaAs) technology

French firm Sofradir is to acquire Sagem and Thales' infrared (IR) detector technology development and manufacturing facilities.

Sagem and Thales bring to Sofradir IR technologies originally developed for their internal purposes.

IR detectors are used in many military, space, commercial and scientific applications.

They are utilised in thermal imagers, missile seekers, surveillance systems, targeting systems and observation satellites. Their performance and price are key to the competitiveness of optronics systems.

Sagem will transfer to Sofradir its InSb technology. The Quantum Well-Infrared Photodetector (QWIP) and InGaAs technologies will also be transferred to Sofradir from the GIE III-V Lab, an economic interest group with partners Alcatel Lucent, Thales and research institute CEA (the French nuclear energy and alternate energies commission).

By consolidating these IR technologies under one roof, Sofradir joins a small circle of IR detector manufacturers with expertise in all the cooled and uncooled IR technologies.

Sofradir believes the acquisition will pave the way to a global leadership position in the imaging market. The firm maintains it is currently ranked number one for volume deliveries of IR detectors based on its Mercury Cadmium Telluride (HgCdTe) technology.

Serge Adrian, senior vice president of Land Defence at Thales, and Philippe Petitcolin, chairman and CEO of Sagem, praised the agreement that strengthens a key technopole and further enhances years of research initially carried out by Thales, and then by the III-V Lab and Sagem. He said, "We are confident that Sofradir will take these IR activities to the next level and benefit from the synergies between the different IR technologies."

"The technologies from Sagem and the III-V Lab enable Sofradir to have from this point forward the complete portfolio of infrared technologies. These assets consolidate Sofradir's leadership position," added Philippe Bensussan, chairman and CEO of Sofradir.

"With the new technologies, Sofradir, along with its subsidiary ULIS, will be able to select the technology best adapted to our clients' applications. We are in a fortified position to offer IR products with more innovation, performance and compactness in order to respond to any IR market need," added Bensussan.

Opel laser uses POET optoelectronic platform

The III-V gallium arsenide (GaAs) based monolithic platform could change the roadmap for smartphones, tablet and wearable computers

Opel's U.S. affiliate, Odis Inc. has produced an integrated laser device in its Planar Optoelectronic Technology (POET) process.

The laser enables high-performance devices fusing optical and electronic devices together on a single chip.

By allowing the production of components with increased speed, density, reliability, and lower costs, the III-V POET process offers the ability to push Moore's Law to the next level. This overcomes current silicon-based bottlenecks, and could change the roadmap for a broad range of applications, such as smartphones, tablet and wearable computers.

After years of development, the fabrication of the first Vertical Cavity Laser, (VCL) utilising Odis'patented POET GaAs III-V technology is a significant success.

Incremental progress over the years has led to what many consider to be the next phase of semiconductor development which is to surpass the capabilities of complementary metal oxide semiconductor (CMOS) technology for the next generation of high speed low power applications. It is now widely believed that CMOS technology advances have reached a saturation point.

The new laser serves as the basis for chip-to-chip interconnection, and complements numerous other optoelectronic devices already demonstrated by Odis – including heterostructure field effect transistors (HFETs), optical thyristors, pulsed lasers, and super-radiant light emitting devices – all able to be monolithically fabricated via the POET process.

"Rarely can one be part of a development that truly has the potential to change the way the things work on so many different levels and platforms. We believe that this is 'the key milestone' and indeed this is one of those moments. Dr. Taylor and the Odis team have chosen to achieve the most difficult laser first and have done so under extreme duress. This is not just an endorsement of the Odis' Team but also of the POET process itself," summarises Peter Copetti, Executive Director of the Board of Opel.

Copetti adds, "The reset of our milestone timelines by approximately 8 weeks because of equipment repair caused by Hurricane Sandy is obviously a disappointment to everyone involved, but we believe it is merely a bump in the road. In the long run, it should have no material impact on monetising POET and continuing to deliver shareholder value."

Led by Chief Scientist Geoffrey Taylor, the team of scientists and technologists at Odis see the latest achievement as one of the most significant milestones of a decades-long effort.

Taylor notes, "I'm extremely proud of the team who overcame equipment setbacks triggered by Hurricane Sandy that reset our timelines. I'm confident POET remains on track with its vision of full monolithic integration and its applications in microprocessing."

The POET advantage is the merging of optical devices into the growth and fabrication that supports complementary HFET analogue and digital functions. The *n*-channel and *p*-channel FETs take Opel Technologies Inc. advantage of the high mobilities inherent to strained quantum wells.

At the same time, the quantum wells provide the active emitter for lasers and amplifiers and the active absorber for detectors and modulators.

The intimate connections between diverse device types enables novel gate designs which dramatically reduce the power consumed in the opto-electronic (OE) and electro-optic conversions. The VCL has the small footprint required for dense circuit layout and enables vertical connections from anywhere in the circuit plane to fibre or to other stacked chips.

What's more, the same VCL structure enables in-plane and edge emitting operation based upon proprietary OE designs. Opel believes the availability of the integrated VCL will change the architecture and design for future complementary integrated circuits.

Moving forward, development will lower the threshold current, increase the output power and optimise the in-plane version of the VCL. Also, the complementary transistor circuit capability will be enhanced by reducing the feature size to the 100 nm scale incorporating Odis' new self-aligned contact technology.

With transistor cutoff frequencies around 38 GHz for a 0.7μm gate, the scaling is expected to produce 260 GHz transistors with big improvements in circuit speed.

POET's short-term industry solution is expected to include an optical interface as a single chip to connect existing CMOS processors. The optical

interface chip integrates the laser, modulator, modulator driver, detector, receiver amplifiers, serialiser/deserialiser, clock and data recovery, and phase-locked-loop circuits monolithically.

The longer-term solution would look to replacing CMOS gates with POET complementary HFET gates.

POET processors would provide their own optical output and also perform the optical receive function and therefore the need for a separate interface chip would no longer be required.

“This is a key milestone in our acceleration of POET for commercial application,” notes Leon M. Pierhal, CEO of Opel. “Opel now has all components in place for on-chip integration of photonic circuits in the same semiconductor framework as electronic circuits.”

Pierhal continues, “Hurricane Sandy’s effect was felt at Odis’s R&D facility at the University of Connecticut. Sandy’s devastation affected all members of the Odis staff and the Odis facility itself. Equipment damage within the facility caused by Sandy made the recovery from the storm and the completion of the VCL extremely difficult. It took a herculean effort to complete the VCL.”

He adds, “The damage inflicted on the delicate equipment must now be effectively and permanently addressed in order to continue with POET’s milestone achievements. A rebuild and retrofitting period of six to eight week is being planned for December and January which will delay the rollout planning process.”

The POET platform is currently the basis for a number of key Odis commercial and military projects. These include optical code division multiple access devices for avionics systems, combined RF/optical phased arrays, optoelectronic directional couplers, and ultra-low-power random access memory.

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PIC market to top $1.5 billion by 2022

These devices, many based on indium phosphide (InP) and gallium arsenide (GaAs) technology, have changed the dynamics of the optical network industry

According to a new MarketsandMarkets publication, the total market is expected to reach almost $1,55 billion by 2022, at a CAGR of 26.3 percent.

Photonic integrated circuits (PICs) are also known as planar light wave circuits or integrated optoelectronic devices.

The technology has revolutionised the optical network industry. Its ability to process large amount of data at huge speeds makes it an important contributor in enhancing the transmission capacity of optical fibre communications.

PICs have changed the dynamics of the optical network industry by increasing optical performance and reliability while reducing physical size, power consumption and heat dissipation.

Currently, 500 Gbps PICs have been developed to deliver high-capacity transmission while optimising power, cooling, space and operational simplicity. PICs are being developed for other applications like optical sensors, quantum computing and biomedical.

Quantum computing is forecasted to be commercialised by 2017. It will take the market by storm from the moment it gets launched. It is predicted to grow at a phenomenal rate of 139.6 percent from 2017 to 2022.

The emergence of silicon photonics has also changed market dynamics as it has enabled large scale production of PICs at low cost.

At the moment, the market leaders are developing medium and large PICs capable of incorporating 100-1000 components/functions in a single InP based monolithic substrate.

There are various types of integration techniques used to fabricate PICs, which include integration techniques such as module, hybrid and monolithic.

The raw materials consist of InP and GaAs, lithium niobate, silica on silicon and silicon on Insulator.

Presently North America is the biggest market for PICs followed by Europe and APAC. However APAC is anticipated to emerge as the market leader by 2022 because of the prolific growth of datacentres and access network in that region.

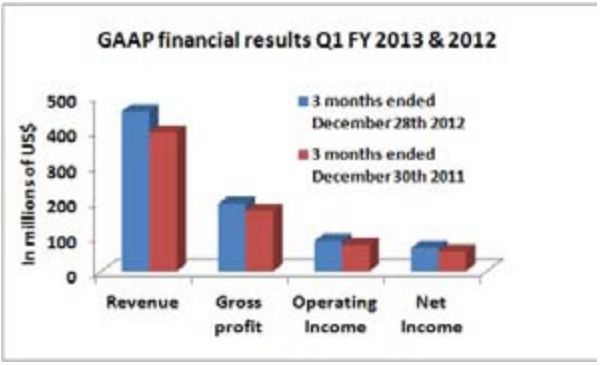
The report from MarketsandMarkets, which describes the subject in more detail is, "Global Photonic Integrated Circuit (Ic) & Quantum Computing Market (2012 - 2022) by Application [Optical Fiber Communication and Sensors, Biomedical], Integration [Hybrid, Module and Monolithic], Components, Raw Materials and Geography."]

RF Electronics

Skyworks smashes Q1 FY 2013 forecast

The company delivered revenue of $454 million, up 15 percent Year-Over-Year

Skyworks Solutions, Inc., an innovator of III-V analogue semiconductors, has reported first fiscal quarter 2013 results for the period ending December 28th, 2012.



Revenue for the quarter was $453.7 million, up 15 percent when compared to $393.7 million in the first fiscal quarter of 2012 and exceeding the company's guidance of $450 million.

On a GAAP basis, operating income for the first fiscal quarter of 2013 was $86.6 million and diluted earnings per share was $0.34, up from $0.30 for the same quarter last year. Basic earnings per share was $0.35 as opposed to $0.31 for FY Q1 2012.

"As our results and guidance reflect, Skyworks is enabling anytime, anywhere communications across a diverse set of end markets and applications," said David J. Aldrich, president and chief executive officer of Skyworks.

"We're capitalising on growing consumer and enterprise demand for ubiquitous connectivity spanning all modes of wireline and wireless communications. In fact, our analogue semiconductor solutions are increasingly at the heart of everything from smartphones to smart appliances to home security systems to satellites to medical sensors to hybrid vehicles. This market diversity coupled with Skyworks' leadership scale, product breadth and system IP is setting the stage for continued market outperformance and shareholder value creation."

Second Fiscal Quarter 2013 Outlook

"Given order visibility and specific product launches, we expect to continue to gain market share and capture additional content per platform in the seasonally low March quarter," said Donald W. Palette, vice president and chief financial officer of Skyworks. "Specifically, for the second fiscal quarter of 2013, we anticipate revenue to be up 15 percent year-over-year with better than normal seasonality to approximately $420 million with non-GAAP diluted earnings per share of $0.47."

Skyworks hosted a conference call with analysts to discuss its first fiscal quarter 2013 results and business outlook. A replay of the conference call can be accessed on Skyworks' website by calling 800-475-6701 (domestic) or 320-365-3844 (international), access code: 275282.

RFMD changes share repurchase program

The company's board of directors has authorised an extension of its 2011 share repurchase program to repurchase up to $200 million of the company's common stock through January 31st, 2015

Since January 2011, RFMD has repurchased $49.9 million of its common stock under this program, leaving it with additional authorisation of up to $150.1 million under the program as a result of this extension.

RFMD's share repurchase program authorises the company to repurchase shares from time to time through solicited or unsolicited transactions in the open market or in privately negotiated transactions.

The number of shares to be purchased and the timing of the purchases will be based on market conditions RFMD extends share repurchase program and other factors.

The firm says the program may be discontinued at any time.

Rubicon has shipped 400,000 large dimension sapphire wafers

The wafers are building block for LEDs used in HDTVs, laptops, smart phones and tablets and RFICs

Rubicon Technology has shipped a total of 400,000 large diameter sapphire wafers to LED and SoS/ RFIC manufacturers.

Sapphire is a key building block for LEDs used in HDTVs, laptops, smart phones and tablets. Another significant market for sapphire is Silicon-on-Sapphire (SoS) Radio Frequency Integrated Circuits (RFICs).

SoS RFIC chips deliver high RF performance with low power consumption, a small form factor, and significantly reduced crosstalk in antenna applications that are pervasive in smart phones and other consumer devices.

Rubicon claims it was the first firm to develop large diameter sapphire wafers for use in the RFIC market and customise needs for the LED industry.

"This latest milestone demonstrates Rubicon's continuing leadership in the volume delivery of high quality large-diameter sapphire wafers," says Raja M. Parvez, President and CEO of Rubicon Technology.

"Our emphasis on vertical integration - achieving cost efficiencies and control of sapphire production – enables us to scale production and ensures our customers an unparalleled, reliable supply of high quality, large diameter sapphire wafers that meet their unique and exacting specifications. Rubicon's capabilities are increasingly important as LED manufacturers seek to reduce costs throughout the manufacturing process to make LED-based lighting more affordable for consumers and encourage adoption worldwide."

IMS Research estimates that the overall LED market will reach nearly $10.9 billion in 2012 with $2.9 billion in lighting. By 2015, IMS projects that the LED market will reach $13.9 billion with the lighting market nearly doubling to $5.8 billion in three year.

RFMD Introduces 5GHz WiFi Module for 802.11ac Notebook and Mobile Equipment Applications

RF Micro Devices the designer and manufacturer of high-performance radio frequency components, today introduced the highly-integrated RFFM4501E front end module (FEM) for 802.11ac notebook and mobile equipment applications. RFMD's newest WiFi FEM meets or exceeds the system requirements for 802.11ac connectivity in the 5.150GHz – 5.850GHz frequency band and is optimized to support multiple applications, including notebooks, mobile routers, and low-power customer premises systems.

The RFFM4501E integrates a +17.5dBm (80MHz MCS9) PA at 3.3V, a low insertion loss/high isolation single pole two throw (SP2T) switch, harmonic filtering, and a low noise amplifier (LNA) with bypass mode, for equipment manufacturers seeking to adjust receive sensitivity. The receive chain provides 12.5dB of typical gain with only 12mA of current and an excellent noise figure of 2.5dB. Separate Rx/Tx 50 Ohm ports simplify matching and provide input and output signals for both the

transmit and receive paths.

The RFFM4501E is optimized to mate with the 802.11ac chipset of a leading semiconductor company. The ultra-small form factor (3mm x 3mm x 1.1mm) and high level of integration of the RFFM4501E shrink the product footprint, reduce external component count, minimize assembly costs, speed time-to-market, and enable industry-leading product performance.

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

This is according to Strategy Analytics' GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review July - September 2012: Microelectronics."

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth.

The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

"The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

This viewpoint summarises financial, product, contract and employment developments from leading semiconductor device suppliers from July - September of 2012. These announcements address a variety of commercial and military applications products and companies that use GaAs, GaN, SiC, SiGe and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

RFMD introduces integrated InGaP PA modules for WiFi

The devices are built using the firm's advanced indium gallium phosphide HBT process

RFMD's new RFPA520x series of three-stage WiFi PA modules are designed for 802.11b/g/n applications.

Other uses include consumer premise equipment, picocells, femtocells, data cards and terminals and ISM band transmitter applications. They can also be used in wireless access points, gateways, routers and set top box appliances.

Each is a high-performance, highly integrated solution with minimal external components, eliminating the need for any external matching

components and greatly reducing layout area, bill of materials and manufacturing costs for the customer application.

These PAs have high linear output power while maintaining excellent power added efficiency (PAE). RFPA5200 comes in a 4mm x 4mm x 1mm, 10-pin laminate package, while RFPA5201 comes in a 14-pin, 7mm x 7mm Multi-Chip Module (MCM).

Features include:

POUT: RFPA5200: 27dBm, 5V < 3% Dynamic EVM RFPA5201: 29dBm, EVM = 3%; 11n MCS7 HT40

High PAE: RFPA5200: 21% RFPA5201: 18.5%

High gain: RFPA5200: 33dB RFPA5201: 33.5dB

Input and output matched to 50Ω

Integrated power detector, biasing, harmonic filtering, and enable pin

Both parts are available now in production quantities. Pricing for 5000 pieces begins at $1.26 each for RFPA5200 and $2.64 each for RFPA5201.

RFMD reveals 5GHz WiFi module for 802.11ac

The RFFM4501E is based on the firm's InGaP HBT and GaAs pHEMT technologies and is designed for notebook and mobile equipment devices

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RFMD`s Kobayashi awarded 2013 IEEE Fellow

Kobayashi has been acknowledged for his work in gallium arsenide (GaAs) MMIC and indium phosphide (InP) technology

RFMD Fellow Kevin W. Kobayashi has been named a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) by the IEEE Board of Directors.

The IEEE grade of Fellow was conferred on Kobayashi in recognition for his contributions to monolithic microwave integrated circuits (MMICs).

The IEEE is one of the world's largest professional associations for the advancement of technology.

Less than one-tenth of one percent of the total IEEE voting membership is recognised each year by the IEEE Board of Directors for elevation to IEEE Fellow.

Bob Bruggeworth, CEO and president of RFMD, says, "Kevin is an outstanding engineer with an extraordinary record of accomplishments. His extensive industry knowledge and deep expertise across multiple technologies are valuable assets to RFMD and to our customers. We stand with

the IEEE in congratulating Kevin for his industry achievements and for his recognition as IEEE Fellow."

Kobayashi is the principle author of 130 technical publications and the inventor of 48 U.S. patents. Noteworthy are his inventions improving the broadband linearity and dynamic range of fundamental MMICs such as the Darlington pair, Gilbert cell, Doherty, cascode, and distributed amplifier topologies.

His early work on GaAs MMIC technology established the foundation for many of the first HBT, HEMT, and MESFET MMIC insertions in national space satellite systems and for the first commercial GaAs HBT MMIC products for the wireless industry. He was early to recognize the benefits of GaAs HBT for RF and microwave applications, and he was first to design a microwave GaAs HBT Darlington feedback amplifier, later helping to commercialise it into a high volume product.

Kobayashi's contributions to MMICs span multiple compound semiconductor and silicon technologies. He helped prove the viability of monolithic GaAs BiFET-type solutions in challenging microwave designs. He also demonstrated the advantages of InP HBT for millimetre-wave and fibre optic applications, later inventing a wide dynamic range transimpedance amplifier currently deployed in an industry-leading 40 Gbps InP receive optical subassembly (ROSA).

More recently, Kobayashi has been engaged in the development of GaN MMICs, having achieved record low noise and wideband linearity expected to enable future radio architectures. One of his HEMT-HBT MMIC demonstrations (the world's first) is displayed in the MTT historical exhibit, along with a GaAs HBT MMIC he developed.

Kevin Kobayashi serves on several IEEE conference committees and has served as an associate editor of the Journal of Solid-State Circuits, applying his extensive RF and microwave experience in technical reviews of emerging silicon RF, millimetre-wave and fibre optic ICs.

RF power amplifier sales for wireless Infrastructure on the road to recovery

According to ABI Research, despite the downturn in 2012, the RF market in the foreseeable future in the Asia-Pacific region, particularly China, will remain the most important region

Although 2012 turned out to be an off year for RF power amplifiers and devices for wireless infrastructure the market still held its own. The current year should be viewed as a breathing space before both segments resume stable and moderate growth after an explosive 2011.

The Asia-Pacific Region, including Japan, continues to account for over 75 percent of the RF power semiconductor devices that are sold into the mobile wireless infrastructure segment.

According to ABI Research research director Lance Wilson, "For the foreseeable future the Asia-Pacific region, particularly China, will remain the most important region and focus for RF power amplifiers and high-power RF devices for wireless infrastructure."

Despite the off year RF power amplifier sales for wireless infrastructure will top $2.4 billion and RF power device sales will be over $600 million.

LTE will become an increasingly important factor in both of these businesses even though the rollout has not been as rapid as the industry would like. Nevertheless, it is already worldwide in scope. "Although LTE has not significantly impacted RF power amplifier and device sales as of yet," says Wilson, "it is going to bolster RF power sales in the wireless infrastructure space from 2012 on."

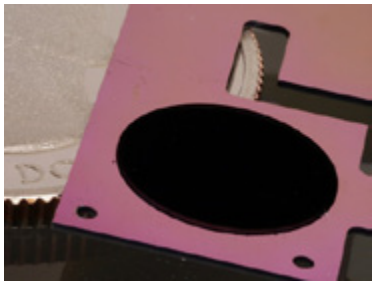
Lasers

Simplifying laser power measurements for telecoms

NIST's prototype carbon nanotube device is a silicon chip topped with circular mats of carbon nanotubes standing on end

NIST has demonstrated a chip-scale instrument made of carbon nanotubes that may simplify absolute measurements of laser power.

The device is especially suited to transmitting light signals used in optical fibres in telecommunications networks.



The circular patch of carbon nanotubes on a pink silicon backing is one component of NIST's new cryogenic radiometer, shown with a quarter for scale. Gold coating and metal wiring has yet to be added to the chip. The radiometer will simplify and lower the cost of disseminating measurements of laser power. (Credit: Tomlin/NIST)

The prototype device, a miniature version of an instrument called a cryogenic radiometer, is a silicon chip topped with circular mats of carbon nanotubes standing on end.

NIST says the mini-radiometer builds on its previous work using nanotubes, the world's darkest known substance, to make an ultra efficient, highly accurate optical power detector.

"This is our play for leadership in laser power measurements," project leader John Lehman says. "This is arguably the coolest thing we've done with carbon nanotubes. They're not just black, but they also have the temperature properties needed to make components like electrical heaters truly multifunctional."

National metrology institutes around the world measure laser power by tracing it to fundamental electrical units. Radiometers absorb energy from light and convert it to heat. Then the electrical power needed to cause the same temperature increase is measured.

NIST researchers found that the mini-radiometer accurately measures both laser power (brought to it by an optical fibre) and the equivalent electrical power within the limitations of the imperfect experimental setup. The tests were performed at a temperature of 3.9 K, using light at the telecom wavelength of 1550nm.

The tiny circular forests of tall, thin nanotubes called VANTAs ("vertically aligned nanotube arrays") have several desirable properties. More importantly, they uniformly absorb light over a broad range of wavelengths and their electrical resistance depends on temperature.

The versatile nanotubes perform three different functions in the radiometer.

One VANTA mat serves as both a light absorber and an electrical heater, and a second VANTA mat serves as a thermistor (a component whose electrical resistance varies with temperature).

The VANTA mats are grown on the micro-machined silicon chip, an instrument design that is easy to modify and duplicate. In this application, the individual nanotubes are about 10nm in diameter and 150μm long.

By contrast, ordinary cryogenic radiometers use more types of materials and are more difficult to make. They are typically hand assembled using a cavity painted with carbon as the light absorber, an electrical wire as the heater, and a semiconductor as the thermistor.

Also, these instruments need to be modelled and characterised extensively to adjust their sensitivity, whereas the equivalent capability in NIST's mini-radiometer is easily patterned in the silicon.

NIST plans to apply for a patent on the chip-scale radiometer. Simple changes such as improved temperature stability are expected to greatly improve device performance.

Future research may also address extending the laser power range into the far infrared, and integration of the radiometer into a potential multipurpose "NIST on a chip" device.

More details of this work are described in the following articles:

"Carbon nanotube electrical-substitution cryogenic radiometer: initial results," by N.A. Tomlin *et al* in*Optics Letters*, Vol. 38, No. 2. Jan. 15, 2013.

NIST Tech Beat article, "Extreme Darkness: Carbon Nanotube Forest Covers NIST's Ultra-dark Detector," at www.nist.gov/pml/div686/dark_081710.cfm.

and

NIST Tech Beat article, "Prototype NIST Device Measures Absolute Optical Power in Fiber at Nanowatt Levels," at www.nist.gov/pml/div686/radiometer-122011.cfm.

JDSU executives restructure

The firm has promoted Rex Jackson as executive VP and CFO and appointed Susan Spradley as SVP and GM of the Communications Test and Measurement Business segment

JDSU has appointed Rex Jackson as executive vice president and chief financial officer, and Susan Spradley as senior vice president.

Spradley will have the responsibility of developing and managing of the company's communications test and measurement product portfolio.

Jackson reports to Tom Waechter, JDSU's president and chief executive officer, and has served as acting CFO since September 2012.

He joined JDSU two years ago as senior vice president, Business Services, with responsibility for several corporate functions, including Information Technology, where he has driven significant operational improvements. Jackson brings strong financial management experience to the company.

Prior to JDSU, Jackson served as executive vice president and chief financial officer at Symyx Technologies, where he led the company's acquisition of MDL Information Systems and subsequent merger with Accelrys. Jackson also served as acting CFO at Synopsys and held executive positions with Avago, AdForce and Read-Rite.

"Rex's strong performance as acting CFO and his deep knowledge of the company's strategy to drive profitable growth - combined with his prior experience as a public company CFO - make him an excellent choice for this key leadership position," said Waechter.

Susan Spradley joins JDSU as senior vice president and general manager of the Communications Test and Measurement (CommTest) business segment. Reporting to David Heard, CommTest's president, she is responsible for the development and management of the communications test product portfolio, including instruments, probes, software applications and service assurance solutions.

Spradley brings more than 20 years of telecommunications industry experience to JDSU, serving in executive positions at Nokia Siemens Networks and Nortel. Spradley was appointed by the President of the United States to serve on the National Security Telecommunications Advisory Committee and is chair of a White House and National Science Foundation initiative, called U.S. Ignite, to promote U.S. leadership in developing applications and services for broadband and software - defined networks.

"Sue brings unique experience and strong relationships with the world's leading network equipment manufacturers and service providers to JDSU," said Heard. "She is ideally suited to advance our communications test growth strategy as we transition from traditional test and measurement to providing an integrated portfolio of instruments and software for the enablement of networks, services and applications."

Jenoptik to present 300mm wafer packaging technology

The photodiodes are made from a range of III-phosphides, arsenides, nitrides and silicon carbide

The company says it is the main sponsor of the SPIE Startup Challenge 2013 to support young entrepreneurs.

In the field of laser material processing, Jenoptik will present the femtosecond laser JenLas D2.fs with improved parameters.

Laser JenLas D2 fs

Maintaining stable beam quality, the output power and pulse repetition rate of the laser have been increased to allow for faster material processing in industry and medical technology.

Also, the 1 kilowatt fibre laser JenLas fiber cw 1000 for application in material processing, in particular for non-contact cutting and welding of metals with high flexibility and speed will be showcased.

Jenoptik will also present new ultra-precision optics processed using Ion Beam Figuring (IBF) at Photonics West.

The new F-Theta lens series Silverline complements Jenoptik's portfolio of full fused-silica lenses for micro-processing with high-power fibre and picosecond lasers.

In the field of sensor systems, Jenoptik will introduce the high-definition thermography camera IR-TCM HD 1024 to the US market. The handheld camera allows for the detailed and precise analysis of temperature distributions, in particular in the case of large objects or large focusing distances.

Jenoptik is also supporting the entrepreneur competition "SPIE Startup Challenge".

This year Jenoptik will again be the lead sponsor of the annual entrepreneur competition of SPIE, the international society for optics and photonics. SPIE fellow Jay Kumler, responsible for the U.S. activities of the Jenoptik Optical Systems division, will be judge member for the SPIE Startup Challenge 2013 competition, which serves to support entrepreneurial projects.

Aspiring entrepreneurs from the field of optical and photonic technologies participating in the SPIE Startup competition will pitch their innovative business ideas to a team of expert judges.

"The SPIE Startup Challenge has become an outstanding opportunity to see early-stage innovation in progress," says Jay Kumler. "Partnering with SPIE as lead sponsor for the past two years is one tool that Jenoptik uses to encourage entrepreneurship in our Group and in our industry. The event fits our values and our culture very well."

The ten finalists will receive sponsorship opportunity to attend the Entrepreneurship Academies organised by the University of California. The top three finalists will also receive a financial prize.

Mid-Atlantic/Chesapeake rep offers Firecomms FOTs

Firecomms' new fibre optic transceivers are suited to industrial automation, transportation and medical markets

Firecomms has signed a representative agreement with Colrud-Lowery to better serve key industrial automation, transportation, and medical businesses in the Mid-Atlantic/Chesapeake region.

A representative of electro-mechanical and passive components in the Mid-Atlantic/Chesapeake region, Colrud-Lowery is known among its customers and distribution partners as a team of technical sales professionals with a commitment to exceed expectations.

"We are very excited about the opportunity to help

Firecomms expand its footprint in the plastic optical fibre market ," says Colrud-Lowery Vice President Jeb Bartle. "Firecomms is an energetic company with new products that should dovetail nicely with our marketplace."

"As our fibre optical transceivers are ideal for industrial automation, transportation, and medical applications, we have sought a representative in the Mid-Atlantic/Chesapeake region that will effectively serve large businesses in these markets," adds Lawrence Thorne, Firecomms Vice President of Sales and Marketing, North America. "Due its excellent reputation among both its customers and partners, we have chosen Colrud-Lowery to offer our OptoLock, LC, and new RedLink fibre optical transceivers to key customers in that region."

Firecomms recently announced a significant expansion of its line of fibre optical transceivers, which now includes:

RedLink, a series of DC-capable transmitters and receivers for industrial command and control applications that are drop-in compatible with the Versatile Link range of products. Firecomms RedLink range is perfect for low-speed and DC-capable applications, such as IGBT/thyristor control and fault feedback or field I/O, in areas where immunity from harmful EMI or high voltage signals is required.

The first LC connectors designed for use with plastic optical fibre (POF) and other large core glass fibres such as HCS. Known for its compact form factor, the LC connector is widely used in the optical networking industry. The company specifically developed the LC product range due to its recognised durability and reliability for industrial automation applications.

Firecomms innovative OptoLock plugless fibre optic transceivers, which along with the LC connectors are ideal for Ethernet- or TCP/IP-based applications as well as for proprietary optical link solutions.

In addition to its industrial fibre optic transceivers, Firecomms now offers an accompanying line of cable assembly solutions to enable quick field installations without extensive training.

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

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The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

"The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

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Optical market still facing tough times

Firms in the LED and equipment market are still facing rapidly declining prices and waning demand and are finding it difficult to increase revenue and income. However, it's not all bad news - product development remains a bright spot

Rapidly declining pricing, softening demand and the continuing uncertainty of the global economy are creating challenges for manufacturers at all stages of the optical industry supply chain.

Most of the companies that manufacture equipment, material and devices for LEDs, optoelectronic devices and photovoltaic devices are seeing declining revenue and income, or outright losses.

This is according to the Strategy Analytics report, "Compound Semiconductor Industry Review July – September 2012: Optoelectronics, Materials and Equipment" It captures financial announcements from companies such as Soitec, Aixtron, AXT, Hitachi Cable, JDSU, Finisar, Oclaro, Emcore, GigOptix, IQE, Kopin, Cree, OpNext, First Solar and Spire.

Despite declining financials at many of these companies, the report concludes that product development activities remain strong with the announcement of several new LED and higher data rate optical components.

"With a few notable exceptions like Dowa, First Solar and Cree, most of the other companies in this report struggled to increase revenue and income," observes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "Companies in the LED and equipment market are trying to address rapidly declining prices in conjunction with declining demand and they are finding it difficult to increase revenue and income in this environment."

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Companies in the optical component segment of the supply chain are developing products for higher data rate networks, but most of the equipment orders at the front-end of the optical supply chain are going to research institutions rather than production expansions."

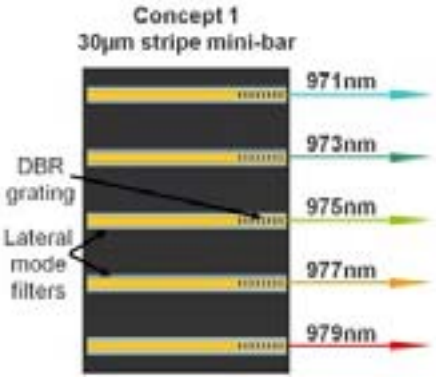
Here come the BRIDLE diode lasers

A new consortium has been set up to develop III-V diode-laser mini-bars for industrial applications

A consortium of companies and research institutes from five European countries have joined forces in an EC funded research project.

Their aim is to achieve dramatic improvements in the brilliance of high-power direct diode laser systems.

BRIDLE makes use of a modular, scalable and upward compatible approach, employing advanced technologies and beam combination architectures, leading to a diode laser source that delivers more than 2kW output power from a Ø100µm, NA less than 0.15 optical fibre with a power conversion efficiency of over 40 percent.



BRIDLE diode-laser mini-bar design concept based on tapered emitters

Novel diode-laser mini-bars will be developed by the consortium targeting a three times higher

brilliance compared to commercially available broad area emitters. They also aim to accomplish dense and coarse spectral multiplexing schemes pursued for power scaling.

What's more, coherent beam combining techniques that phase-couple bars to produce nearly diffraction limited output will be investigated.

During the project, a sequence of increasingly brilliant demonstrators will be developed, each targeting a specific industrial application. Manufacturability and cost down-scaling issues are also addressed by integrating micro-optical beam shaping and beam combination into the production process.

The project, was initially coordinated by Dilas Diodenlaser GmbH in Germany. The consortium includes researchers from University of Nottingham, United Kingdom, the Fraunhofer Institute for Laser Technology ILT and the Ferdinand Braun Institute FBH, both Germany, the Laboratoire Charles Fabry of the Institut d'Optique at CNRS, France and the industrial partners Modulight of Finland and Bystronic, Switzerland.

Ultratech acquires assets of Cambridge Nanotech

The firm is expanding its nanotechnology and IP portfolio with atomic layer deposition to enhance capability in new market opportunities such as semiconductors

Ultratech, Inc., a supplier of laser-processing systems used to manufacture semiconductor devices has acquired the assets of Cambridge Nanotech, Inc. (Cambridge).

Based in Cambridge, *Massachusetts,* Cambridge was an innovator in atomic layer deposition (ALD) solutions with hundreds of system installations in research and manufacturing settings worldwide.

Financial terms of the transaction were not disclosed.

With this acquisition, Ultratech expands its nanotechnology and intellectual property (IP) portfolio with ALD technology to provide solutions for new layers within the electronics industry and entry into new markets, such as biomedical and energy.

Due to the increasing interest in nanoscience, ALD has emerged as a critical technology for depositing precise nanometre-thin films. Typical applications of ALD require the manufacture of very precise nanometre - thin, pinhole - free and conformal thin films on many shapes and geometries.

As a result, this technology will be in high demand in volume manufacturing environments and in particular for micro-electro-mechanical systems (MEMs), implantable devices in the biomedical sector and batteries and fuel cells in the energy arena.

ALD is an enabling technology and provides coatings and material features with significant advantages to other existing techniques.

Ultratech Chairman and Chief Executive Officer Arthur W. Zafiropoulo says, «As a global leader in experimental ALD solutions, Cambridge has developed a portfolio of valuable technology and systems. We plan to integrate the intellectual property acquired from Cambridge Nanotech into Ultratech and include the ALD systems in our nanotechnology product group. By increasing our IP and expanding our nanotechnology portfolio to new levels, we expect to generate a new revenue stream in existing and new markets. We have focused on technology solutions and support our global customer operations. We expect that this acquisition will enhance our short-term as well as our long-term growth expectations.»

Ultratech, Inc. designs, manufactures and markets photolithography and laser processing equipment. Founded in 1979, the company›s lithography products deliver high throughput and production yields at a low, overall cost of ownership for bump packaging of integrated circuits and HB-LEDs.

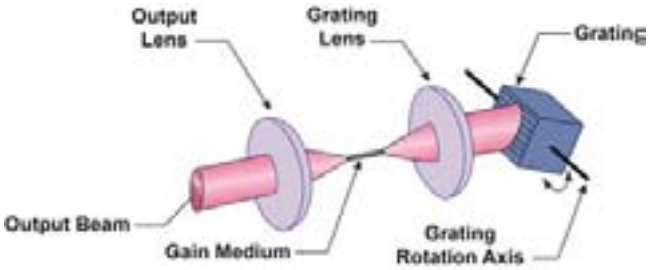
A pioneer of laser processing, Ultratech developed laser spike anneal technology, which increases device yield, improves transistor performance and enables the progression of Moore›s Law for 32 nm and below production of state-of-the-art consumer electronics.

Daylight Solutions secures 16th US patent for QC lasers

The latest patent relates to a method of combining beams from individual QCL sources to create a single beam of greater combined power and/or a multiple wavelengths

Daylight Solutions has announced the issuance of the company's 16th patent relating to its Quantum Cascade Laser (QCL) based technology.

As an early pioneer in QCL-based systems, Daylight Solutions has multiple patents either issued or pending that range from component level inventions to applications utilising mid-infrared laser technology.



External Cavity quantum cascade Laser design

The latest patent involves combining beams from individual QCL sources to create a single beam of greater combined power and/or a multiple wavelengths. The technique is valuable in a number of applications where high power or a combination of different wavelengths is necessary.

One such application is infrared countermeasures (IRCM), where mid-infrared lasers are used to protect aircraft from heat-seeking missiles.

"Daylight Solutions continues to receive significant patents relevant to both our core technology and our broad range of applications. The company has now been awarded 16 patents with over 400 claims. Daylight Solutions is committed to our leadership position in QCL-based technology development, ensuring the greatest competitive advantage for our customers," says Timothy Day, Daylight Solutions' CEO and CTO.

IPG Photonics CEO transfers stock for estate planning purposes

The CEO of the III-V fibre laser and amplifier manufacturer continues to beneficially own 15 percent of IPG Photonics common stock

Valentin P. Gapontsev, founder, Chief Executive Officer and Chairman of IPG Photonics has gifted 110,000 shares of IPG common stock to a new irrevocable trust.

The Valentin Gapontsev Trust III, dated December 13th, 2012 (Gapontsev Trust III) is intended for estate planning purposes.

Gapontsev Trust III purchased from Gapontsev 890,000 shares of IPG common stock and a 2 percent ownership interest in IP Fibre Devices (UK) Ltd. with a promissory note. The transfers of the unregistered stock to Gapontsev Trust III were not made on the open market. As required, Gapontsev will file a Form 4 reporting the transfers of stock to Gapontsev Trust III using appraised values.

After the transfers to Gapontsev Trust III, Gapontsev continues to beneficially own 7,981,933 shares of IPG Photonics common stock, or 15.6 percent of the Issuer's outstanding shares. This is comprised of 627,931 shares of IPG Photonics common stock owned directly by Gapontsev and 7,354,002 shares of common stock owned by IP Fibre Devices (UK) Ltd., of which Gapontsev is the sole managing director.

The trustees of the Trust are officers and employees of IPG Photonics and include Eugene Scherbakov, Alex Ovtchinnikov, Angelo Lopresti and Valentin Fomin.

IPG Photonics offers $0.65 per share one-off dividend

The manufacturer of III-V high-power fibre lasers and amplifiers is rewarding its stock holders as business is booming

It seems that not everyone is a casualty of the global recession.

The Board of Directors at IPG Photonics has approved a $0.65 per share one-time special cash dividend on its outstanding common stock.

This is payable on or around December 28th, 2012 to stockholders of record at the close of business on December 21st, 2012.

“Given our confidence in the company’s long-term growth prospects, our strong balance sheet and additional cash generated this year, the Board decided to reward our shareholders with a one-time special cash dividend,” says Chairman and Chief Executive Officer Valentin Gapontsev. “We will continue to have sufficient capital to fund our growth strategy, including new product launches and complementary acquisitions. With the possibility of tax increases on dividends, this dividend provides a tax efficient opportunity to return capital to all our shareholders.”

Oclaro takes first step in Opnext merger litigation

It is alleged that members of Opnext and its board breached their fiduciary duties to Opnext stockholders by entering into the merger agreement

The Superior Court of California in and for the County of Alameda has granted preliminary approval of the settlement of four pending putative class actions filed in that Court challenging the proposed merger between the Company, Tahoe Acquisition Sub, Inc., and Opnext, Inc.

The actions are as follows: (1) Zilberberg v. Abbe, Case No. RG12623460; (2) Welty v. Bosco, Case No. RG12624240; (3) Greenberg v. Abbe, Case No. RG12624444; and (4) Graf v. Opnext, Inc., Case No. RG12624798.

The defendants in each case are Opnext and the members of Opnext’s Board, and the Company and Tahoe Acquisition Sub, Inc.

Each action alleges that the Opnext defendants breached their fiduciary duties to Opnext stockholders by entering into the merger agreement. Each action further alleges that the Oclaro defendants aided and abetted those breaches of fiduciary duties.

The proposed settlement was previously disclosed in a Current Report on Form 8-K that was filed with the Securities and Exchange Commission on November 26th, 2012.

Under the proposed settlement, the remaining plaintiffs have agreed to settle these matters for additional disclosures only, subject to court approval. Plaintiffs have agreed to limit their application for fees and costs to $235,000. Also, the parties agreed that the two actions filed in the Delaware Court of Chancery challenging the merger, which have been consolidated under the caption In re Opnext, Inc. Shareholders Litigation, C.A. No. 7400-VCL, would be dismissed.

The proposed settlement is subject to final Court approval. The court has set a final approval hearing for January 31st, 2013, at 10:00 a.m. in Department 17 of the court, the Honourable Steven A. Brick, presiding.

The court’s preliminary approval order requires the company to provide a detailed notice to shareholders of the terms of the proposed settlement on a Current Report on Form 8-K.

Oclaro to offer $25 million of notes due 2018

The laser diode manufacturer’s Notes will be exchangeable into shares of common stock of the company

Oclaro, Inc. has announced that its wholly-owned subsidiary, Oclaro Luxembourg S.A. (the “Issuer”), has commenced a private offering, subject to market and other conditions.

Offered are approximately $25 million in aggregate principal amount of Exchangeable Senior Secured Second Lien Notes due 2018 (the “Notes”), to qualified institutional buyers pursuant to Rule 144A under the Securities Act of 1933, as amended (the “Securities Act”).

The Notes will be exchangeable into shares of

common stock of the company. The indenture governing the Notes will contain covenants restricting the company's ability and the ability of certain subsidiaries of the company to incur debt, make certain restricted payments, create liens, sell or dispose of certain assets and enter into certain mergers or corporate transactions.

The Issuer's obligations under the Notes will be guaranteed by the company and certain of its domestic and foreign subsidiaries, and will be secured by second priority liens on substantially all the tangible and intangible assets of the company, the Issuer and the guarantors. The interest rate, exchange rate and other terms of the Notes will be determined at the time of the pricing of the offering.

The company intends to use the net proceeds of the offering for general corporate purposes, including working capital. In addition, the company may use a portion of the net proceeds to acquire or invest in complementary businesses, products or technologies. The company's management will have significant discretion in applying the net proceeds of the offering.

This communication does not constitute an offer to sell or the solicitation of an offer to buy any securities and shall not constitute an offer, solicitation or sale in any jurisdiction in which such offer, solicitation or sale would be unlawful.

The Notes, the guarantees and the shares of the company's common stock issuable upon exchange of the Notes will not be registered under the Securities Act, or the securities laws of any other jurisdiction. They may not be offered or sold in the United States absent registration under the Securities Act or an applicable exemption from registration requirements.

Pfeiffer Vacuum expert honoured for X-ray laser innovation

X-ray laser research has advanced the analysis of compound semiconductors and many other materials

Christoph Bostedt has been awarded the Röntgen Prize of the Justus-Liebig University of Gießen

For over fifty years, Pfeiffer Vacuum, together with the Erich-Pfeiffer Foundation and the Ludwig-Schunk Foundation, has sponsored the Röntgen Prize for young scientists in the field of radiation physics.

Manufacturing processes for solar cells, semiconductors and DVDs are a few examples of applications for vacuum technology.

Vacuum plays a major role in research & development and environmental technology, as well as in the analytical and automotive industries. It is also used in MOCVD growth.

Bostedt is currently a researcher at Stanford Linear Accelerator Laboratory in the USA, where he is a team leader in the Linear Coherent Light Source (LCLS) in the field of nuclear and molecular physics.

Bostedt was awarded the Röntgen Prize for his research in innovative X-ray lasers. His work with the free-electron lasers FLASH and LCLS is especially highlighted. He was able to also take advantage of vacuum solutions by Pfeiffer Vacuum in his scientific work.

X-ray lasers, which are much brighter and have a much shorter pulse duration than other sources, have opened up a large range of new experiments. They also have a high repetition rate.

This has created a very large volume of experimental data from such sources. For example the CXI beamline at LCLS can produce ten times more data than the ATLAS detector at LHC during one year of continuous operation.

The tiny wavelength of X-rays allows us resolve the arrangement of atoms in many materials such as compound semiconductors.

Pfeiffer Vacuum provides hybrid and magnetically levitated turbopumps. The firm's product portfolio comprises backing pumps, measurement and analysis devices, components as well as vacuum chambers and systems.

InGaAs '4-D' transistor could be the future for computers

Indium gallium arsenide is one of the several promising semiconductors being studied to replace silicon

A new type of transistor shaped like a Christmas tree has arrived just in time for the holidays, but the prototype won't be nestled under the tree along with the other gifts.
"It's a preview of things to come in the semiconductor industry," says Peide "Peter" Ye, a professor of electrical and computer engineering at Purdue University.

Researchers from the universities of Purdue and Harvard created the transistor, which is made from a material that could replace silicon within a decade.
Each transistor contains three tiny nanowires made not of silicon, like conventional transistors, but from InGaAs. The three nanowires are progressively smaller, yielding a tapered cross section resembling a Christmas tree.

The research builds on previous work in which the team created a 3-D structure instead of conventional flat transistors. The approach could enable engineers to build faster, more compact and efficient integrated circuits and lighter laptops that generate less heat than today's.
New findings show how to improve the device performance by linking the transistors vertically in parallel.

"A one-story house can hold so many people, but more floors, more people, and it's the same thing with transistors," Ye comments. "Stacking them results in more current and much faster operation for high-speed computing. This adds a whole new dimension, so I call them 4-D."
The findings will be detailed in two papers to be presented during the International Electron Devices Meeting taking place between Dec 8th and 12th in San Francisco. One of the papers has been highlighted by conference organisers as among "the most newsworthy topics and papers to be presented."

The newest generation of silicon computer chips, introduced this year, contain transistors having a vertical 3-D structure instead of a conventional flat design. However, because silicon has a limited "electron mobility" - how fast electrons flow - other materials will likely be needed soon to continue advancing transistors with this 3-D approach, Ye adds.

Transistors contain critical components called gates, which enable the devices to switch on and off and to direct the flow of electrical current. Smaller gates make faster operation possible. In today's 3-D silicon transistors, the length of these gates is about 22 nanometres (nm), or billionths of a metre.
The 3-D design is critical because gate lengths of 22 nm and smaller do not work well in a flat transistor architecture. Engineers are working to develop transistors that use even smaller gate lengths; 14 nm are expected by 2015, and 10 nm by 2018.

However, size reductions beyond 10 nm and additional performance improvements are likely not possible using silicon, meaning new materials will be needed to continue progress, Ye says.
Creating smaller transistors also will require finding a new type of insulating, or "dielectric" layer that allows the gate to switch off. As gate lengths shrink smaller than 14 nm, the dielectric used in conventional transistors fails to perform properly and is said to "leak" electrical charge when the transistor is turned off.

Nanowires in the new transistors are coated with a different type of composite insulator, a 4 nm thick layer of lanthanum aluminate with an ultrathin, half-nanometre layer of aluminium oxide. The new ultrathin dielectric allowed researchers to create transistors made of InGaAs with 20 nm gates, which is a milestone, Ye continues.

The work, based at the Birck Nanotechnology Center in Purdue's Discovery Park, was funded by the National Science Foundation and the Semiconductor Research Corp.

IQE secures £1 million InP laser contract

The firm has secured a contract to produce indium phosphide wafers for lasers in telecommunications

IQE received its first single order valued at more than £1 million for advanced laser wafers to enable a new generation of fibre-optic communications devices.

Although InP wafers are much more fragile and more expensive than GaAs substrates there are many benefits to this material

In the telecoms industry, they are invaluable.

For example, Infinera relies on its InP PIC technology to provide fast broadband communication throughout the world.

IQE's new order is to be delivered during the first half of 2013 with further significant follow-on orders expected, driven by strong demand in China for datacentre applications and infrastructure build out.

The wafers will be produced at IQE's Cardiff manufacturing facility in its 100mm InP platforms.

Optical interconnects are on the brink of rapid growth driven by strongly increasing demand for "big data" applications across data centres, fibre-to-the-home (FTTH), backbone interconnection of 4G/LTE base stations and active optical cable (AOC) interconnects between computers and peripheral consumer electronic devices, to replace current copper USB2 cables.

Drew Nelson, President and CEO of IQE, says, "IQE has established a clear leadership position in the design and supply of advanced semiconductor wafers for a wide range of optoelectronic applications. This latest order for a new range of low-cost, high-performance optical fibre components marks a key milestone in the adoption of optical interconnects for a range of high volume applications."

Solar

Emcore delivers millionth III-V solar cell

The multi-junction solar cell to Space Systems/Loral (SS/L) will represent more than a megawatt of power delivered into space

Emcore and Space Systems/Loral will celebrate the occasion of Emcore's 1 millionth solar cell with a special event at Emcore's Albuquerque facilities during the week of February 25th, and with a commemorative award symbolising the feat.

Emcore has been supplying SS/L with high-efficiency, multi-junction solar cells for more than 10 years. In May 2009, the firm announced a long term supply agreement with SS/L to continue manufacturing and delivering solar cells for its spacecraft programs through 2014.

Emcore's business relationship with Space Systems/Loral has been integral to the development of the company's photovoltaics division and the growth of its space satellite solar power business.

"The Emcore team continually demonstrates their dedication to our business," says Vivian Mackintosh, Vice President of Supply Chain Management at Space Systems/Loral. "Emcore is more than just a supplier to SS/L. We have developed a close collaborative working relationship that ensures on time delivery and the highest level of quality."

"Delivering 1 million solar cells for more than 50 successful satellite launches by Space Systems/Loral is a tremendous milestone for Emcore and our space satellite solar business," adds Hong Hou, Chief Executive Officer at Emcore. "We are especially proud to have achieved this milestone with our solar cells meeting all requirements for performance and reliability. We are delighted and very grateful to continue this relationship, and we look forward to working with Space Systems/Loral to power their satellite missions for many years to come."

Emcore's multi-junction solar cells have a Beginning-Of-Life (BOL) conversion efficiency nearing 30 percent and the option for a patented, onboard monolithic bypass diode to provide one of the highest available powers to interplanetary spacecraft and earth orbiting satellites.

First Solar implores stockholders to reject tender offer

The cadmium telluride (CdTe) firm has been offered a mini tender offer by TRC Capital Corporation

First Solar has been notified of an unsolicited "mini-tender" offer by TRC Capital Corporation (TRC) to purchase up to 2 million shares, or approximately 2.3 percent, of the firm's outstanding common stock at a price of $30 per share in cash.

TRC's offer price is approximately 5 percent less than the $31.58 closing price of First Solar's common stock on January 22nd, 2013, the day before the mini-tender offer commenced.

First Solar does not endorse TRC's mini-tender offer and recommends that First Solar stockholders do not tender their shares in response to the offer because it is a mini-tender offer at a price below the market price for First Solar shares (as of the date First Solar received notice of the offer) and is subject to numerous conditions.

According to TRC's offer documents, First Solar stockholders who have already tendered their shares may withdraw their shares at any time prior to 12:01 a.m. New York City time, on February 22nd, 2013, the expiration date set forth in the offer documents (unless extended), by following the procedures described in the offer documents.

First Solar urges stockholders to obtain current market quotes for their shares, to review the conditions to TRC's mini-tender offer, to consult with their brokers or financial advisors and to exercise caution with respect to this mini-tender offer. First Solar says it is not associated with TRC, its mini-tender offer or the offer documentation.

TRC has made many similar mini-tender offers for shares of other companies. Mini-tender offers are designed to seek to acquire less than 5 percent of a company's outstanding shares, thereby avoiding many disclosure and procedural requirements of the Securities and Exchange Commission (SEC) that apply to offers for more than 5 percent of a company's outstanding shares. As a result, mini-tender offers do not provide investors with the same level of protections as provided by larger tender offers under United States securities laws.

The SEC has cautioned investors about these offers, noting that "some bidders make mini-tender offers at below-market prices, hoping that they will catch investors off guard if the investors do not compare the offer price to the current market price."

QuickerTek CIGS 62 W Solar Juicz charger powers Apple products

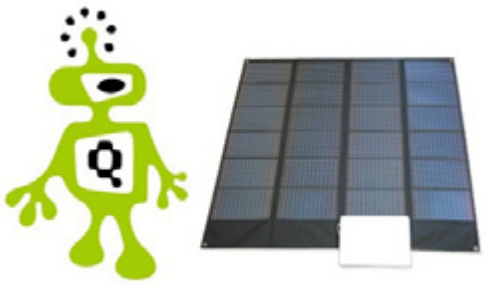
Apple MacBook Pro, Retina display and MacBook Air users now have the freedom solar power offers and the satisfaction of lowering the carbon footprint

QuickerTek, a provider of mobile power and wireless networking products to Apple computers, has revealed a 62 Watt (W) Solar Juicz solar power charger.

The company claims its new, higher performance solar charger is faster and packs more power in a smaller size.

QuickerTek believes it has improved efficiency of more than 39 percent over the previous Solar Juicz model as a direct result of using new technology as well as a philosophy of continual improvement.

Faster charge time is provided by higher wattage (62 W vs 55 W of the previous model).



62 W Solar Juicz charger

What's more, users can charge the laptop battery while using the Solar Juicz at the same time - something not always possible using other solar products. If you have sunlight, you have power,

whenever you need it.

Solar Juicz users gain 1.5 to 2 times greater power than more common thin-film flexible solar materials, by using CIGS technology. The product yields a 10.5 to 11 percent average efficiency - ideal for power on the go.

The firm says there is no other CIGS technology solar product available for any Apple device.

MacBook users can now spend even more time working away from the wall power outlet. Even if the laptop battery is completely dead, the Solar Juicz charges and powers the MacBook laptop simultaneously.

The latest product also comes ready to use right out of the box with either a Apple Magsafe 1 or a Apple Magsafe 2 power cable. This allows users to power and charge a wide variety of mobile devices from Apple.

Solar Juicz also charges QuickerTek's extensive line of Apple Juicz external battery products.

QuickerTek says it also regularly makes custom cables for users who need the convenience of solar power for other devices, such as digital still and video cameras.

The solar panel itself is flexible - allowing for easy transport and use. The higher efficiency technology is only 1534 square inches - 40 percent more compact than the previous 2478 square inches. The lighter and flexible solar panel also adapts to irregular surfaces better - providing an easy way to use the sun, regardless of the surroundings.

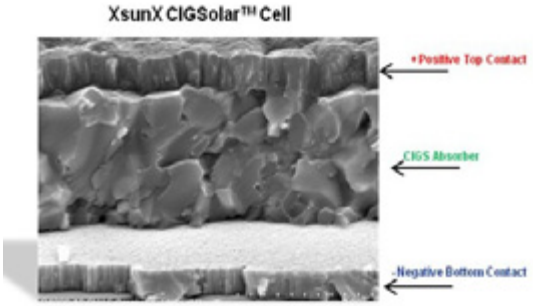
The 62 W Juicz has a reduced retail price of $999 and is available from QuickerTek's global dealer network. The new Solar Juicz module is backed with a one-year warranty on parts and labour.

XsunX commences CIGSolar CIS processing

The company has begun the final phase in preparing its system for customer demonstrations

XsunX has begun processing CIS films with its recently completed CIGSolar TFPV solar cell evaporation system.

The company has been testing and calibrating the deposition source technology in its new evaporation system so that it could transition to processing CIGS films.



"Recently we initiated the last phase necessary for preparing our CIGSolar TFPV solar cell evaporation system for customer demonstrations with the initiation of CIS (Copper Indium and Selenium) film processing," says Tom Djokovich, CEO of XsunX.

"This represents a major step forward and allows us to then transition to CIGS (Copper Indium Gallium and Selenium) films and the completion of the system's readiness for demonstrations," adds Djokovich.

The firm's technology utilises multi-small area thermal co-evaporation technology to deposit the CIGS solar absorber onto thin stainless steel substrates. The stainless steel substrate can be sized to match silicon solar cells for use as a low cost alternative to silicon solar cells.

What's more, the flexible aspect of the stainless steel substrate could also be used in applications where flexibility is required such as building-integrated PV (BIPV) applications.

According to analysts, markets for BIPV installations are predicted to grow by $5 billion U.S. over the next two years. The flexibility of CIGSolar cells could offer BIPV manufacturers the potential to use cells manufactured using the CIGSolar process in their products, opening up new market opportunities for XsunX. With the closure of some thin film manufacturers and scaling back of production with others, the Company has begun to receive inquiries related to BIPV applications for CIGSolar cells.

"There was a lot of buzz over CIGS PV that began to develop in 2009 and grew into 2010," states Djokovich. "But with the rapid decline in silicon pricing, many companies focused on producing products to compete with silicon module assemblers have either closed or sold out."

"XsunX took a different approach with CIGSolar. Rather than develop a product that attempts to compete with assemblers of silicon solar modules, which is a business path that has seen the demise of numerous thin film companies such as Solyndra, XsunX's CIGSolar is designed to offer pre-existing silicon module assemblers a lower cost replacement to silicon."

"Our business objective is to leverage the many GW of existing assembly capacity in the market - not compete with it. Now it appears that the flexibility of our stainless steel substrates may also offer an alternative cell for BIPV assemblers as well. At this time, we are pleased to find interest in our CIGSolar technology coming from multiple areas in the solar market," concludes Djokovich.

Photovoltaic module shipments swell in Q4 2012

Despite this positive sign the situation of the global PV industry remains critical and a substantial recovery of the supply-demand balance is not expected to occur before the second half of 2013

After a disastrous third quarter of 2012 featuring extremely low factory utilisation rates across the entire photovoltaic (PV) supply chain, a surge in demand was seen in the final quarter of the year for PV modules.

A new PV module shipment record of 11 gigawatts (GW) was reached in the fourth quarter according to the IHS Solar Integrated Market Tracker from information and analytics provider IHS.

The third quarter of 2012 dealt another blow to the global photovoltaic industry. After a relatively strong second quarter resulting in global installations of 7.8 GW, markets softened again. "Installations in the third quarter amounted to just 7.5 GW. Wholesalers, EPCs, and PV suppliers were forced to carefully control their inventory levels due to falling prices and low shipment levels and production cuts were the consequence," comments Principal Analyst Stefan de Haan.

In the third quarter of 2012, average module capacity utilisation fell to 49 percent, cell capacity utilisation to 56 percent, wafer capacity utilisation to a record-low 55 percent, and polysilicon capacity utilisation to 63 percent. In parallel, prices continued their slide in the third quarter of 2012 resulting in module industry revenues of only $6 billion - the lowest value since the second quarter of 2009. These difficult conditions were reflected in an increasing number of suppliers exiting the market.

"In the fourth quarter of 2012 global PV markets rebounded sharply. Very strong demand from Asia, with the surge driven largely by China and Japan, helped to compensate for sluggish demand in Europe. IHS estimates that global PV installations were 10.1 GW in the fourth quarter of 2012. In particular leading Chinese module suppliers benefited from the uptick in demand and shipped much more than previously expected," points out de Haan.

In total, 11 GW of global module shipments are estimated for the fourth quarter of 2012 - a new record for the industry. As anticipated by IHS, average market pricing for crystalline modules declined to $0.65 per watt at the end of 2012, down from $0.70 at the end of September.

Importantly, however, the price decline lost momentum in the course of the fourth quarter. Towards the end of the year some module prices even increased. Record-level shipments paired with stabilising prices drove a profound recovery of revenues. According to the IHS Solar Integrated Market Tracker, fourth quarter 2012 module revenues grew by a stunning 42 percent quarter-over-quarter, reaching $8.5 billion.

In the first quarter of 2013 suppliers are predicted to experience the usual seasonal weakness of global solar markets. Global PV installations are forecast to drop to 6.7 GW in this quarter. As a result upstream shipments and revenues will temporarily come under pressure again.

With prices forecast to decrease by another 4 -5 percent in the first quarter of 2013 (compared to the fourth quarter of 2012), module revenues will fall

back to the critical levels of the third quarter of 2012 - or even below. This will force more suppliers to review their business models and eventually leave the solar market.

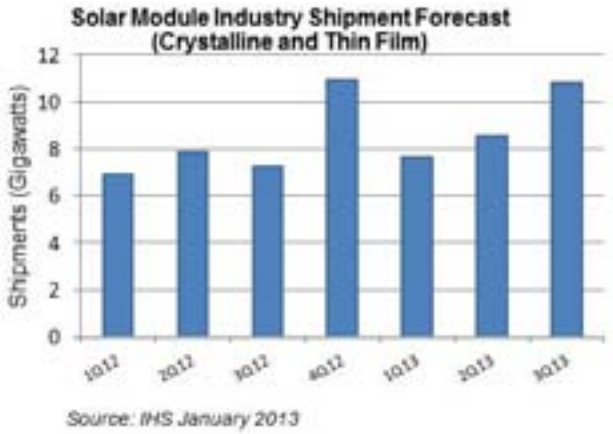
After a tough first quarter, a substantial increase in global demand is forecast to drive increasing revenues and stabilising prices in the second half of 2013.

IHS forecasts 35 GW of global installations in 2013, up 10 percent over 2012. Although this level of growth is lower than previous years, it will drive a continuous improvement of shipments and revenues in the polysilicon to module supply chain throughout 2013.

Recent positive signals from authorities in several key markets like China and France raise hopes for the recovery of the PV industry to happen even faster. “Whilst it’s too early to give the all-clear for the PV supplier industry, there is increasing indication that the year 2013 will mark the turnaround,” concludes de Haan.

The chart below presents a forecast of global shipments of the photovoltaic module industry (crystalline and thin film).

IHS Solar Module Industry Shipment Forecast (Crystalline and Thin Film) Q3 2013

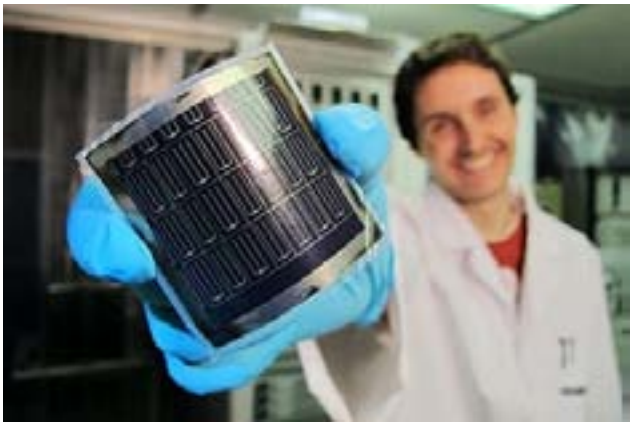


Empa raises the bar with CIGS efficiency of 20.4 percent

The research institute says it has achieved a new world record for (copper indium gallium (di)selenide) solar efficiency

Scientists at Empa, the Swiss Federal Laboratories for Materials Science and Technology, have developed thin film solar cells on flexible polymer foils with a new record efficiency of 20.4 percent for converting sunlight into electricity.

The cells are based on CIGS semiconducting material known for its potential to provide cost-effective solar electricity. The technology is currently awaiting scale-up for industrial applications.



High-efficiency flexible CIGS solar cells on polyimide film developed at Empa with a novel process

To make solar electricity affordable on a large scale, scientists and engineers have long been trying to develop a low-cost solar cell, which is both highly efficient and easy to manufacture with high throughput.

Now a team at Empa’s Laboratory for Thin Film and Photovoltaics, led by Ayodhya N. Tiwari, has made another leap ahead.

They achieved a 20.4 percent energy conversion efficiency for thin film CIGS solar cells on flexible polymer substrates, a massive improvement over the previous record of 18.7 percent achieved by the same team in May 2011.

Tiwari's team has been investigating and developing various thin film solar cell technologies for some time. Over the years the laboratory has boosted the photovoltaic conversion efficiency of flexible CIGS solar cells time and again, from 12.8 percent in 1999 - the group's first world record - to 14.1 percent in 2005, 17.6 percent in 2010 and 18.7 percent in 2011.

The latest in the series of records has been achieved by modifying the properties of the CIGS layer, grown at low temperatures, which absorbs light and contributes to the photo-current in solar cells. The cell efficiency value was independently certified by the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany.

What's more, Empa's new record efficiency for flexible solar cells now exceeds the record value of 20.3 percent for CIGS solar cells on glass substrates - and equals the highest efficiencies for polycrystalline silicon wafer-based solar cells. "We have now - finally - managed to close the "efficiency gap" to solar cells based on polycrystalline silicon wafers or CIGS thin film cells on glass", says Tiwari.

Thin film, lightweight and flexible high-performance solar modules are attractive for numerous applications such as solar farms, roofs and facades of buildings, automobiles and portable electronics and can be produced using continuous roll-to-roll manufacturing processes that offer further cost reductions compared to standard silicon technologies. In other words, they have the potential to enable low-cost solar electricity in the near future.

"The series of record efficiencies for flexible CIGS solar cells developed at Empa demonstrates that thin film solar cells can match the excellent performance of polycrystalline silicon cells. Now it is time for the next step, the scale-up of the technology to cover large areas in a cost-efficient roll-to-roll manufacturing process with an industrial partner", says Gian-Luca Bona the Director of Empa. For this purpose, Empa is collaborating with Flisom, a start-up company involved in industrialisation of flexible CIGS solar cells.

The research work has been supported over the years by the Swiss National Science Foundation (SNSF), the Commission for Technology and Innovation (CTI), the Swiss Federal Office of Energy (SFOE) and the EU Framework Programmes.

Ascent Solar reveals charger for Samsung Galaxy S III smartphone

The EnerPlex is powered by the firm's CIGS technology

Ascent Solar Technologies has launched the EnerPlex solar assisted battery case for the Samsung Galaxy S III, which is now available for sale.

The EnerPlex Surfr for Galaxy S III takes advantage of Ascent's ultra-light, thin and flexible solar panels and enables Galaxy users to charge their smartphones with sunlight in addition to conventional charging methods to extend the usage time.

The Surfr was displayed at CES 2013 last week, along with other new products from the company. The EnerPlex Surfr cases will also be available in the US through additional retail channels in the near future.

The EnerPlex case for Galaxy S III is uniquely enabled by the lightweight, thin and highly customizable form factor of Ascent's CIGS solar cells, allowing solar technology to be integrated into the thinnest and lightest solar-enabled iPhone case on the market. Paired with an ultra-thin lithium-ion battery the EnerPlex case provides hours of additional audio, web and talk time for users.

Ascent Solar's President and CEO, Victor Lee, says, "We were pleased and excited by the response the Surfr for the S III garnered at CES 2013. The interest and accolades received continue to affirm the Surfr's position as the premium solar & battery case available on the market today."

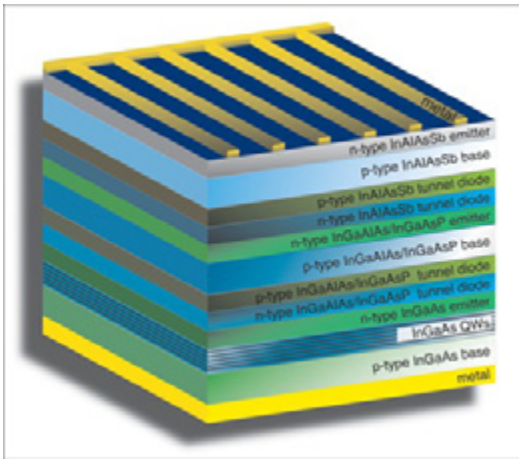
NRL III-V solar cell could beat the 50 percent barrier

Grown on indium phosphide (InP), the cell is based on the band structure of InAlAsSb used in detector

and laser applications

U.S. Naval Research Laboratory scientists in the Electronics Technology and Science Division, in collaboration with the Imperial College London and MicroLink Devices, Inc., Niles, Ill., have proposed a novel triple-junction solar cell.

They say the cell has the potential to break the 50 percent conversion efficiency barrier, which is the current goal in multi-junction photovoltaic development.



Schematic diagram of a multi-junction solar cell formed from materials lattice-matched to InP and achieving the bandgaps for maximum efficiency

“This research has produced a novel, realistically achievable, lattice-matched, multi-junction solar cell design with the potential to break the 50 percent power conversion efficiency mark under concentrated illumination,” says NRL research physicist Robert Walters. “At present, the world record triple-junction solar cell efficiency is 44 percent under concentration and it is generally accepted that a major technology breakthrough will be required for the efficiency of these cells to increase much further.”

In multi-junction solar cells, each junction is ‘tuned’ to different wavelength bands in the solar spectrum to increase efficiency. High bandgap semiconductor material is used to absorb the short wavelength radiation with longer wavelength parts transmitted to subsequent semiconductors.

In theory, an infinite-junction cell could obtain a maximum power conversion percentage of nearly 87 percent. The challenge is to develop a semiconductor material system that can attain a wide range of bandgaps and be grown with high crystalline quality.

By exploring novel semiconductor materials and applying band structure engineering, via strain-balanced quantum wells, the NRL research team has produced a design for a MJ solar cell that can achieve direct band gaps from 0.7 to 1.8 electron volts (eV) with materials that are all lattice-matched to an InP substrate.

“Having all lattice-matched materials with this wide range of band gaps is the key to breaking the current world record,” adds Walters. “It is well known that materials lattice-matched to InP can achieve band gaps of about 1.4 eV and below, but no ternary alloy semiconductors exist with a higher direct band-gap.”

The primary innovation enabling this new path to high efficiency is the identification of InAlAsSb quaternary alloys as a high band gap material layer that can be grown lattice-matched to InP. Drawing from their experience with Sb-based compounds for detector and laser applications, NRL scientists modelled the band structure of InAlAsSb and showed that this material could potentially achieve a direct band-gap as high as 1.8eV.

With this result, and using a model that includes both radiative and non-radiative recombination, the NRL scientists created a solar cell design that is a potential route to over 50 percent power conversion efficiency under concentrated solar illumination.

Recently awarded a U.S. Department of Energy, Advanced Research Projects Agency-Energy (ARPA-E) project, NRL scientists, working with MicroLink and Rochester Institute of Technology, Rochester, New York, will execute a three year materials and device development program to realise this new solar cell technology.

Hanergy completes MiaSolé acquisition

Hanergy’s US acquisition of the copper indium gallium diselenide (CIGS) firm follows its purchase of German thin-film maker Solibro last year. This now makes Hanergy one of the world’s largest

clean-energy companies

China's largest privately-owned clean-energy company thin-film PV firm Hanergy finalised the acquisition of MiaSolé with a 100 percent stake in the firm.

MiaSolé is a California-based pioneer and manufacturer of CIGS thin-film photovoltaic solar panels.

Hanergy expects with additional investment and commercial execution, that MiaSolé's value will exceed $2 billion. Strategic China-United States' partnership will boost CIGS efficiency and deploy this cutting-edge technology across a larger global scale.

The China-US strategic partnership follows a 9-month search by MiaSolé, which has already attracted more than $550 million from investors including KPCB, Vantage Point and other significant venture investors.

The acquisition will significantly boost the operations of MiaSolé. Upon completion of the transaction, Hanergy plans to ramp up MiaSolé's California-based factory to full capacity. The Sunnyvale plant's 100-plus employees in engineering, technology and manufacturing will be preserved, and Hanergy expects to hire additional employees. What's more, Hanergy will make sustained investment in MiaSolé's R&D.

The transaction has received regulatory approvals by the Committee on Foreign Investment in the United States (CFIUS) and Chinese Authorities.

Li Hejun, Chairman of Hanergy Holding Group, comments, "Our acquisition of MiaSolé is another landmark deal and key milestone to facilitate the global clean-energy technology integration after we acquired German thin-film technology provider Solibro. Hanergy is determined to be a global renewable-energy leader. In the solar-energy sector, Hanergy is committed to developing thin-film PV technology, providing turn-key solutions, and developing solar plants."

Hejun adds, "The future of solar energy is thin-film technology. This acquisition allows us to add a highly efficient flexible product to our portfolio. Hanergy's vision to lead CIGS technology globally and its combined strength with Solibro and MiaSolé, now make for a diversified and compelling product, which will be offered to a global customer base. I believe this successful China-US clean-energy cooperation will deliver fruitful results through our mutual efforts."

John Carrington, CEO of MiaSolé, continues, "MiaSolé has advanced solar technology by developing the highest efficiency and lowest-cost CIGS modules but we needed to align with a strategic partner in order to deploy our technology across a larger global scale. I greatly appreciate and identify with Hanergy's unique business model, its focus on and belief in thin-film solar technology, and its vision of providing clean-energy solutions to the world."

"This acquisition of MiaSolé is a win-win outcome for both companies. Hanergy will secure our CIGS technology, which boasts the world's highest conversion efficiency, to complement its existing technologies and promote the company's leap-forward development in its global technological integration. MiaSolé will enjoy a fully optimised capital structure, enabling us to focus on R&D and capacity breakthroughs, and become more competitive by riding on Hanergy's global advantages," notes Carrington.

The MiaSolé acquisition follows Hanergy's agreement to acquire Q.Cells' thin-film subsidiary Solibro in Germany last year. Hanergy decided to invest in the leading CIGS co-evaporation technology that Solibro has developed over the last 25 years.

After the completion of the acquisition, Solibro will ramp up to a yearly production capacity of 100 MW in Thalheim to supply Hanergy's European customers. Though MiaSolé's CIGS follows a different technological line, the two can share the patents and thus improve the conversion efficiency. MiaSolé has set flexible PV efficiency world record at 15.5%. It is expected that the CIGS efficiency will further rise to above 17 percent within 24 months, and the production cost will drop to sub $.50 within 24 months.

Hanergy's thin-film PV production capacity has achieved 3GW in total. Thin-film solar cells have the exclusive advantages of low material-consumption, low energy-consumption, and non-pollution.

Thin-film solar cells can be made on flexible substrates to form lightweight and flexible PV modules. Such flexible PV modules are easy to install because no supporting holders are needed. Therefore, it is significantly beneficial to apply the flexible thin-film solar modules to the situation of non-bearing or limited-bearing roofs. Hanergy will continue to focus on thin-film technology, which proves to be the best path to take for our future.

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

This is according to Strategy Analytics' GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review July - September 2012: Microelectronics."

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth.

The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

"The positive news for the compound semiconductor industry is that most companies showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

This viewpoint summarises financial, product, contract and employment developments from leading semiconductor device suppliers from July - September of 2012. These announcements address a variety of commercial and military applications products and companies that use GaAs, GaN, SiC, SiGe and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

First Solar Campo Verde solar project kicks off

The CdTe (cadmium telluride) solar project will generate enough electricity to power approximately 50,000 average California homes and create 250 construction jobs

First Solar has started construction of the 139 megawatt Campo Verde Solar Project, located near El Centro in Imperial County, California.

The solar power plant is expected to be completed in 2013.

Economic benefits of the project include

approximately 250 construction jobs, as well as over $230 million in new economic activity to the Imperial Valley, according to a county study.

The project gained the approval it needed on December 18th, 2012, from the Imperial Irrigation District (IID) for easements required to cross IID's Westside Main Canal with the project's transmission line.

Earlier approvals included a decision to issue a Right of Way grant from the U.S. Bureau of Land Management (BLM) and a Conditional Use Permit from Imperial County.

"The County of Imperial is very pleased to see the commencement of construction of the Campo Verde Solar Project, which brings numerous benefits to the Valley and our citizens," says Ray Castillo, County Board President.

"First Solar's project brings much needed jobs and economic development to the Valley at a time when it is sorely needed. The project also pays added tax revenue, funds for agricultural benefits and community benefits while helping the County diversify its economy. We've been working to attract projects like this for the past five or six years and are glad to see it's finally happening. These projects are really our legacy for the Imperial Valley," points out Castillo.

"First Solar is grateful to the IID, Imperial County, and the BLM for their support of this project," continues James F. Cook, First Solar Project Development Director. "Campo Verde is creating badly needed jobs and will help the county and state reach their renewable energy goals."

First Solar will construct the project using its advanced thin film PV modules that generate clean, renewable energy with no emissions, waste or water consumption during operation. The project will generate enough electricity to power approximately 50,000 average California homes, displacing 80,000 metric tons of CO2 per year, the equivalent of taking 15,000 cars off the road.

First Solar heats up South America with Solar Chile acquisition

Using First Solar's CdTe (cadmium telluride) modules, the investment is aimed at advancing PV power plant projects in a sustainable market

First Solar has acquired Solar Chile, a Santiago-based solar development company.

Fundación Chile was an early investor in Solar Chile. The acquisition culminates in a strategic working alliance that First Solar and Fundación Chile formed in October 2011.

Solar Chile has a portfolio of early- to mid-stage utility-scale photovoltaic (PV) power projects totalling about 1.5 gigawatts (GW) in Regions I, II, III, and XV in northern Chile, including the Atacama Desert region, which offers the highest solar irradiance in the world.

"We have been very impressed by the quality of the Solar Chile team and the projects they are developing, and we believe that together we will bring even more value to the Chilean market," says Jim Hughes, First Solar CEO. "Combining Solar Chile's market knowledge and promising project portfolio with First Solar's resources, technology and strong execution track record offers Chile a rapid and proven path to add significant solar generation capacity, helping to meet high energy demand and support economic growth."

"First Solar's acquisition of Solar Chile is a milestone of enormous significance to our country," said Alvaro Fischer, President of Fundación Chile. "It highlights the tremendous potential that solar PV energy has to change the demography and the economy of northern Chile, opening it up to new opportunities beyond mining and fishing, into water desalinization, hydrogen production or large green data centres."

"Chile faces a growing energy demand from its sustained economic growth," explains Hernán Cheyre, Executive Vice-President of CORFO, the Chilean government's economic development agency. "Solar energy provides a sustainable and clean energy source that takes advantage of our

outstanding clear skies and irradiance. The growth of the solar industry and the arrival of First Solar validates Chile´s position as a regional hub for entrepreneurship and innovation."

First Solar has a global development pipeline of projects under contract to utilities totalling 3 GW, with 2 GW under construction. It has constructed more than 600 MW of PV power projects worldwide.

Under the terms of the agreement, the five-person Solar Chile team is joining First Solar, and Fundación Chile will provide ongoing consultation services. Terms of the transaction were not disclosed.

First Solar takes on a new SVP in Project Development

Tim Rebhorn will be responsible for the CdTe company's global project development strategy and execution

First Solar has appointed Tim Rebhorn as Senior Vice President, Project Development.

He reports to First Solar CEO Jim Hughes.

"Tim will play a crucial role in implementing First Solar's strategy to provide fully integrated photovoltaic power solutions in sustainable markets around the world," says Jim Hughes. "He brings proven strengths in business development, mergers and acquisitions, integration, value creation and strategy implementation."

Rebhorn has more than 30 years of experience in the power generation business as a senior executive in the gas, electricity, generation and distribution industry segments. Most recently, he was CEO of Quail Nuclear Specialty Services, an industrial construction company primarily supporting the nuclear power industry.

Previously, he was Managing Director of Resolutions Management, where he provided strategic support for clients in energy, steel, fuel cell, engineering and construction, petroleum and manufacturing industries.

Earlier executive positions include Merrill International and Stewart & Stevenson. He began his career in the U.S. Navy, where he served in the Naval Nuclear Propulsion Program and as a NATO Staff Planning Officer.

Rebhorn is a graduate of the U.S. Naval Academy and earned an MBA from Texas A&M University.

Solar Frontier CIS cells hit a record 19.7 percent efficiency

The firm's cadmium free copper indium selenide cell was cut from a 30cm x 30cm substrate, demonstrating the high possibility for further increase.

Together with Japan's New Energy and Industrial Technology Development Organisation (NEDO), Solar Frontier, has achieved energy conversion efficiency of 19.7 percent for cadmium-free, thin-film solar cells measuring approximately 0.5 cm2.

Solar Frontier says this is a world record.

The results were verified by the National Institute of Advanced Industrial Science and Technology (AIST). It has been ten years since the previous record of 18.6 percent was surpassed.

This world record was achieved using cells cut from a 30cm x 30cm substrate, rather than specifically-developed small area cells, demonstrating high potential for further increases.

Solar Frontier's Atsugi Research Centre which has developed Cadmium-free CIS cells that have achieved an energy conversion efficiency of 19.7%

What's more, the formation method utilised by Solar Frontier to achieve the result is the same method it uses for mass-production, a process of sputtering followed by selenisation.

The firm has chosen this method over co-evaporation due to greater efficiencies in mass production and aims to surpass the current record of 20.3 percent efficiency set with the co-evaporation method.

"This new achievement in energy conversion efficiency indicates the high level of Solar Frontier's technology and the high potential of CIS technology," says Satoru Kuriyagawa, Chief Technology Officer, Solar Frontier.

"The CIS thin-film modules currently available from Solar Frontier have gained a reputation for high performance in actual power generation, as they are not easily affected by shadows or high temperatures. Now, even higher real-world performance can be expected by applying this new basic technology. We will continue working to further enhance our technological capabilities with the aim of setting a world record for thin-film solar cells overall," continues Kuriyagawa.

Solar Frontier's CIS modules are manufactured at the company's Kunitomi Plant, which boasts world-class production capacity and cutting-edge technology. Since the Kunitomi Plant started commercial production in February 2011, it has steadily increased its production efficiency.

Currently, the CIS thin-film solar modules produced at Kunitomi have a conversion efficiency that exceeds 13 percent, and the amount of electricity generated (kWh) per installed capacity (kW) exceeds that of other solar modules.

Showa Shell Sekiyu and Solar Frontier intend to contribute even further to the expansion of Japan's energy industry and local production and consumption using environmentally-friendly CIS thin-film solar modules made in Japan.

First Solar extends collaboration with Intermolecular

The program targets conversion efficiency gains beyond First Solar's cadmium telluride roadmap

Intermolecular and First Solar have entered into a two-year collaboration and licensing agreement focused on further increases to the conversion efficiency of First Solar's CdTe solar cell technology.

Under the new collaborative development program, First Solar and Intermolecular researchers will work together to develop disruptive new approaches to increasing the performance of CdTe solar cell technology using Intermolecular's proprietary High Productivity Combinatorial (HPC) platform. The program targets substantial gains in First Solar's module conversion efficiency beyond its previously announced roadmap.

"We are excited to extend and deepen our collaboration with IMI. The combinatorial approach to material and process screening has shown promise to augment First Solar's already world-leading research and development capabilities in CdTe solar technology, enabling better performance and faster time-to-market" says Raffi Garabedian, First Solar's Chief Technology Officer.

"This program targets disruptive advances in our module performance which will be additive to our current roadmap. We are confident this effort will bear fruit in the coming years, combining with our other new R&D advances to extend our leadership in photovoltaic technology and further enhance value for our power plant customers."

Sandeep Nijhawan, Vice President and General Manager of Intermolecular's Clean Energy Group, adds, "We are excited to partner with First Solar, a global leader in thin-film photovoltaic technology and systems. Extending and expanding the collaboration with First Solar after working closely with them last year represents tremendous validation of our value proposition. We look forward to be closely working with First Solar to further increase CdTe solar cell conversion-efficiency by leveraging our HPC platform and capabilities."

Intermolecular's mission is to improve R&D efficiency in the semiconductor and clean-energy industries through collaborations that use its HPC platform, which allows R&D experimentation to be performed at speeds up to 100 times faster than traditional methods.

The firm has pioneered a proprietary approach to accelerate research and development, innovation, and time-to-market for the semiconductor and clean energy industries. The approach consists of its proprietary HPCTM platform, coupled with its multi-disciplinary team.

Through paid collaborative development programs (CDPs) with its customers, Intermolecular develops proprietary technology and intellectual property for its customers focused on advanced materials, processes, integration and device architectures.

QuantumClean acquires Advent Cleaning Technology

The provider of high-purity outsourced process tool parts, cleaning and surface treatment to the solar and LED industries has added quartz fabrication to its portfolio

QuantumClean, has acquired Advent Cleaning Technology, Inc. (Advent) semiconductor parts cleaning business located in Carrollton, Texas.

The acquisition of Advent enhances QuantumClean's regional cleaning capabilities and adds quartz fabrication and repair to QuantumClean's already extensive portfolio of semiconductor parts refurbishment services.

"We are pleased to acquire Advent Cleaning Technology, long-recognised in the industry for their strong customer orientation and quality focus. Advent is a perfect fit with QuantumClean's strategy to continually increase its value to its semiconductor wafer fabrication, OEM and OPM customers through the offering of greater capabilities and convenience," comments Scott Nicholas , CEO & President of Quantum Global Technologies, LLC.

"With the Advent acquisition, QuantumClean now operates fifteen Advanced Technology Cleaning Centers and three world class ChemTrace microcontamination analytical laboratories in seven countries employing nearly 1,000 employees dedicated to providing the industry's most technologically advanced high-purity semiconductor parts cleaning and analytical services," Nicholas continues.

ChemTrace is a reference analytical testing laboratory primarily serving the semiconductor, solar and related industries by providing answers and solutions to its customers' micro-contamination related issues. Founded in 1993, ChemTrace also provides independent analytical verification of process tool part cleaning effectiveness for many of QuantumClean's semiconductor fab, OEM and OPM customers which have critical cleaning requirements.

III-V solar cell pushes efficiency boundaries

NREL researchers offer insights into the progress of record-breaking multi-junction cells

It takes out-of-the-box thinking to outsmart the solar spectrum and set a world record for solar cell efficiency.

The solar spectrum has boundaries and unalterable rules. And no matter how much solar cell manufacturers want to bend those rules, they can't.

So how can we make a solar cell that has a higher efficiency than the rules allow?

That's the question scientists in the III-V Multi-junction Photovoltaics Group at the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) faced 15 years ago. They were searching for materials they could grow easily that also have the ideal combinations of band gaps for converting photons from the sun into electricity with unprecedented efficiency.

A band gap is an energy that characterises how a semiconductor material absorbs photons, and how efficiently a solar cell made from that material can extract the useful energy from those photons.

"The ideal band gaps for a solar cell are determined by the solar spectrum," notes Daniel Friedman,

manager of the NREL III-V Multi-junction Photovoltaics Group. “There’s no way around that.”

But this year, Friedman’s team succeeded in bending the rules of the solar spectrum and NREL and its industry partner, Solar Junction, won an R&D 100 award from R&D Magazine for a world-record multi-junction solar cell.

The three-layered cell, SJ3, converted 43.5 percent of the energy in sunlight into electrical energy - a rate that has stimulated demand for the cell to be used in concentrator photovoltaic (CPV) arrays for utility-scale energy production.

The record of 43.5 percent efficiency at 415 suns was eclipsed with a 44 percent efficiency at 947 suns. Both records were verified by NREL. This is NREL’s third R&D 100 award for advances in ultra-high-efficiency multi-junction cells.

CPV technology gains efficiency by using low-cost lenses to multiply the sun’s intensity, which scientists refer to as numbers of suns.

Friedman says earlier success with multi-junction cells - layered semiconductors each optimised to capture different wavelengths of light at their junctions - gave NREL a head start.

The SJ3 cells fit into the market for utility-scale CPV projects. They’re designed for application under sunlight concentrated to 1,000 times its normal intensity by low-cost lenses that gather the light and direct it at each cell.

In regions of clear atmosphere and intense sunlight, such as the U.S. desert Southwest, CPV has outstanding potential for lowest-cost solar electricity. There is enough available sunlight in these areas to supply the electrical energy needs of the entire United States many times over.

Bending Material to the Band Gaps on the Solar Spectrum

Sunlight is made up of photons of a wide range of energies from roughly zero to four electron volts (eV). This broad range of energies presents a fundamental challenge to conventional solar cells, which have a single photovoltaic junction with a single characteristic band gap energy.

Conventional cells most efficiently convert those photons that very nearly match the band gap of the semiconductors in the cell. Higher-energy photons give up their excess energy to the solar cell as waste heat, while lower-energy photons are not collected by the solar cell, and their energy is completely lost.

This behaviour sets a fundamental limit on the efficiency of a conventional solar cell. Scientists overcome this limitation by using multi-junction solar cells. Using multiple layers of materials in the cells, they create multiple junctions, each with different band gap energies. Each converts a different energy range of the solar spectrum.

An invention in the mid-1980s by NREL’s Jerry Olson and Sarah Kurtz led to the first practical, commercial multi-junction solar cell, a GaInP/GaAs two-junction cell with 1.85-eV and 1.4-eV bandgaps that was recognised with an R&D 100 award in 1990, and later to the three-junction commercial cell based on GaInP/GaAs/Ge that won an R&D 100 award in 2001.

NREL Principal Scientist Jerry Olson holds examples of the first multi-junction cells that were developed in the 1980s based on his scientific breakthrough

The researchers at NREL knew that if they could replace the 0.67-eV third junction with one better tuned to the solar spectrum, the resulting cell would capture more of the sun’s light throughout the day. But they needed a material that had an atomic structure that matched the lattice of the layer above it - and that also had the ideal band gap.

“We knew from the shape of the solar spectrum and modelling solar cells that what we wanted was a third junction that has a band gap of about 1.0 electron volt, lattice-matched to gallium arsenide,”

Friedman comments. “The lattice match makes materials easier to grow.”

They concentrated on materials from the third and fifth columns of the periodic table because these III-V semiconductors have similar crystal structures and ideal diffusion, absorption, and mobility properties for solar cells.

But there was seemingly no way to capture the benefits of the GaAs material while matching the lattice of the layer below, because no known III-V material compatible with GaAs growth had both the desired 1-eV band gap and the lattice-constant match to GaAs.

That changed in the early 1990s, when a research group at NTT Laboratories in Tokyo working on an unrelated problem made an unexpected discovery. Even though GaN has a higher band gap than GaAs, when you add a bit of nitrogen to GaAs, the band gap shrinks - exactly the opposite of what was expected to happen.

“That was very surprising, and it stimulated a great deal of work all over the world, including here at NREL,” Friedman says. “It helped push us to start making solar cells with this new dilute nitride material.”

Good Band Gaps, but Not So Good Solar Material

The new solar cells NREL developed had two things going for them - and one big issue.

“The good things were that we could make the material very easily, and we did get the band gap and the lattice match that we wanted,” Friedman says. “The bad thing was that it wasn’t a good solar cell material. It wasn’t very good at converting absorbed photons into electrical energy. Materials quality is critical for high-performance solar cells, so this was a big problem.”

Still, NREL continued to search for a solution.

“We worked on it for quite a while, and we got to a point where we realized we had to choose between two ways of collecting current from a solar cell,” Friedman says. “One way is to let the electrical carriers just diffuse along without the aid of an electric field. That’s what you do if you have good material.”

If the material isn’t good, though, “you have to introduce an electric field to sweep the carriers out before they recombine and are lost,” Friedman adds.

But to do that, virtually all impurities would have to be removed. And the only way to remove the impurities would be to use a different growth technique.

Using Molecular Beam Epitaxy to Virtually Eliminate Impurities

Solar cells are typically grown using MOVPE.

“It works great, except you always get a certain level of impurities in the material. That’s usually not a problem, but it would be an issue for this novel material, with the gallium arsenide diluted with nitrogen,” Friedman points out.

However, a different growth technique, MBE, used in an ultra-high vacuum, (10-13 atmospheres), can lower the impurities to the point where an electric field can be created in the resulting photovoltaic junction. And that would make the otherwise promising gallium-arsenide-dilute-nitride material work as a solar cell.

“The only problem was that there was no one in the entire world manufacturing solar cells by MBE,” Friedman says.

But that was soon to change.

Partnering with Stanford University Startup, Solar Junction

A Stanford University research group with expertise in the use of MBE for other electronic devices saw an opportunity. In around 2007, they spun out a startup company they named Solar Junction.

Because Solar Junction was a mix of enthusiastic recent Ph.D.s and experienced hands from outside the established solar cell field, “they weren’t tied to the constraints of thinking this couldn’t be done, that the only economically viable way to make solar cells was with MOVPE,” Friedman says.

The federal lab and the startup got together. Solar Junction won a $3 million DOE/NREL Photovoltaic

Technology Incubator contract to develop a commercial multi-junction cell using dilute nitrides, and also received more than $30 million of venture-capital funding for this commercialisation effort. To see more about NREL's Incubator projects, see the NREL news release.

"So Solar Junction had this good idea. But now they had to prove that you could actually make a high-efficiency solar cell with this," Friedman continues. "Otherwise, who cares? People can make a lot of claims, but it's very simple to know whether you have a good solar cell or not - you just measure it."

It didn't take that long, Friedman points out. By 2011, NREL had certified a new efficiency record for Solar Junction's SJ3 cell. The cell achieved an efficiency of 43.5 percent under concentrated sunlight, a significant step beyond the previous multi-junction efficiency record of 41.6 percent, and far beyond the maximum theoretical efficiency of 34 percent for traditional one-sun single-junction cells.

Dilute-Nitride Junction Eliminates Need for Heavy Germanium Layer

With the new dilute-nitride junction, the germanium layer, which constitutes about 90 percent of the weight of the cell, is no longer needed. That may not be a big deal when it's part of a huge fixed utility-scale array.

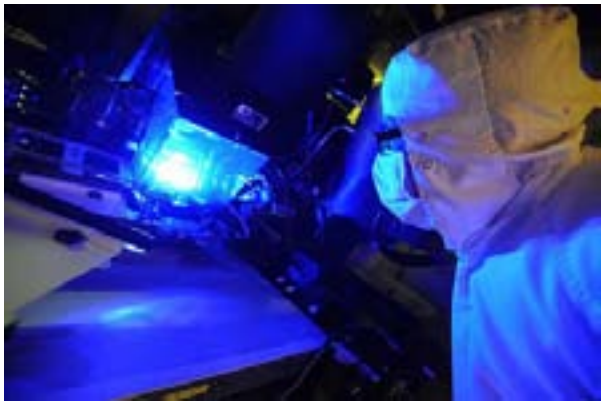
But when solar cells are used to power satellites, reduction in weight means a smaller rocket is needed to launch into space, potentially reducing costs significantly. The lighter weight is also essential for the military, which is increasingly asking soldiers to carry backpacks that include solar devices to power electronics.

Serendipitously, if the germanium substrate is retained, it has essentially the ideal band gap of 0.7 eV for a fourth junction, perfect for capturing longer wavelengths of the solar spectrum. That paves the way for a 50 percent-efficient solar cell in the not so distant future.

The cost to manufacture the SJ3 cell is competitive with that of the industry-standard GaInP/GaAs/Ge cell, according to Solar Junction. Its greater efficiency translates to significant cost-of-energy savings.

According to a report released this fall from IMS Research, the CPV market is forecast to double in 2012 and reach almost 90 megawatts. The World Market for Concentrated PV (CPV) - 2012 predicts installations of CPV will grow rapidly over the next five years to reach 1.2 gigawatts by 2016.

Because of its design and size, SJ3 is an instant plug-in replacement for the standard cell now used by the space and CPV industries. So, for example, if a 40 percent-efficient cell were replaced with a 44 percent-efficient cell, this would instantly increase the entire system power output by close to 10 percent.



An operator inspects a photolithography tool used to manufacture high-efficiency Solar Junction concentrator solar cells. NREL's pioneering multi-junction work led to the Solar Junction SJ3 solar cell with tuneable bandgaps, lattice-matched architecture, and ultra-concentrated tunnel junctions. (Credit: Daniel Derkacs/Solar Junction)

"This is really a classic example of NREL developing something and then industry picking it up and running with it and making it a great commercial success," Friedman mentions. "We started with some very basic materials research. We took it to the point where it made sense for industry to take over and take it to the marketplace."

"We conceived the cell, demonstrated the individual parts, and let the world know about it," Friedman comtinues. "But Solar Junction put all the parts together with record-breaking results, made it work with MBE, and commercialised it at a time when no one else seemed to be interested in or able to do it."

And now, utilities are ordering the SJ3 cells so fast that Solar Junction has depleted its pilot-scale stock and gone into partnership with manufacturer IQE to

ramp up to full manufacturing scale.

Soitec to open III-V solar manufacturing facility in San Diego

With a new factory, Soitec will become one of the top three manufacturers of solar modules in the USA

Soitec has announced the grand opening of its North American solar manufacturing facility in San Diego.

Less than a year after the facility was acquired by Soitec, the factory is equipped with a state-of-the-art automated production line and is operational.

The concentrator photovoltaic (CPV) modules produced in San Diego will support hundreds of MWp of contracts for utility-scale projects in California. In 2011, the California Public Utilities Commission (CPUC) approved 300 MWp of PPAs which are expected to use Soitec's Concentrix technology.

Concentrix technology uses Fresnel lenses to concentrate sunlight 500 times and focus it onto small, highly efficient multi-junction solar cells. This technology has helped achieve AC system efficiency increases of 25% in actual operating conditions.

The basic research underpinning the Concentrix technology was developed over more than a decade at Germany's Fraunhofer ISE, Europe's largest solar research institute. In 2005, the Institute founded a spin-off, Concentrix Solar, to commercialise the technology. Soitec acquired Concentrix Solar in 2009.

Soitec acquired the 176,000 square-foot manufacturing centre on 14.8 acres of land in December 2011. This major project for Soitec represents an investment of more than $150 million.

The company has completed on schedule an extensive upgrade of the facilities to install fully automated manufacturing equipment and processes. The first module was produced in October, and the first phase (140 MWp) of the production line is now operational, as initially planned. The factory has been designed to reach 280 MWp in capacity when in full production.

M+W U.S., Inc, a subsidiary of the M+W Group - an engineering and construction partner for technology-based clients and renowned in constructing solar cell manufacturing facilities, was the general contractor for the facility construction work. At the peak of construction, over 280 people were employed on the site.

The factory should create 450 jobs at full capacity, including employees for the joint venture Reflexite Soitec Optical Technology, LLC. This new company operates a manufacturing operation within the facility developing and manufacturing leading- edge silicone-on-glass (SOG) Fresnel lens plates used in Soitec's CPV modules.

"I want to congratulate Soitec on the opening of its factory here in San Diego, and thank the many organisations and individuals who worked together to help bring the company to San Diego. The city, CleanTECH San Diego, the Regional EDC, UC San Diego and SDG&E combined their resources to show Soitec that San Diego was as enticing as any other region in the desert Southwest, and as a result Soitec chose to bring 450 new jobs to San Diego and invest in the future of their company here because of our green credentials and our leadership in renewable energy," comments San Diego Mayor Bob Filner.

With this manufacturing plant, Soitec will become one of the top three manufacturers of solar modules in the USA. This will help Soitec provide cost-effective renewable energy systems and put the company in an ideal position to support its customers with a dedicated local team.

"By producing high volumes of CPV modules at this facility, we are now able to help California meet its renewable energy goals and further support the US market. Soitec already manages six factories around the world, and this gives us strong expertise in industrial processes, manufacturing and quality systems. We have also installed CPV systems in 14 countries on 4 continents. I am very pleased and honored that we can now offer the full benefits of this know-how in meeting US needs," says André-Jacques Auberton-Hervé, chairman and CEO of

Soitec.

Soitec's CPV technology uses triple-junction cells mounted on a glass plate. Fresnel lenses (manufactured using silicone on glass) concentrate sunlight 500 times before it reaches these cells, which convert it into electricity.

A metal frame holds two glass plates to form highly robust, durable and resilient modules. By combining several modules on biaxial trackers (based on a Soitec proprietary algorithm automatically optimising their position based on the path of the sun), maximises energy generation throughout the day.

With yields of 30% from its CPV modules, Soitec achieves at least twice the performance of conventional photovoltaic technologies. Combined with low installation and maintenance costs, this leading efficiency is making CPV technology the most cost-efficient solution for high-volume power generation in regions with high direct normal irradiation (DNI).

Emcore quarterly incomes bounce back

Although operations related to the impact from the floods in Thailand are fully restored, yearly revenues have decreased by over 18 percent

Emcore Corporation, a provider of compound semiconductor-based components, subsystems, and systems for the fibre optics and solar power markets, has announced its financial results for its fourth quarter and fiscal year ended September 30th, 2012.

Quarterly financial results

Consolidated revenue for the fourth quarter ended September 30th, 2012 was $47.5 million, which represents an 8.9% decrease compared to the prior year. On a segment basis, revenue for the Fibre Optics segment was $30.1 million, a 2.7% decrease compared to the prior year. Revenue for the Photovoltaics segment was $17.4 million, representing a 17.9% decrease compared to the prior year.

Consolidated gross profit was $4.6 million, which represents a 54.2% decrease compared to the prior year. Consolidated gross margin was 9.7%, a decrease from the 19.2% gross margin reported in the previous year. On a segment basis, Fibre Optics gross margin was 2.4%, which is a reduction from the 18.0% gross margin reported in the prior year.

Photovoltaics gross margin was 22.2%, an increase from the 21.0% gross margin reported in the the same quarter last year.

The consolidated operating loss was $6.3 million, which represents an $8.1 million improvement in operating loss when compared to the prior year. The quarter-over-quarter variance was primarily due to the $4.0 million of insurance recoveries relating to the Thailand flood partially offset by higher severance-related costs from corporate restructuring.

The consolidated net loss was $6.6 million, representing a $7.7 million improvement in net loss when compared to the same quarter last year. The consolidated net loss per share was $0.27 compared to $0.61 in the prior year and $0.38 in the immediate preceding quarter.

Annual Financial Results

Consolidated revenue for fiscal 2012 was $163.8 million, which represents an 18.5% decrease compared to the prior year. On a segment basis, revenue for the Fibre Optics segment was $96.2 million, a 23.5% decrease compared to the prior year primarily due to the Thailand flood in October 2011. Revenue for the Photovoltaics segment was $67.6 million, a 10.2% decrease compared to the prior year primarily due to lower sales to an

international customer.

Consolidated gross profit was $17.8 million, which represents a 58.3% decrease compared to the prior year. Consolidated gross margin was 10.9%, a decrease from the 21.3% gross margin reported in the prior year. On a segment basis, Fibre Optics gross margin was 4.5%, representing a decrease from the 18.5% gross margin reported in the FY 2011. Photovoltaics gross margin was 20.0%, a reduction from the 26.0% gross margin reported in the prior year.

During fiscal 2012, lower fibre optics revenues due to the impact from the Thailand flood resulted in higher manufacturing overhead as a percentage of revenue. Manufacturing of certain fibre optics components was moved to company-owned facilities in the U.S., which involved higher labour and other related costs. Instead of completely rebuilding all flood-damaged manufacturing lines, management decided to realign the company's fibre optics product portfolio and focus on business areas with strong technology differentiation and growth opportunities.

During the year ended September 30th, 2012, management identified $1.6 million of inventory on order related to manufacturing product lines that were destroyed by the Thailand flood and will not be replaced. This expense was recorded within cost of revenues on the firm's statement of operations and comprehensive loss. Photovoltaics gross margins declined when compared to prior periods primarily due to lower revenues with unfavourable product mix changes, as well as lower manufacturing yields on new products.

The consolidated operating loss was $35.6 million, which represents a $3.1 million increase in operating loss when compared to the prior year.

The consolidated net loss was $39.2 million, representing a $5.0 million increase in net loss when compared to the prior year. The consolidated net loss per share was $1.66, a $0.12 increase in net loss per share when compared to FY 2011.

As of September 30th, 2012, order backlog for the Photovoltaics segment totalled $43.3 million, which represents a 6.3% decrease from $46.2 million reported as of June 30, 2012. The order backlog as of September 30th, 2012 and June 30, 2012 included $1.9 million and $5.1 million, respectively, of terrestrial solar cell orders from the Suncore joint venture.

Order backlog is defined as purchase orders or supply agreements accepted by Emcore with expected product delivery and/or services to be performed within the next twelve months. Product sales from the Fibre Optics segment are made pursuant to purchase orders, often with short lead times, and revenue from this segment is still limited by the rebuilding of Emcore's production capacity.

Business Outlook

On a consolidated basis, Emcore expects revenue for the first quarter ended December 31st, 2012 to be in the range of $49 to $51 million, which includes revenue from the Suncore joint venture that was previously deferred.

IHS : Top ten 2013 solar market predictions

The analyst group are releasing a detailed report on the most likely 2013 scenario

"The photovoltaic industry is in the midst of wrenching change, buffeted by government incentive cuts and nose-diving prices that has hurt solar suppliers worldwide, rocked by trade disputes among its major players, and hamstrung by a sputtering global economy," says Ash Sharma, director, solar research at IHS

"However, there are some bright spots ahead: Solar installations are on the rise, technology is becoming

more efficient, and a weak EU market roiled by financial turmoil will be offset by an ascendant China and the United States," he adds.

Below are the top 10 predictions for 2013 from the IHS solar research team.

1. The global PV market will achieve double-digit installation growth in 2013, but market revenue will fall to $75 billion. Industry revenues - measured as system prices multiplied by total gigawatts installed - peaked at $94 billion in 2011, but fell sharply to $77 billion in 2012, as presented in the figure below. Revenue is projected to decline once again in 2013 to $75 billion, on the back of lower volume growth and continued system price declines, given that PV component prices continue to fall.

2. The solar module industry will consolidate further in 2013. As 2012 comes to a close, fewer than 150 companies will remain in the photovoltaic upstream value chain, down from more than 750 companies in 2010. Most of the consolidation will involve companies going out of business entirely. Many integrated players, particularly those based in China, will fold up shop in 2013. The large expense of building and then operating integrated facilities that are underutilised will be more than many can handle financially.

3. PV module prices will stabilise in 2H 2013 as oversupply eases. Despite a drastic decline in prices along the silicon supply chain since March 2011, solar prices will stabilise by mid-2013. Changes in market dynamics will help restore the global supply-demand balance.

4. Solar trade wars will rage on in 2013, yielding few winners. As of November 2012, there were six different solar trade cases proceeding involving China, Europe, the United States and India. This cycle of sanction and retaliation will not help solve the fundamental challenge of overcapacity plaguing the global PV industry.

5. South Africa and Romania will emerge as PV markets to watch in 2013. The two countries next year will expand from virtually no solar installations to capacity of several hundred megawatts. The PV uptake in both markets is driven by distinct factors. In South Africa, PV additions will mainly stem from the tenders awarded in 2012; in Romania, the growth driver will be a green certificate (GC) scheme that will stay in place until 2014.

6. Double-digit returns remain possible for European PV projects in 2013. With the subsidy schemes that are currently in place, all EU countries continue to offer attractive conditions for both private and institutional investors. Meanwhile, an evaluation of no-incentive scenarios shows that the most mature market segments are on the cusp of grid parity, allowing healthy returns on investment.

7. Solar will surpass wind in the United States. The year 2013 marks an important milestone, representing the first time that new U.S. solar PV capacity additions will be greater than those made by wind. This is partly a result of the near-term uncertainty over the federal production tax credit for wind. However, it is also a reflection of solar PV's increasing competitiveness as a form of renewable power generation in some key U.S. markets.

8. China will become the world's largest PV market. Total PV installations in China next year are predicted to surpass 6 gigawatts, allowing the country to surpass Germany as the No. 1 solar market on the planet.

9. Energy storage will transform the solar industry. Batteries increasingly are being seen as an attractive way of retaining PV electricity, letting people use the power later in the day to avoid paying high prices for electricity from the grid. Next year IHS forecasts a big jump in the number of residential PV systems installed with batteries attached.

10. New technology will revive equipment vendors' prospects. Improved technologies will help PV manufacturers cut costs, increase margins and ultimately distinguish themselves from the competition. Such a focus creates an opportunity for both manufacturers and equipment suppliers to obtain larger revenue streams.

First Solar launches 92.5-Watt CdTe PV module

The firm's latest cadmium telluride Series 3 module is the latest milestone on the First Solar's cost-efficiency roadmap

First Solar has released its most advanced thin-film photovoltaic (PV) module, the Series 3 FS-392, which is rated at 92.5 W.

The new FS-392 module maintains all the existing IEC certifications and UL listings for the Series 3 family, including UL listing for 1000 V systems.

"The FS-392 demonstrates the success of First Solar's R&D investment to drive higher and higher module conversion efficiencies into production," says Tom Kuster, First Solar Vice President of Product Management and System Technology. "This increase in module efficiency, coupled with our thin-film technology's real-world yield advantage when compared to crystalline silicon PV, results in higher energy density and lower levelised cost of energy (LCOE)."

One of the drivers of First Solar modules' performance advantage over crystalline silicon solar modules is a lower temperature coefficient, delivering higher energy yields at elevated operating temperatures typical of utility-scale power plants in sunny regions.

Also, according to Lux Research, CdTe modules are set to become the cheapest in the years to come.

Lux: CdTe to pip CIGS to the post in costings

Solar module production costs will fall to as low as $0.48/W in 2017. Although CIGS modules will drop the most, nearly matching crystalline silicon, cadmium telluride will remain the low-cost leader

The solar industry is reeling from overcapacity and supply outstrips demand by two to one. It needs to drive costs lower in order to overcome diminished subsidies and regain profitability and the cost reductions it needs are at hand, according to Lux Research.

Module prices have fallen precipitously over the past four years to a low of $0.70/W but the cost of goods sold (COGS) for modules has not reached this level, resulting in massive losses for most module manufacturers.

"With pressure from competitors, customers, and policy-makers to drop prices even further, manufacturers need to drive costs down to survive and thrive during the coming years of growth in the demand market," says Ed Cahill, Lux Research Associate and the lead author of the report titled, "Module Cost Structure Update: Path to Profitability."

Lux Research conducted a cost and sensitivity analysis, examining the impacts of drivers like low-cost manufacturing locations, high efficiency, increased capacity utilisation, and higher production yields on module COGS. Among their findings:

CIGS has the greatest potential to cut cost. COGS will fall across the board between 2012 and 2017, but the rate of decline will be the steepest for CIGS thin-film modules, which can shave $0.14/W off the cost to $0.64/W.

CdTe remains the low cost leader. Despite the travails of its main champion, First Solar, CdTe thin-film modules will remain the cheapest solar option in 2017, at $0.48/W, down from the current $0.67/W.

Efficiencies are the key driver. Manufacturing location has the greatest potential influence on COGS but overcapacity makes opening new facilities in low-cost countries unlikely. Consequently, increasing module efficiencies will make the most difference, up to $0.09/W for mc-Si and $0.21/W for CIGS.

Pioneer PV launches 'microsolar' CIGS outfit

The firm's copper indium diselenide microsolar-scale panels are suited to many applications. These include mobile consumer electronics, parking meters, remote industrial sensors, rural water filtration and purification systems

Pioneer PV Solutions, a next-generation, thin-film microsolar CIGS company, has officially launched its operations.

Pioneer plans to provide high-quality, off-the-shelf, compact solar solutions for rechargeable and DC power applications to an underserved, multibillion dollar market segment suffering from an

inconsistent solar product supply chain.

Pioneer AAA battery charger

Despite significant advancements in solar power technology and the prodigious growth of the large-scale power module market, the opposite end of the form-factor spectrum has not benefited much from the increased quality and performance.

Today's leading photovoltaic module manufacturers focus on the residential, commercial and utility power segments, with little or no attention paid to the needs and requirements of low-power applications requiring up to 40 watts.

"There is no question that the efficiency, durability, and quality of 'big solar' technologies has vastly improved over the past 20 years," explains Vincent Kapur, vice president of business development for Pioneer PV.

"Yet off-the-shelf 'small solar' solutions are not adequately matched to the needs of the wide variety of microsolar applications. They are often the result of a 'scrapyard legacy,' where castoff crystalline-silicon cells are broken up and manually assembled into suboptimal mini-modules, with little attention paid to quality control, reliability, and performance. The economics of force-feeding the leftovers of traditional big solar technologies into small solar applications doesn't make sense anymore," continues Kapur.

The range of addressable applications that can employ microsolar-scale panels represents a vast "mega-niche," from mobile consumer electronics to parking meters, remote industrial sensors to rural water filtration and purification systems.

One of the largest emerging markets is lighting in the developing world, where some 1.4 billion people have extremely limited or nonexistent access to the electrical grid and in many cases rely on inefficient and polluting kerosene lamps - or nothing at all. A recent International Finance Corp. study on solar off-grid lighting in seven Asian countries identified a potential market of 75 million households, which currently spend approximately $2.2 billion on kerosene annually, in India alone.

Pioneer PV is actively engaged with a number of OEM integrators on high-end, low-cost solar charging solutions for their product lines. It continues to pursue additional strategic funding to expand its market development efforts and finance the build-out of a dedicated thin-film microsolar production line. The company leverages mature CIGS technologies specifically developed by a veteran PV development team to address the requirements of the growing suite of compact solar-powered applications.

First Solliance CIGS cells are 13.85 percent efficient

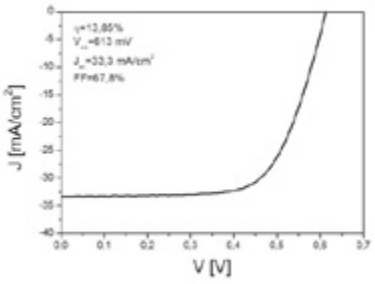
The facility where the cells were grown will also be used to improve the solar cell efficiency of new and emerging CZTS absorber thin film photovoltaic materials

At the new CIGS facility of the Solliance collaboration platform in Eindhoven, the Netherlands, the first CIGS solar cells with 13.85 percent efficiency have been fabricated.

This encouraging result is the starting point for further improvements of the cells efficiency, large-area uniformity and run-to-run variability. The facility will also be used for advancing the alternative thin-film (TF) PV activities of Solliance.

In September 2012, the last tool of the CIGS solar base-line facility was installed and accepted at Solliance partner TNO in Eindhoven. In this CIGS facility, a reference flow was developed resulting in the first CIGS TF-PV cells fully made with the facility's equipment.

The highest efficiency obtained by the first full run was 13.85 percent as shown below.



CIGS solar cell with 13.85 percent efficiency fabricated in the new CIGS facility of Solliance

This is similar to industrial CIGS modules with an efficiency of 13-14 percent, but still below the laboratory record efficiency of 20.3 percent on a CIGS solar cell recently reported by ZSW (Stuttgart).

Based on this encouraging result, further improvements of the CIGS cell efficiencies are expected in the next months through an intensified collaboration of TNO and imec in this CIGS facility.

The main focus of the facility will be to improve the large-area uniformity and to reduce run-to-run variability of the CIGS solar cell manufacturing.

The obtained stable and reproducible reference process flow will serve as a solid baseline for developing improved cell concepts and for innovating process equipment for individual process steps.

The facility has all the processing tools needed for a full CIGS solar cell flow on substrates up to 30 x 30cm2 and will be used as a pre-pilotline for testing cell and process equipment concepts.

This CIGS facility of Solliance will also be used for the alternative TF-PV activities of Solliance, aiming to improve the solar cell efficiency of the new and emerging CZTS absorber TF-PV materials. This new absorber is expected to solve the availability problem of the indium and gallium material of the CIGS absorber when these are used in large volume manufacturing. The new CZTS absorber material consists of only abundant elements like copper, zinc, tin, selenium and sulphur.

The imec thin-film solar cell activities, focusing on CZTS and organic PV, are integrated in the Solliance collaboration platform.

Solliance's ambition is to strengthen the position of the Eindhoven-Leuven-Aachen triangle (ELAT region) as a world player in thin film PV. Solliance aims to realise this ambition by joint use of state-of-the-art infrastructure, alignment of research programs, and close cooperation with the solar TF-PV business community.

Global Solar Energy slashes workforce by 70 percent

The employees of the CIGS manufacturer mostly affected are dedicated to Global Solar's roofing product line

Arizona based Global Solar Energy, Inc., has taken cost-cutting measures as it continues to progress the previously announced sale process and evaluate strategic options.

The manufacturer of CIGS flexible solar technology and portable solar products has reduced its work force by about 70 percent to preserve operational and production flexibility. The reduction in force consisted primarily of employees dedicated to Global Solar's roofing product line. Key technical staff and management have been retained, as well as a production team focused on select customer orders.

Related to recent events, CEO of Global Solar, Jeffrey Britt states, "We continue to work toward a solution which will preserve Global Solar's industry-leading CIGS technology and production capabilities. We have had a very strong level of investor interest which has been predicated on Global Solar's high quality products and technological strength."

Ascent Solar reveals more EnerPlex products

The firm's latest EnerPlex Jumpr battery packs use the firm's CIGS technology

The EnerPlex Jumpr is a multipurpose battery

pack that gives users the capability to store solar power generated from their EnerPlex Kickr IV solar chargers or from a conventional plug in power source. The charged Jumpr can then be used to recharge or power electronic devices in virtually any setting.

The Jumpr product line includes the Model 4400, rated for 4400 milliamp-hours, that can provide about 3 recharges to your smartphone. It also includes the larger Model 7800, rated for 7800 milliamp-hours, which will charge larger devices such as tablet computers.

“The EnerPlex Jumpr, with its power storage capability and compact design, is a great addition to our recently announced Kickr IV portable solar charging units. With these two innovative products everyone from backpackers to road warriors can virtually live life untethered and power their smartphones or other electronic devices off-grid,” says Victor Lee, Ascent’s President & CEO.

The EnerPlex Jumpr is available for sale standalone or bundled with Kickr IV through Ascent’s official website at www.enerplex.biz.

In line with its previous Kickr IV announcement, Ascent will continue to pledge 10 percent of the revenues from Jumpr through the end of the year to support the American Red Cross in the continued recovery effort of Hurricane Sandy.

The EnerPlex brand represents Ascent Solar’s line of consumer products. These products, many of which are integrated with Ascent Solar’s CIGS technology, provide consumers with the ability to integrate solar into their everyday lives, while enabling them to free themselves and their electronics from the outlet.

Global Photonic Energy unveils potential grid parity GaAs solar cell

The cell which reuses gallium arsenide is 20 percent efficient and is ultra-lightweight and flexible and has a potential of $0.45 per watt

Global Photonic Energy Corporation (“GPEC”), a developer of a sustainable Organic Photovoltaic technology, has demonstrated a thin-film solar cell that could provide electricity at grid parity, or the cost of traditionally provided electricity.

Stephen R. Forrest of the University of Michigan says the breakthrough, presented at the Fall Meeting of the Materials Research Society, is the result of substantially reduced production costs.

It is based on a patent-pending invention that reuses the same GaAs wafer multiple times to produce solar cells. This unlimited wafer reuse approach to conventional “epitaxial lift off” technology typically leads to wafer damage. Hence a very limited number (1 to 2) of wafer reuses, has the potential to reduce the cost of a typical GaAs solar cell to below $1 per Watt (peak).

“This exciting development implies that ultra-high efficiency solar cells based on gallium arsenide can eventually produce electricity at or below grid parity.” Forrest states. “Using integrated solar concentrators and our adhesive-free, cold-weld bonding technology to plastic substrates, we estimate electricity could be produced as low as $0.45 cents per Watt, compared to traditional grid parity of $1 per Watt.”

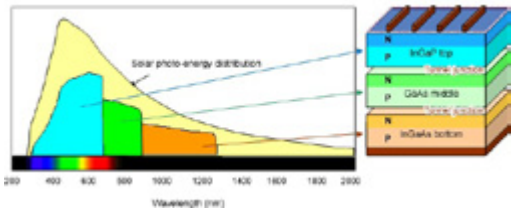
“This is a historic development for GPEC,” states Dean Ledger, President and CEO of GPEC. “In addition to its dramatically reduced cost structure, this demonstration in the University of Michigan laboratories can be used for numerous applications because these high-efficiency solar cells, deployed on roll-up plastic sheets, are ultra-lightweight and flexible. These applications include use in off-grid locations, spot powering of vehicles, mobile military equipment and satellites.” Ledger says GPEC will commercialise its technology through licensing of its intellectual property, becoming part of its foundational portfolio of more than 425 patents.

Sharp`s III-V solar cell breaks barriers with 37.7 percent efficiency

The indium gallium arsenide (InGaAs) triple junction based device has three photo-absorption layers which are stacked together

Sharp Corporation has achieved one of the world's highest solar cell conversion efficiencies of 37.7 percent.

The basic structure of this latest triple-junction compound solar cell uses proprietary Sharp technology that enables efficient stacking of the three photo-absorption layers, with InGaAs as the bottom layer.



Wavelength Distribution of Solar Photo-Energy and Wavelength Sensitivity of Triple-Junction Compound Solar Cell

Sharp achieved this breakthrough a research and development initiative promoted by Japan's New Energy and Industrial Technology Development Organisation (NEDO) on the theme of "R&D on Innovative Solar Cells".

The measurement of 37.7 percent, conversion efficiency was confirmed at the National Institute of Advanced Industrial Science and Technology (AIST).

To achieve this increase in conversion efficiency, Sharp capitalised on the ability of the new cell to efficiently absorb light from different wavelengths in sunlight and convert it into electricity.

The firm also increased the active area for converting light into electricity through optimal processing of the cell edges. These improvements led to higher maximum output levels for the solar cell and enabled Sharp to achieve a solar cell conversion efficiency of a massive 37.7 percent.

Sharp's aim for the future is to apply this latest development success to concentrator photovoltaic power systems that use lenses to collect and convert sunlight into electricity. The company also foresees numerous other practical applications for the cells, such as in space satellites and vehicles.

Opel laser uses POET optoelectronic platform

The III-V gallium arsenide (GaAs) based monolithic platform could change the roadmap for smartphones, tablet and wearable computers

Opel's U.S. affiliate, Odis Inc. has produced an integrated laser device in its Planar Optoelectronic Technology (POET) process.

The laser enables high-performance devices fusing optical and electronic devices together on a single chip.

By allowing the production of components with increased speed, density, reliability, and lower costs, the III-V POET process offers the ability to push Moore's Law to the next level. This overcomes current silicon-based bottlenecks, and could change the roadmap for a broad range of applications, such as smartphones, tablet and wearable computers.

After years of development, the fabrication of the first Vertical Cavity Laser, (VCL) utilising Odis'patented POET GaAs III-V technology is a significant success.

Incremental progress over the years has led to what many consider to be the next phase of semiconductor development which is to surpass the capabilities of complementary metal oxide semiconductor (CMOS) technology for the next generation of high speed low power applications. It is now widely believed that CMOS technology advances have reached a saturation point.

The new laser serves as the basis for chip-to-chip interconnection, and complements numerous other optoelectronic devices already demonstrated by Odis – including heterostructure field effect transistors (HFETs), optical thyristors, pulsed lasers, and super-radiant light emitting devices – all able to be monolithically fabricated via the POET process.

"Rarely can one be part of a development that truly has the potential to change the way the things work on so many different levels and platforms. We believe that this is 'the key milestone' and indeed this is one of those moments. Dr. Taylor and the Odis team have chosen to achieve the most difficult laser first and have done so under extreme duress.

This is not just an endorsement of the Odis' Team but also of the POET process itself," summarises Peter Copetti, Executive Director of the Board of Opel.

Copetti adds, "The reset of our milestone timelines by approximately 8 weeks because of equipment repair caused by Hurricane Sandy is obviously a disappointment to everyone involved, but we believe it is merely a bump in the road. In the long run, it should have no material impact on monetising POET and continuing to deliver shareholder value."

Led by Chief Scientist Geoffrey Taylor, the team of scientists and technologists at Odis see the latest achievement as one of the most significant milestones of a decades-long effort.

Taylor notes, "I'm extremely proud of the team who overcame equipment setbacks triggered by Hurricane Sandy that reset our timelines. I'm confident POET remains on track with its vision of full monolithic integration and its applications in microprocessing."

The POET advantage is the merging of optical devices into the growth and fabrication that supports complementary HFET analogue and digital functions. The *n*-channel and *p*-channel FETs take Opel Technologies Inc. advantage of the high mobilities inherent to strained quantum wells.

At the same time, the quantum wells provide the active emitter for lasers and amplifiers and the active absorber for detectors and modulators.

The intimate connections between diverse device types enables novel gate designs which dramatically reduce the power consumed in the opto-electronic (OE) and electro-optic conversions. The VCL has the small footprint required for dense circuit layout and enables vertical connections from anywhere in the circuit plane to fibre or to other stacked chips.

What's more, the same VCL structure enables in-plane and edge emitting operation based upon proprietary OE designs. Opel believes the availability of the integrated VCL will change the architecture and design for future complementary integrated circuits.

Moving forward, development will lower the threshold current, increase the output power and optimise the in-plane version of the VCL. Also, the complementary transistor circuit capability will be enhanced by reducing the feature size to the 100 nm scale incorporating Odis' new self-aligned contact technology.

With transistor cutoff frequencies around 38 GHz for a 0.7μm gate, the scaling is expected to produce 260 GHz transistors with big improvements in circuit speed.

POET's short-term industry solution is expected to include an optical interface as a single chip to connect existing CMOS processors. The optical interface chip integrates the laser, modulator, modulator driver, detector, receiver amplifiers, serialiser/deserialiser, clock and data recovery, and phase-locked-loop circuits monolithically.

The longer-term solution would look to replacing CMOS gates with POET complementary HFET gates.

POET processors would provide their own optical output and also perform the optical receive function and therefore the need for a separate interface chip would no longer be required.

"This is a key milestone in our acceleration of POET for commercial application," notes Leon M. Pierhal, CEO of Opel. "Opel now has all components in place for on-chip integration of photonic circuits in the same semiconductor framework as electronic circuits."

Pierhal continues, "Hurricane Sandy's effect was felt at Odis's R&D facility at the University of Connecticut. Sandy's devastation affected all members of the Odis staff and the Odis facility itself. Equipment damage within the facility caused by Sandy made the recovery from the storm and the completion of the VCL extremely difficult. It took a herculean effort to complete the VCL."

He adds, "The damage inflicted on the delicate equipment must now be effectively and permanently addressed in order to continue with POET's milestone achievements. A rebuild and retrofitting period of six to eight week is being planned for December and January which will delay the rollout planning process."

The POET platform is currently the basis for a number of key Odis commercial and military projects. These include optical code division multiple access devices for avionics systems, combined RF/optical phased arrays, optoelectronic directional couplers, and ultra-low-power random access memory.

The longer-term solution would look into replacing CMOS gates with POET complementary HFET gates. Opel says POET processors would provide their own optical output and also perform the optical receive function therefore a separate interface chip would no longer be required.

IQE & Solar Junction to pump up the volume of solar cells in 2013

The deal with Solar Junction, which produces 44 percent efficiency III-V wafers, should position IQE to become one of the key epiwafer suppliers to the CPV market

IQE has made significant progress in its commercial relationship with Solar Junction.

In February 2012, IQE announced an exclusive manufacturing and technology transfer agreement with Solar Junction and laid out a series of goals.

These milestones were in order to deliver full 3Junction (3J) structures to Solar Junction based on successful installation and commissioning of customised production scale MBE tools, and subsequent technology transfer from Solar Junction.

Completion of this was planned for the fourth quarter of 2012.

IQE and Solar Junction have together delivered full 3J wafers. Commercial production is expected to begin in the first half of 2013, initially with customer product qualification quantities, moving to volume production in the second half of the year.

Independently, Solar Junction has successfully qualified its cells to full IEC specifications with several customers, and is strongly engaged with all leading CPV systems houses.

Drew Nelson, IQE Chief Executive, says, “Our deal with Solar Junction earlier this year will significantly accelerate our well established CPV strategy and position us to become the key epiwafer supplier to the CPV market. The combination of Solar Junction’s core materials IP and technology, with its recently improved world record efficiencies of 44 percent, together with our own IP and manufacturing capabilities, provides a compelling route to significantly higher cell efficiency and cost effective, high volume production for the CPV industry.”

“That combination is now all but complete and we are on track to move to commercial volume production during 2013. As we approach the end of our financial year, we are also confident that we will meet our earnings expectations. The transformational deals completed with Solar Junction and RFMD earlier this year are highly complementary and position the Group for accelerating growth in rapidly expanding markets,” adds Nelson.

China to acquire First Solar CdTe modules

First Solar will work with Zhenfa to deploy its cadmium telluride modules to power up the Xinjiang province

First Solar is to supply 2 megawatts (MW) of its CdTe solar modules to one of Zhenfa’s New Energy Science & Technology Co., Ltd. solar projects in Xinjiang province in the first quarter of 2013.

The collaboration will be First Solar’s first commercial demonstration project in China and provide a strong platform to showcase the company’s photovoltaic (PV) technology.

“This agreement marks an important step forward in First Solar’s efforts to support China’s renewable energy goals with its advanced solar technologies and global solar industry expertise,” says Bruce Yung, Managing Director and Vice President of Business Development for First Solar in China.

“We are excited to work with a strong partner like

Zhenfa to demonstrate our advanced thin-film technology. I expect this will be the first of many opportunities for collaboration between First Solar and leading Chinese companies, both within China and globally."

"We are very happy about our partnership with First Solar, which is providing its world-class PV technology to one of our key projects. By sharing experience, expertise and technologies we are creating a very strong combination. We look forward to exploring additional opportunities to work together to generate clean, renewable energy for China and the world," adds Zha Zhengfa, Chairman of Zhenfa.

Yung adds, "An important element of First Solar's business strategy is to work with Chinese partners to create shared value both in China and abroad. The agreement between First Solar and Zhenfa will serve as a positive example of win-win collaboration between leading renewable energy companies from China and the United States."

Power Electronics

Raytheon opens UK`s first SiC foundry

The silicon carbide "foundry" facility has been officially opened for power electronic device development

Raytheon says its application of SiC electronic systems will place the UK in a leading position in a number of markets.

The firm's technology will be used to develop high-efficiency, smaller, low-weight power conversion products used in harsh environments across the automotive, aerospace, geothermal explorations, oil and gas, and clean energy sectors.

The Secretary of State for Scotland, Michael Moore, who opened the foundry, says, "Today marks an important demonstration of what we can achieve in the UK through collaboration. The silicon carbide foundry is the first of its kind in the UK and represents the fusion of Raytheon's investment in UK manufacturing technology with university expertise, backed by UK Government funding from the Technology Strategy Board."

This scientific and engineering endeavour born out of Raytheon Glenrothes has placed Scotland in a unique leadership position globally, enhanced by universities across the UK.

The investment has created a team of engineering specialists working in the production of silicon carbide devices and systems designed to operate at high temperatures, specialists who will continue to shape and influence advanced manufacturing processes and technologies.

Raytheon's ability to process SiC utilises high-temperature annealing and high-temperature or high-voltage ion implantation. The components provide unique properties in electronics: SiC has the ability to operate at higher voltages and greater temperatures than pure silicon, and at a third of the weight and volume. This improves operational performance and reduces system operating costs. Raytheon says it is the first company to have successfully tested SiC circuit devices at temperatures up to 4000C.

Bob Delorg, chief executive, Raytheon UK, says,"Raytheon's investment in the foundry coupled with support from the Technology Strategy Board exceeds £3.5 million to date. This places the company at the start of a journey to exploit new global markets for this cost-efficient material, which is estimated to bring significant new business to Raytheon in Scotland in the coming years."

He continues,"As well as employing industry-leading engineers and scientists, we have made substantial commitments to develop new engineering talent to maintain our technological edge in high temperature silicon carbide. We are supporting Ph.D. students and undergraduates, and we are giving apprentices and young graduates the opportunity to develop their careers in this new and exciting arena of next-generation semiconductor technology."

"What was previously unachievable is now possible with silicon carbide,as it allows for smaller and lighter electronics to operate in harsh environments,

and addresses a real customer need for significant energy efficiency savings in the manufacture of power switching and rectifying components (AC/DC converters)."

Ian Watson, director of the aerospace, defence, security and space trade organisation, ADS Scotland, adds, "Today we see Raytheon UK gearing up for future success -through investment, collaboration and diversification. At ADS, we know one of the main challenges industry faces as it looks to the future is continuing technological discovery to stay ahead of global competition."

"To address this challenge, it is vital that industry and academia work together to advance technology and fully explore commercial applications. Raytheon's new facility at Glenrothes is a brilliant example of this and shows the company to be confident not only about its own future, but also the future of the United Kingdom as a home to market leading innovation."

"This sector with companies such as Raytheon that operate in Scotland contributes billions in sales, millions in R&D and thousands in jobs. It demonstrates exactly why aerospace and defence are at the heart of the economy and why their success is crucial to our overall future economic prospects."

Power supplies to drive semiconductor market

Although the global market for semiconductors used in power supplies is forecast to grow at a robust 6.5 percent in 2013, growth opportunities differ widely by semiconductor product and by applications

Despite a largely flat market for power supplies in 2012, IMS Research, (now part of IHS), predicts that the market will offer strong opportunities for some semiconductor manufacturers in 2013.

Its report, "The World Market for Semiconductors in Merchant Power Supplies - 2012," analyses the opportunity for semiconductors in both the AC-DC and DC-DC power supply market and provides forecasts to 2016.

Apart from silicon, the main products used in power applications are GaN and SiC.

Strongest growth is predicted for MPU/MCU/DSP/DSC products at 35 percent in 2013.

Although this is currently one of the smallest markets for semiconductors used in power supplies, it is projected to grow by $45 million from 2012 to 2016 owing to adoption of digital power and advanced power factor correction (PFC) techniques.

Associate Director of IMS Research's power management and conversion group, Ryan Sanderson, comments, "Demands for greater efficiency and increased power density continue to drive opportunities for semiconductor vendors. The market for digital power alone is forecast to quadruple in the next five years, as a direct result of this. Many more opportunities exist, however, linked to legislation and design changes."

Other growth drivers include the increase in demand for power supplies which use synchronous rectification at the output, a trend projected to account for a large part of the $80 million growth forecast for the power MOSFET market from 2012 to 2017.

Also, the combined market for AC-DC switching regulators (integrated FET) and switching controllers (external FET) is predicted to grow by $270 million in the next five years. This is driven in part by demand for more intelligent solutions in cell phone chargers to cope with requirements for "no-load power consumption" and strong demand from applications such as tablets and LED lighting.

Sanderson adds, "2012 was a difficult year for many semiconductor vendors who sell into power supplies, with reduced demand from many sectors. Demand from end markets such as notebook PCs and industrial applications, which typically offer steady growth, was much weaker than average. Opportunities did exist, however, particularly in tablet PCs and the rapidly expanding market for LED lamps and luminaires. These opportunities are forecast to drive further growth in 2013 and beyond.

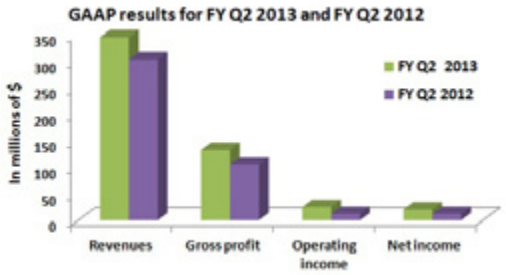
Cree quarterly results shining bright

Revenues increased 14 percent year-over-year to a record $346 million. Net Income increased 69 percent year-over-year to $20.4 million

Cree has announced revenue of $346.3 million for its second quarter of fiscal 2013, ended December 30th, 2012.

This represents a 14 percent increase compared to revenue of $304.1 million reported for the second quarter of fiscal 2012 and a 10 percent increase compared to the first quarter of fiscal 2013.

GAAP net income for the second quarter was $20.4 million, or $0.18 per diluted share, an increase of 69 percent year-over-year compared to GAAP net income of $12.1 million, or $0.10 per diluted share, for the second quarter of fiscal 2012.



“Fiscal Q2 was another strong quarter with record revenue and earnings per share that were higher than our target range due to stronger sales in both LEDs and Lighting combined with improved gross margins,” said Chuck Swoboda, Cree Chairman and CEO.

“Overall company backlog is in line with seasonal trends for our fiscal Q3. Longer term, we remain focused on driving adoption through innovation, and with our broad understanding of the technology levers from materials through systems, we see opportunities to move the market even faster than what has been experienced to date.”

Q2 2013 (GAAP) Financial Metrics

Gross margin increased 170 basis points from Q1 of fiscal 2013 to 38.5 percent.

Cash and investments increased $69.5 million from Q1 of fiscal 2013 to $885.8 million.

Accounts receivable (net) decreased $17.7 million from Q1 of fiscal 2013 to $144.6 million, with days sales outstanding of 38.

Inventory increased $5.3 million from Q1 of fiscal 2013 to $185 million, with days of inventory declining to 78 days.

GAAP based Business Outlook:

For its third quarter of fiscal 2013 ending March 31st, 2013, Cree targets revenue in a range of $325 million to $345 million with GAAP gross margin targeted to be similar to Q2. The gross margin targets include stock-based compensation expense of approximately $2.4 million.

Operating expenses are targeted to be similar to Q2. The tax rate is targeted at 17.0 percent for fiscal Q3. Net income is targeted at $17 million to $23 million, or $0.15 to $0.20 per diluted share. This target is based on an estimated 116.7 million diluted weighted average shares.

Triquint markets 32V GaN-on-SiC RF transistors

The gallium nitride power transistors are optimised for efficiency and offer lower overall system costs

Richardson RFPD, Inc. has announced immediate availability and full design support capabilities for two 35W GaN radio frequency power transistors from TriQuint Semiconductor.

The T1G4003532-FL and T1G4003532-FS are 37W (P3dB) discrete GaN on SiC HEMTs that operate from DC to 3.5 GHz.

The devices are constructed with TriQuint’s 0.25µm process, which features advanced field plate techniques to optimise power and efficiency at high drain bias operating conditions.

This optimisation can potentially lower system costs by decreasing the number of amplifier line-ups needed and lowering thermal management costs.

The new transistors operate at 32V for improved overall circuit efficiency, offer high compressed gain and greater than 33W of compressed output power, and may be used as a driver or final stage.

The T1G4003532-FL is offered in a bolt down flanged package; the T1G4003532-FS is in a solder down earless package. Both are ideally-suited for commercial and military radar, professional and military radio communications systems, test instrumentation, jammers, and wideband or narrowband amplifiers.

The devices are in stock and available for immediate delivery.

First microwave AlGaN/GaN HEMTs on 8 inch silicon

Recent research demonstrates the feasibility of achieving high performance III-nitride HEMTs on 8 inch diameter Silicon (111) for high-frequency and high-power device applications

A Singapore Research Team has demonstrated the direct-current and microwave performances of 0.3-μm-gate-length AlGaN/GaN HEMTs grown on an 8 inch diameter silicon substrate.

The researchers say this is the first demonstration of sub-micron gate GaN HEMTs on 8 inch silicon.

The team was composed of scientists from Nanyang Technological University (NTU), A*STAR Institute of Microelectronics (IME) and A*STAR Institute of Materials Research and Engineering (IMRE).

The High-Electron-Mobility Transistors (HEMTs) were grown using the MOCVD Veeco TurboDisk k465i system.

The fabrication and the characterisation of the submicron devices were performed at NTU. The submicron-gate devices on crack-free AlGaN/GaN HEMT structures exhibited good DC and microwave characteristics.

This work demonstrates the feasibility of achieving good performance AlGaN/GaN HEMTs on 8 inch diameter Silicon (111) for low-cost high-frequency and high-power switching device applications.

Currently, many major silicon fabs worldwide are also pursuing the growth and process development of GaN devices on 8 inch silicon substrates. They would utilise their 8 inch line to reduce the chip cost and increase the chip functionalities by combining with CMOS circuitries.

Figure 1 shows a photograph of crack-free AlGaN/GaN HEMT structures grown on a full 8 inch diameter Silicon (111) substrate, with a starting substrate resistivity of ~100 Ω-cm.

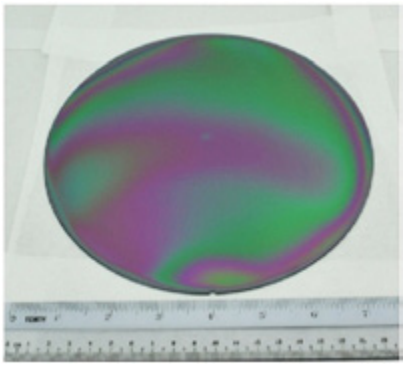


Figure 1. Photograph of crack-free AlGaN/GaN HEMT structure on 8-inch diameter Si(111)

The device structure is: *i*-GaN (2nm)/*i*-Al0.17Ga0.83N (18 nm)/GaN (1050 nm)/AlN (10 nm)/GaN (870 nm)/AlN (10 nm)/GaN/Al1−*x*Ga*x*N (1000 nm) multiple layers/AlN (100 nm)/8 inch Silicon (111).

The grown GaN HEMT structure exhibited an average two dimensional electron gas (2DEG) mobility (*m*H) of 1550 cm2V-1s-1, sheet carrier concentration (*n*s) of 0.84 × 1013 cm-2, and an average *R*sh of < 400 Ω/sq. The product *n*s × *m*H is

1.26 × 1016 V-1s-1 and the surface RMS roughness of AlGaN/GaN HEMT structure is 0.25 nm. These figures are equivalent to previously reported data in the literature for AlGaN/GaN heterostructures grown on 4 inch to 6 inch diameter silicon substrates.

The submicron-gate devices were fabricated using a conventional process technique. The device dimensions are: gate length (Lg) = 0.3 µm; gate width (Wg) = (2 × 75) µm; gate-drain spacing (Lgd) = 2 µm.

Figure 2 shows the small-signal microwave characteristics of AlGaN/GaN HEMTs on 8 inch diameter Silicon (111) for VD = 10 V and Vg = -2.4 V.

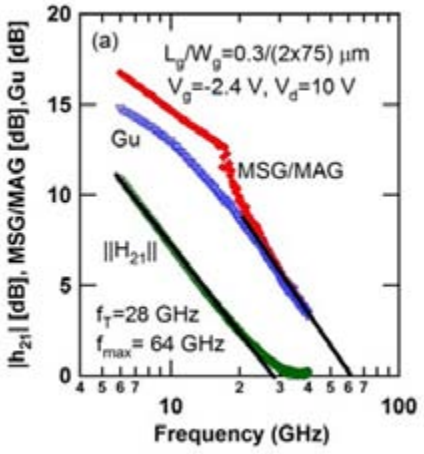


Figure 2. Small-signal microwave characteristics of AlGaN/GaN HEMT structure on an 8 inch diameter silicon substrate

The device exhibited good pinch-off characteristics with *I*Dmax = 853 mA/mm, *g*mmax = 180mS/mm, threshold voltage = -3.8 V, *f*T = 28 GHz and *f*max = 64 GHz. The *f*T×*L*g is 8.4 GHz.µm, which is comparable to the AlGaN/GaN HEMTs fabricated on smaller diameter silicon substrates.

The observed *f*max/*f*T > 2 to 2.66 is due to the occurrence of good quality buffer GaN with low buffer leakage current (4.8 × 10-3 mA/mm at 100 V).

The 2-µm-gate HEMT in the same device structure exhibited a *BV*gd of 188 V which is almost equivalent to the lateral buffer breakdown voltage (*BV*Buff) of 192 V. The presence of a higher screw- and edge- dislocation density at the hetero-interfaces usually leads to a lower *BV*Buff.

In the future, the researchers aim to optimise the growth of GaN-on-silicon to improve the buffer quality and reduce the wafer bowing.

This research work was supported by SERC-A*STAR under the TSRP program grant Nos. 102-169-0126 and 102-169-030.

More details of this work has been published in the paper, “Direct Current and Microwave Characteristics of Sub-micron AlGaN/GaN High-Electron-Mobility Transistors on 8-Inch Si(111) Substrate,” by S. Arulkumaran, G. I. Ng, S. Vicknesh *et al* in *Japanese Journal of Applied Physics,* 51, 111001 (2012). DOI: 10.1143/JJAP.51.111001

Compound semiconductor market still floundering

Despite some revenue growth, the GaAs, GaN, SiC and SiGe markets are suffering at the expense of a stronger silicon market

With financial results in for the second calendar quarter of 2012, the compound semiconductor industry showed sequential revenue growth, but the industry is only slightly ahead of 2011 revenue performance.

This is according to Strategy Analytics’ GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, “Compound Semiconductor Industry Review July - September 2012: Microelectronics.”

While most of the companies highlighted in the report showed sequential revenue increases from the previous quarter, many are struggling in comparison to 2011 revenue. The result is an industry much closer to breakeven than substantive growth.

The report also details several silicon-based product announcements for devices that are directly competitive to their compound semiconductor equivalents.

“The positive news for the compound semiconductor industry is that most companies

showed revenue growth for the quarter, making it the second consecutive quarter that the industry has seen growth", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "However, when you compare the results to 2011, the picture is not as clear. Using this comparison, many of these same companies are struggling to show growth and this reaffirms our position that 2012 will be a low-growth year for the industry".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Part of the issue is the strength of some of the silicon-based product solutions. We are seeing companies like Javelin and Amalfi Semiconductor, which is now part of RFMD along with Peregrine Semiconductor, release some very innovative products that are taking share away from the incumbent compound semiconductor devices".

This viewpoint summarises financial, product, contract and employment developments from leading semiconductor device suppliers from July - September of 2012. These announcements address a variety of commercial and military applications products and companies that use GaAs, GaN, SiC, SiGe and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

Digi-Key to distribute GeneSiC products

The electronic component distributor will supply the firm's silicon carbide power devices globally

Digi-Key Corporation has signed an agreement to distribute GeneSiC Semiconductor's power electronic products based on SiC technologies.

Founded in 2004, GeneSiC Semiconductor's products play a key role in conserving energy in numerous high power systems, running faster, cooler, and more efficiently. This efficiency makes these cutting-edge SiC products ideal for increasing efficiency in energy harvesting applications.

"Digi-Key was the missing piece to our distribution program. This agreement enhances GeneSiC Semiconductor's ability to seed the market with our brand of Silicon Carbide High Voltage, High Temperature, and first of their kind (1N8XX SiC Diode/2N76XX SiC Transistors) Mil-Standard products," says Michael DiGangi, Chief Business Development Officer at GeneSiC Semiconductor.

GeneSiC has one the largest portfolios of commercial SiC diodes, offering SiC switches and the Super Junction Transistor (SJT). These devices are aimed at revolutionising IGBT and FET designs for engineers who are looking for higher performance.

The company is also committed to a portfolio of silicon, high-voltage rectifier products with one of the best forward voltages in the market today. While others have abandoned this market, GeneSiC Semiconductor has been investing in new and exciting products.

"We are excited to add GeneSiC Semiconductor to our expansive line card," says Mark Zack, Vice President, Global Semiconductor Product at Digi-Key. "Adding suppliers as committed to innovation as GeneSiC Semiconductor affirms our commitment to providing the newest, state-of-the-art products to our customers."

GeneSiC's broad portfolio of efficient, high-performance products is available for purchase on the Digi-Key website.

Cambridge Centre for GaN orders tool to purify hydrogen in MOCVD reactor

The centre will use the tool to remove oxygen, moisture and carbon contamination to ensure a stable process regardless of source gas quality or flow rate in gallium nitride products

Power & Energy Inc. (P+E) , has received an order for a PE9000C Series purifier from The Cambridge Centre for Gallium Nitride at the University of Cambridge.

The micro-channel palladium purifier will be used to purify hydrogen for use in a new Aixtron MOCVD reactor. The research team is focused on the cutting edge of GaN research via collaboration with universities and industries throughout the world.

The compact 9000C Series removes oxygen, moisture and carbon contamination to parts-per-trillion levels to assure a stable process regardless of source gas quality or flow rate.

PE9000C Series Hydrogen Purifier

According to Colin Humphreys, the Director of The Cambridge Centre for Gallium Nitride, "We require the highest purity gases for our advanced GaN research, which is why we have chosen the palladium membrane technology in the 9000C Series purifier."

This compact mass spectrometer uses a patent-pending method to concentrate impurities for analysis.

HEMS Hydrogen Analyser

HEMS has a 10 minute analysis cycle time and is self-calibrating.

Three models are available for applications such as semiconductor process control and bulk gas production.

Agilent unveils platform for GaN device analysis

The firm's latest software includes the industry's standard gallium nitride device-modelling program. It delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes

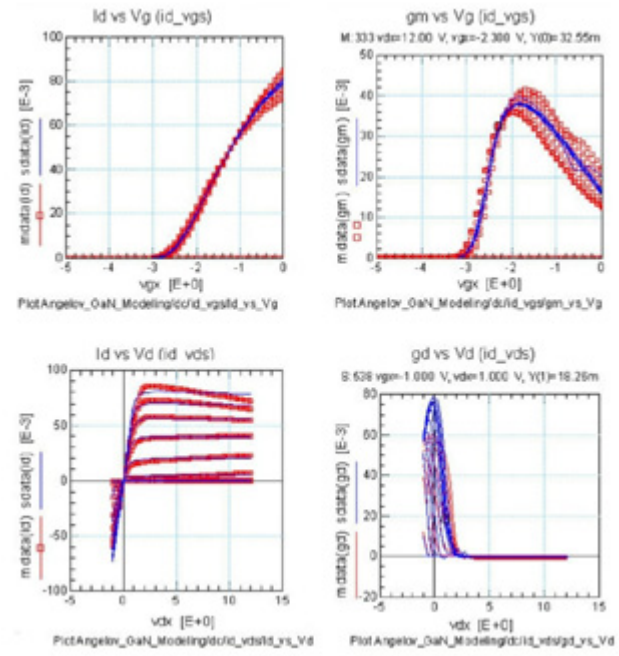
Agilent Technologies has launched a new release of its device modelling software platform, the Integrated Circuit Characterisation and Analysis Program (IC-CAP).

With IC-CAP 2013.01, Agilent introduces major improvements to its flagship product for high-frequency device modelling. One key improvement is turnkey extraction of the Angelov-GaN model, the industry standard compact device model for GaN semiconductor devices.

GaN technology is becoming commonplace in today's high-power RF communication circuits and automotive electronic components. Modelling these devices is challenging due to the impact of trapping and thermal effects on the device electrical characteristics.

Existing GaAs models have been used as a first attempt to model GaN devices, but they are not accurate enough. The Angelov-GaN model, developed by Professor Iltcho Angelov at Chalmers University of Technology, is quickly establishing itself as the industry solution to this dilemma.

Agilent's W8533 Angelov-GaN extraction package, which is part of the IC-CAP platform, was developed in conjunction with industry partners and validated on real GaN processes. It provides a dedicated software environment that allows users to perform the necessary measurements and extraction of the Angelov-GaN model.



Example of graphs from IC-CAP Angelov-GaN Extraction Package

Typical DC and network analysers are supported for making DC and S-parameter measurements and de-embedding. A convenient interface lets users execute a step-by-step extraction flow to obtain the model parameters. A turnkey flow provides quick start modeling of GaN devices. The package also enables complete customisation to optimise the flow to different technology flavours of GaN processes. Simulations are performed using Agilent's Advanced Design System.

IC-CAP 2013.01 also features a new Python programming environment that is up to 100 times faster for typical tasks such as parameter extraction, data analysis, instrument control and interface responsiveness. It enables better code organisation and provides an extensive set of libraries for calculations, instrument control and statistical analysis. With IC-CAP Python, users gain major efficiency when developing their programs. Python programs are interoperable with existing programs, ensuring compatibility with ongoing IC-CAP projects.

"As the leading provider of RF device characterisation and modelling, Agilent continues to make bold improvements to our IC-CAP product," says Roberto Tinti, device modelling product manager with Agilent EEsof EDA. "This release represents a major milestone, as Python greatly improves an engineer's ability to learn and get the most out of IC-CAP. We continue to lead the way in high-frequency modelling with our Angelov-GaN extraction package."

Other new features in IC-CAP 2013 .01 include support of Smartspice simulations and support for gain compression and two-tone intermodulation distortion measurements with Agilent's PNA-X network analyser.

The firm says this is a critical capability since nonlinear device characterisation is essential in verifying model accuracy in real applications. Another part of the platform, IC-CAP WaferPro (a powerful automated on-wafer measurement solution), now features usability and user interface enhancements to facilitate test-plan development.

Agilent IC-CAP software is a device-modelling program that delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes. Providing efficient and accurate extraction of active device and circuit model parameters, IC-CAP performs numerous modelling tasks, including instrument control, data acquisition, graphical analysis, simulation and optimisation. It is used by semiconductor foundries and design houses to characterise foundry processes.

IC-CAP 2013.01 can be downloaded from the link: www.agilent.com/find/eesof-iccap-downloads-and-trials.

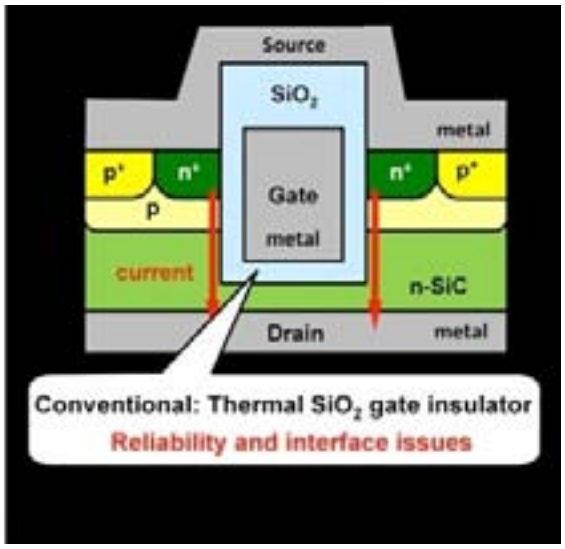
AlON slashes leakage current by 90 percent in SiC

Scientists have demonstrated a 50 percent improvement of the dielectric breakdown field in silicon carbide MOSFETS

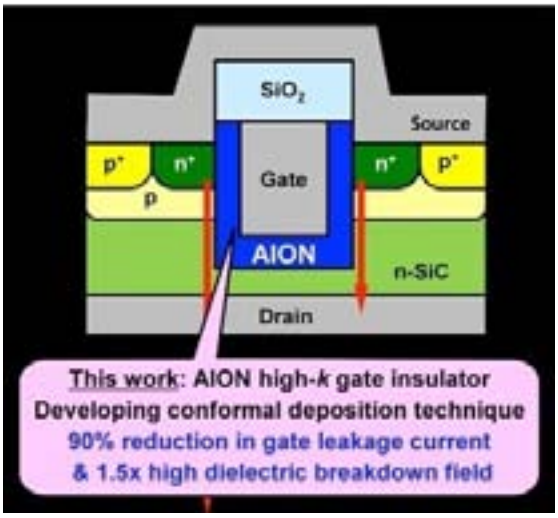
A team composed of researchers from Osaka University, Kyoto University, Rohm and Tokyo Electron have succeeded in developing high-performance and high-reliability SiC MOSFETs.

The scientists implemented high-permittivity aluminium oxynitride (AlON) gate dielectrics.

The diagram below shows a conventional SiC MOSFET.



The researchers modified this structure by using AlON instead of SiO2 in the dark blue region shown in the schematic below.



Thanks to AlON high-k gate dielectrics, a 90 percent reduction in gate leakage current and 50 percent improvement of dielectric breakdown field were achieved.

The researchers say this development is certain to improve SiC MOSFETs and will contribute to realising a low carbon emission society.

This achievement was presented in International Electron Device Meeting (IEDM) by the IEEE on December 10th, 2012.

HexaTech awarded $2.2 million to develop AlN power electronics

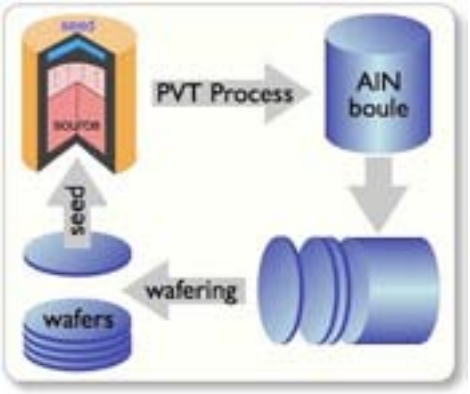
The ARPA-E project will concentrate on using aluminium nitride technology to more efficiently control the flow of electricity across high-voltage electrical lines

HexaTech has received a $2.2 million award from the U.S. Department of Energy Advanced Research Projects Agency - Energy (ARPA-E).

The cash will enable the development of a new power semiconductor technology for the modernisation of the electrical power grid, or “Smart Grid”.

HexaTech’s high-quality AlN technology was identified by the Department of Energy as a transformational, breakthrough technology with significant technical promise.

The firm uses a proprietary process technology for manufacturing AlN crystals and wafers. Starting with inexpensive, commercially available AlN powder, single crystalline AlN boules are grown in custom built furnaces at temperatures exceeding 2000°C. The boules are then sliced into wafers, polished and tested.



Hexatech AlN wafer production process

Using very low dislocation density single crystal AlN substrates, HexaTech will develop novel doping schemes and contact metals for AlN/AlGaN with high aluminium content.

Baxter Moody, Director of Engineering says, “This

contract marks the beginning of a technological leap in device performance and efficiency for power semiconductors. The development will enable a significant step toward producing 20 kV AlN-based Schottky diodes (SBD, JBSD) and transistors (JFET, MOSFET). The ARPA-E contract has opened the door for the material development and research to demonstrate AlN high-voltage, high-efficiency power conversion capability."

For power systems and grid-scale power conversion applications, high efficiency AlN-based power devices will offer a significant reduction in size, weight, and cooling. Power semiconductor devices at this level are not currently available on the market. Experimental devices based on SiC technology are currently being developed. Compared to SiC technology, it is expected that AlN will enable power electronics with a ten times improvement in performance.

Based on the wide bandgap material properties of AlN, the critical field is six times larger, the on resistance will be lower, and the resulting power device area will be smaller for a comparable power level. This is a transformational technology that will revolutionise the power distribution grid.

Controlling GaN-on-silicon(001) growth with insitu monitoring

Laytec has reported EpiCurve TT results obtained during the growth of gallium nitride HEMTs on Si(001) substrates

The growth of GaN on Si(111), especially for LEDs, is quite well known and relatively controllable.

Cooldown-assisted layer cracking as a result of high tensile stress can be prevented and crystal quality can be enhanced by sophisticated interlayers. Many institutions are using LayTec's EpiCurve TT tool with advanced curvature resolution to grow high quality GaN devices on large scale (111) silicon substrates.

Now, this experience is being transferred to growth on Si(001) and Si(110) substrates. This is because GaN based power electronics can be easily integrated with standard silicon electronics (CMOS). What's more, like Si(111), these substrates are also available in large sizes of up to 300 mm.

In October 2012, Jonas Hennig of Otto-von-Guericke Universität Magdeburg in Germany reported results on high performance GaN HEMT structures grown on Si(001). The structures incorporated highly optimised interlayers to control stress and defect density.

The results were presented at the International Workshop on Nitride Semiconductors in Japan.

According to Hennig, *in-situ* growth monitoring by Epi-Curve TT is a great help for their strain engineering.

The well pronounced Fabry-Perot oscillations at 633 nm (red) and 950 nm (blue) in correlation with the smooth development of the curvature show the high quality of the GaN. What›s more, during the growth of interlayers, when the temperature is being reduced, an abrubt increase in curvature can be observed as shown in Figure 1 below.

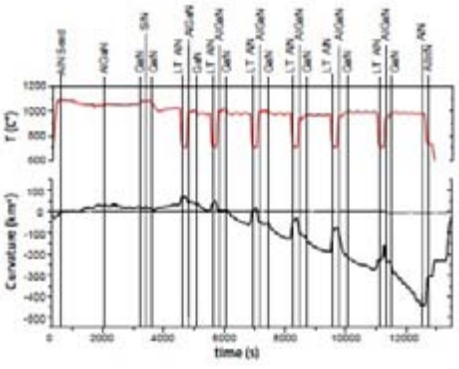


Figure 1: In-situ measurements of temperature (red) and curvature (black)by EpiCurve TT during GaN on Si(001) growth.

The three combined reflectance signals help to determine the growth rates and allow adjustment of the growth parameters. In addition, the 405 nm reflectance (the black line in Figure 2 below), provides information on the structural interface quality.

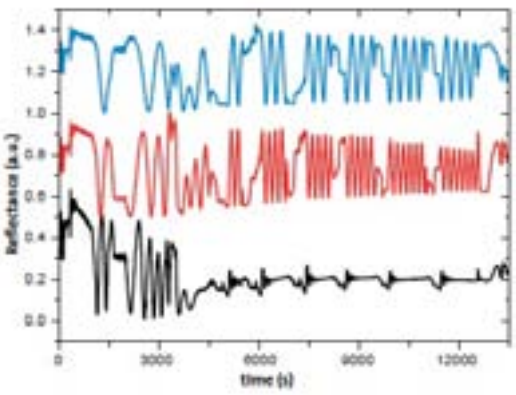


Figure 2: In-situ reflectance measurements by EpiCurve TT at three wavelengths:

blue – 950 nm, red – 633 nm, black - 405nm

The work at Otto-von-Guericke University and other institution which use LayTec's *in-situ* tools for silicon applications shows that the quality of GaN-on-silicon can be significantly improved by advanced curvature monitoring in combination with multiple wavelength reflectance.

IR restructures to commercialise GaN-on-silicon

The firm has appointed former VP and COO Mike Barrow to push gallium nitride technology for power device applications

International Rectifier Corporation has appointed Gary Tanner as Executive Vice President and Chief Operations Officer, effective January 2nd, 2013.

Tanner, 60, will report directly to Oleg Khaykin, President and Chief Executive Officer, and will be responsible for the continued implementation of the company's operational transformation strategy.

Tanner will succeed Mike Barrow, 58, who will now lead the company's efforts to commercialise its GaN on silicon technology.

"As we position IR for the next phase of growth, the execution of our operational transformation strategy and the successful launch of our GaN technology platform will be two of our major focus areas," says Oleg Khaykin, International Rectifier's President and Chief Executive Officer.

"Both Gary and Mike have outstanding track records in the semiconductor industry and I am confident in their leadership and management capabilities to drive two of our most critical initiatives."

"I am excited about the opportunity to join International Rectifier and help build upon the strong foundation that is already in place," adds Gary Tanner. "I look forward to working with IR's talented operations team to continue implementing our operational transformation strategy. We believe that doing so will allow us to re-size our operations, reduce costs, effectively scale the business during an up-cycle and significantly reduce the downward margin pressure during a down cycle."

Tanner brings over 35 years of semiconductor industry experience to IR and most recently served as Chief Executive Officer at Zarlink Semiconductor Inc., which was acquired by Microsemi Corporation in October, 2011.

Prior to his role as Chief Executive Officer. Tanner served as Chief Operating Officer where he was responsible for increasing Zarlink's operational efficiency and streamlining operations. He joined Zarlink in 2007 as Senior Vice President of Worldwide Operations via the acquisition of Legerity where he served as the Head of Operations.

Before Zarlink, Tanner worked for nine years at Intel Corporation, where he held various positions managing domestic and international manufacturing operations. Prior to Intel, Tanner held various management positions in fab operations at National Semiconductor, Texas Instruments and NCR. Tanner holds a Bachelor of Science degree in Technical Management from Regis College.

"The company has made a significant investment in developing GaN technology over the past nine years. As we move from the research and development phase to production, we are putting one of our most senior and talented executives in charge of this strategic initiative to ensure the successful commercialization of this revolutionary new technology," states Khaykin.

"Mike joined IR in 2008 as Executive Vice President and Chief Operations Officer and was the principal

architect of IR's operational transformation strategy. I thank Mike for his leadership and contribution to IR's growth over the past four years and look forward to his continued leadership as the Executive Vice President of GaN Technologies and his success in commercialising the technology. In his new role Mike will be responsible for all aspects of GaN, including process and product development, product marketing, and manufacturing," continues Khaykin.

"I look forward to leading this critical strategic initiative for IR," adds Mike Barrow. "We have a highly talented GaN technology team, a large library of intellectual property, and have successfully validated our GaN technologies with Tier 1 customers. The next step is for us to fully commercialise this exciting new platform. IR is already a market leader in silicon power management technologies and it is my goal to extend this lead and open up new opportunities with our GaN technologies."

China uses Aixtron to move into GaN power electronics

Dynax Semiconductor is to receive its first Aixtron production system to manufacture gallium nitride on silicon carbide (SiC) and silicon substrates

Chinese firm, Dynax Semiconductor Inc. has placed its first purchase order for an Aixtron Close Coupled Showerhead (CCS) CRIUS MOCVD system.

Aixtron CCS system

The reactor will be used to produce GaN and related nitride semiconductor epitaxial layers on SiC and silicon substrates for microwave and power devices.

Aixtron says it will be the first system in China dedicated to GaN electronics.

After installation and commissioning the system is now ready to produce high quality GaN epi-wafers.

"This is an important step for us", NaiQian Zhang, President and CEO of Dynax Semiconductors, comments. "High power and high efficiency GaN electronic devices are the key components for next generation power management and data communications. This disruptive technology will help us achieve a sustainable society. The Aixtron reactor is a proven system for this application".

Frank Wischmeyer, Vice President and Program Manager Power Electronics at Aixtron, says, "The Dynax technical team already has extensive experience with Aixtron's CCS technology. We are looking forward to supporting the customer with our expertise on accelerating the GaN power device market introduction in China."

Compared to conventional silicon devices, GaN electronic devices provide superior performance in RF and power electronic applications in terms of efficiency and power density.

But two major challenges have to be met.

Due to the strong lattice mismatch between GaN and foreign substrates, GaN has to be grown in a special process.

To compete with silicon devices, manufacturing costs have to be as low as possible which requires MOCVD technology to provide high uniformity and reproducibility.

Dynax Semiconductor Inc., Suzhou, was founded in 2011 to manufacture GaN electronic devices. The company is based in Kunshan, Jiangsu province in east China. Dynax produces electronic devices for electronics, data communications, automotives, and motor control markets.

Equipment and Materials

Two Aixtron supervisory board members resign

Holger Jürgensen (deputy chairman of the supervisory board) and Karl-Hermann Kuklies (ordinary member of the supervisory board) have informed the management board of their resignation from office with immediate effect.

Jürgensen studied Physics and Industrial Engineering at RWTH Aachen University and graduated with a Diplom-Physiker (MS in Physics) degree. He joined Aixtron in 1983 and has had several executive placements there.

Holger Jürgensen

Karl-Hermann Kuklies studied Mathematics and Engineering at the University of Münster and joined Aixtron in 1997.

Karl-Hermann Kuklies

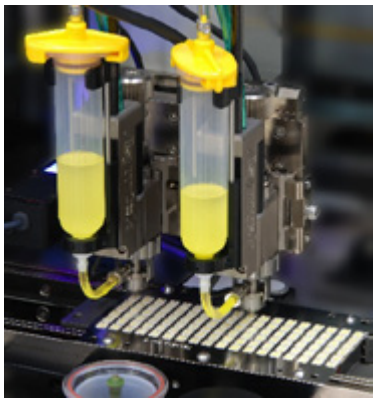
Suitable successor candidates will be proposed for election at the next annual general meeting on May 23rd, 2013.

Nordson showcases phosphor for coating and encapsulation for LEDs

The firm is exhibiting its latest products at LED Korea

Nordson ASYMTEK will demonstrate dispensing solutions for LED and semiconductor packaging at LED Korea 2013.

Applications include phosphor coating for tight CIE LEDs, high-throughput silicone phosphor encapsulation, pure silicone casting, flux, and underfill for flip chip, package-on-package (PoP), chip scale packages (CSP), and ball grid arrays (BGA).



Nordson ASYMTEK LED encapsulation system DJ9500

Also on display will be Nordson ASYMTEK's new NexJet Dispensing System with the one-piece Genius Jet Cartridge. The firm says the system makes dispensing faster, easier, and smarter.

Nordson ASYMTEK's Spectrum S-922N-LED work cell offers consistent dispensing volume for high yields in LED encapsulation. The dual simultaneous jets deliver high throughput that benefits high-volume production and achieves a low-cost solution. The system uses patented CPJ (Calibrated Process Jetting) for automatically ensuring volumetric repeatability during long production runs.

The LED Industry needs technology to deposit conformal phosphors on die or optics for consistent bin control; however, it is challenging to keep the phosphor dispersion in suspension and uniformly mixed.

Nordson ASYMTEK's Spectrum phosphor coating solution meets these challenges. The system includes air management to address safety concerns, a robust interior to minimise damage from phosphor particles, and heated tooling for your specific application.

GAO unveils Identifier with detachable InGaAs detector

The indium gallium arsenide device is suited to identifying dark or live fibre and excessive losses due to misalignment of mechanical splices or poor connections

GAO Instruments has launched a compact fibre optic identifier which provides transmission direction, multiple signal frequency identification and a detachable InGaAs detector.

The model C0230001, employs safe and reliable macro bending technology to avoid the disruption of network communications that would normally be caused due to the need to disconnect or cut the fibre optic cable for identification and testing.

GAO C0230001

With a very small signal loss, normal communications can be maintained while identifying the transmission direction, speed and relative signal strength on its 5-level display.

The portable device offers a wavelength range of 800 to 1700 nm. It identifies signal frequencies of CW, 270 Hz, 1 kHz, and 2 kHz. The identifier is compatible with multiple adapters including Φ250 μm bare fibre, Φ900 μm tight tube fibre and Φ3 mm pigtail fibre.

It provides communication signal indications, comparison light indication and has 5 LED for signal intensity indication. The identifier has a low-voltage indicator and an automatic shutdown function when not in use. Its rechargeable lithium battery allows for more than 4 hours of continuous operation.

The fibre optic identifier belongs to GAO's family of Optical Fibre Identifiers. Another similar product in this line is the Portable Optical Fibre Identifier which features core power display of the fibres, low bending loss and highly efficient output and serves as a tool in the installation and maintenance of telecommunication and CATV systems and other fibre networks.

The two handheld identifiers are simple, rugged, easy-to-use test instruments to detect the presence of network traffic, test tones and multiple signals and determine the direction of signal flow.

Bronkhorst reveals mini MFC for MOCVD growth

The firm's latest device enables higher flow rates for mini Coriolis flow meters

Bronkhorst Cori-Tech B.V. has released a new model in its series of compact Coriolis Mass Flow Meters/Controllers for accurate measurement and control of (very) low flow rates.

With the introduction of mini CORI-FLOW model M15, the maximum flow range of this product line is extended from 0-30 kg/h to 0-300 kg/h. The instruments are suitable for both liquid and gas flow applications.

Mini CORI-FLOW M15 instrument

The firm says its miniature Coriolis sensor features superior response time and high accuracy, irrespective of changing operating conditions with regard to pressure, temperature, density, conductivity and viscosity.

The effective turndown is no less than 1500:1, with easy, on-site possibility for the user to re-range the instrument to his requirements, thus guaranteeing highest process flexibility.

The instruments have a robust IP65 weatherproof housing and are designed to withstand an operating pressure of up to 100 bar. Mini CORI-FLOW offers integrated PID control and close-coupled control valves or pumps, thus constituting very compact Coriolis mass flow control loops.

The Mini CORI-FLOW features digital technology, offering standard analogue and RS232 communication, optional fieldbus interfaces and additional functions such as alarms, totaliser (to measure fluid consumption) and batch dosing. The instruments feature fluid temperature and density as secondary digital outputs.

Multifunctional sensor interface monitor

The new iC-HO controller monitors the flow, gas, pressure and sensor temperature using an energised heating resistor

The latest iC-HO device is a universal sensor interface for the assembly of flow, gas, and pressure sensors.

The units included in the device are a configurable signal conditioner, a fast analogue/digital converter, configurable current sources, temperature drift compensation, digital sensor configuration, an SPI µC interface, adjustable linearisation, and a ratiometric, differential analogue output.

All of these functions are housed on a monolithic chip in a QFN32 package measuring 5 mm x 5 mm.

Resistive mass airflow sensors are driven by iC-HO using two identical reference currents so that the voltage difference conditioned by the programmable amplifier (PGA) can be measured and processed in a digitised form. A temperature control unit is also integrated into the chip.

With gas sensors, a variable tracking controller for two temperatures with a configurable temporal sequence is used. Differential, synchronous recording of the sensor resistance can be configured.

The company says with this controller, splitting the heating resistor and sensor resistor on a sensor MEMS element as iC-HO electrically separates the heating and measurement units.

With pressure sensors, for example, iC-HO provides differential measurement on a resistor measuring bridge as a half or full bridge. By performing an additional measurement the sensor temperature curve can be suitably compensated for.

It is also possible to supply the measuring bridge using a constant current source in place of a voltage.

For flow and gas sensor applications a heating system with a control circuit is also required in addition to the sensor conditioning unit. An on-chip heating controller drives a sensor heating resistor through additional differential sensor inputs and a digital PI controller with D/A conversion. The PI controller can exercise both relative and absolute control over the temperature. A maximum heating current can be specified to protect the external MEMS sensors.

Gain and offset correction of the programmable amplifier (PGA) can be automatically tracked for

the purpose of sensor temperature compensation. The fast, 11-bit A/D converter can either process the measurement values directly or as the difference between two conversions.

The measurement values are output through a ratiometric, differential analogue output. Alternatively, the SPI interface implemented for chip configuration can be used to scan the measurement value and system state through a microcontroller.

Error states and error thresholds can be defined to monitor and diagnose the sensor and chip. These are output through an open collector switching output or the SPI interface.

iC-HO has an internal reference voltage and can output internal analogue signals and the bias current to standard signal pins for calibration.

iC-HO operates from 4.5 V to 5.5 V within a temperature range of -25°C to +104°C. At 5 mm x 5 mm x 1 mm the 32-pin QFN package is extremely compact and has a very good heat dissipation.

The design-in process is supported by ready-to-operate demo boards and software for evaluation with a PC.

Riber makes peace in litigation

The MBE system manufacturer has remained quiet about the terms of the agreement

Riber and the parties in the dispute subject to the Pontoise commercial court ruling of December 11th, 2012 have signed settlement agreements under which they will not appeal against this ruling.

Litigations between the parties are now settled.

Riber revenues rescued by research lab sales

The company says the €27.4 million in revenues for 2012 were in line with objectives

MBE system manufacturer Riber has reported €27.4 million in revenues for 2012, driven by system sales to research laboratories.

Revenues for the fourth quarter of 2012 came to €10.7 million, compared with €10.5 million for the fourth quarter of 2011.

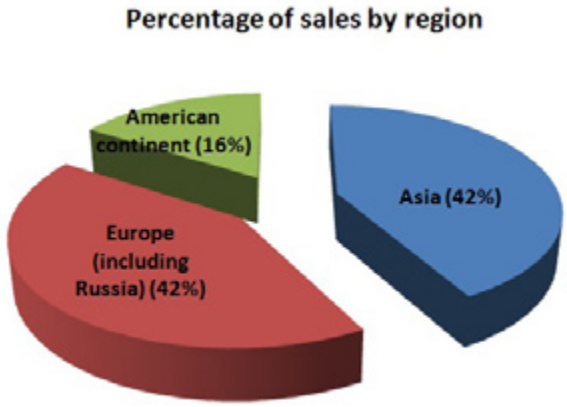
In 2012, the decline in sales of cells and sources was offset by the growth in MBE activity.

During 2012, Riber invoiced and delivered 17 MBE machines compared with 10 in 2011. With 15 systems in 2012, deliveries to research laboratories climbed to an all-time high.

Sales of services and accessories, supported by a commercial recovery plan launched at the end of 2011, were up by 9 percent. This confirmed an upturn in business during the second half of the year.

However, sales of evaporation sources and cells declined due to low investments for OLED production.

On December 31st, 2012, the breakdown of Riber's revenues in terms of percentage are shown below.



Outlook

During the last quarter of 2012, Riber recorded orders for three systems for research laboratories in the US and Austria.

On December 31st, 2012, the order book represented €12.1 million (€19.4 million one year earlier). It includes 11 MBE research systems to be

delivered in 2013.

The services and accessories business has continued to see a positive trend, with Riber's order book coming in 21 percent higher than the previous year.

2012 full-year earnings will be released on April 4th, 2013 (before start of trading).

Avantes & Tornado unite to distribute spectroscopy products

The high-performance HTVS technology will enable spectrometers to overcome the traditional trade-off between sensitivity and resolution

Avantes BV and Tornado Spectral Systems have partnered to design, manufacture and distribute a new line of high performance spectrometers.

Tornado will utilise its proprietary technology, the High Throughput Virtual Slit (HTVS), to design a series of high performance spectrometers which will be manufactured and distributed worldwide by Avantes and its partners or distributors.

The HTVS technology enables spectrometers to overcome the traditional trade-off between sensitivity and resolution. With order(s) of magnitude gain in light throughput at virtually no compromise to resolution, HTVS enables the advent of compact and high-performance spectroscopy solutions at a lower cost than traditional high-performance systems.

Avantes says the partnership will ensure that its customers can access best-in-class products across a wide range of applications.

Tornado's HTVS spectrometer technology has been selected as a PRISM award finalist, winners will be announced at Photonics West, 2013.

Benno Oderkerk, CEO of Avantes says, "We are proud to announce this cooperation and combination of Avantes' market access and comprehensive product line with the technology provided by Tornado to supply the market with the next generation of spectrometers. "

"We believe that Tornado's HTVS-equipped instrumentation forms the foundation of the next generation in optical spectroscopy" continues Arsen Hajian, CTO of Tornado."Our technology will be well represented with our partnership with Avantes, which is a clear leader in quality, manufacturing and customer service."

Veeco impresses KaiStar with GaN MOCVD tool

KaiStar, a JV between Epistar and Shenzhen Kaifa Technology will add to its existing fleet of Veeco MOCVD systems as part of its 2013 LED capacity expansion plan

Veeco Instruments has received an order for multi and single-chamber TurboDisc MOCVD systems, including the new MaxBright M, from KaiStar Lighting Co., Ltd.

TurboDisc MaxBright M GaN MOCVD Multi-Reactor System

KaiStar, a joint venture between Epistar and Shenzhen Kaifa Technology Co., Ltd., is based in Xiamen, China and began LED production in 2012.

The systems will be added to KaiStar's existing fleet of Veeco MOCVD systems as part of its 2013 capacity expansion plan.

MJ Jou, President of Epistar Corporation comments, "This latest capacity expansion in Xiamen is in keeping with our goal to maximise our position in the China LED backlighting, automotive and general illumination market."

"Since we originally selected Veeco as our MOCVD equipment supplier for KaiStar a year ago, we have been extremely impressed with the product quality, service and support we have received. A critical deciding factor has been Veeco's quick process transfer which is important as we share know-how across our LED manufacturing sites. In addition, the TurboDisc's low cost-of-ownership made it a straight-forward decision to turn to Veeco as we add more tools for KaiStar in 2013."

Bill Miller, Executive Vice President of Veeco, says, "We are pleased to support Epistar and Kaifa as they continue to expand their leadership position in the China market through KaiStar and their other joint ventures. We will remain focused on helping them to achieve their manufacturing goals."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System platform is an MOCVD system designed to manufacture high quality, high brightness LEDs. The firm says its MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers accommodating layout configurations compared to the original MaxBright.

Canadian university purchases Veeco MBE system

The reactor will be used for a new nano research centre

The University of Waterloo has purchased a Veeco GEN10 MBE system for its recently opened Quantum-Nano Centre (QNC) hosting the Waterloo Institute for Nanotechnology (WIN) and the Institute for Quantum Computing (IQC).

The system will be installed in the new MBE laboratory being established by Zbig Wasilewski, Endowed Nanotechnology Chair at WIN.

According to Wasilewski, "MBE technology is rich in its application across several fields of study that we are focusing on here at WIN and IQC. After thorough evaluation, we thought the GEN10 was the best choice due to its flexible cluster architecture, system design details, full automation and relatively small footprint. It ideally fits our needs across many research frontiers. Also, given the importance of effusion cells to our research, we thought Veeco would be a great choice given their expertise and our history with their cells."

Jim Northup, Vice President, General Manager of Veeco's MBE Operations, adds, "Our team is very excited that the University of Waterloo has selected the GEN10 as its first piece of equipment to be installed at the new Quantum-Nano Centre. It's a great example of how Veeco's state of the art MBE technology continues to remain at the forefront of broad based research around the world."

The Mike & Ophelia Lazaridis Quantum-Nano Centre opened in the fall of 2012. The QNC is dedicated to allowing faculty and students to pursue quantum information and nanotechnology research at the highest level. Shared between the Institute of Quantum Computing and the Waterloo Institute of Nanotechnology, the building fosters cross-disciplinary collaboration in its many common areas, lounges and meeting rooms.

Veeco's GEN10 MBE system allows for up to three configurable, material specific growth modules, enabling high system utilisation with multiple researchers simultaneously performing unattended growths and calibrations.

BaySpec's InGaAs detector tackles harsh weather

The indium gallium arsenide detector is designed to meet real-world challenges for best-in-class performance, long-term reliability, compact size and optimised power consumption

BaySpec's Nunavut InGaAs detector covers wavelength ranges 900-1700, 1100-2200, and 1250-2500 nm.

The tool also has hermetic-sealing to ensure reliable operation in harsh environments.

BaySpec Nunavut InGaAs detector

Thermoelectric (air) deep-cooling goes down to -60°C while water cooling is an option down to -100°C. Featuring real-time data acquisition, the detector comes in a single 5 volt power supply design.

BaySpec claims it is offering, for the first time in instrumentation history, an affordable, accurate and ruggedised spectral detector.

The Nunavut series employs the latest in opto-electronic components to bring maximised sensitivity at a very competitive price. When matched to a BaySpec NIR-SWIR or Raman spectrograph the firm says the latest addition to its portfolio is a compact, high performance, cost-effective instrument. Each camera is calibrated in the factory after extensive thermal cycling.

The control electronics read out the processed digital signal to extract required information. Both the raw data and the processed data are available to the host. Optimal cooling of the detector arrays allows for greatly improved low-light spectral measurements and reduced dark noise.

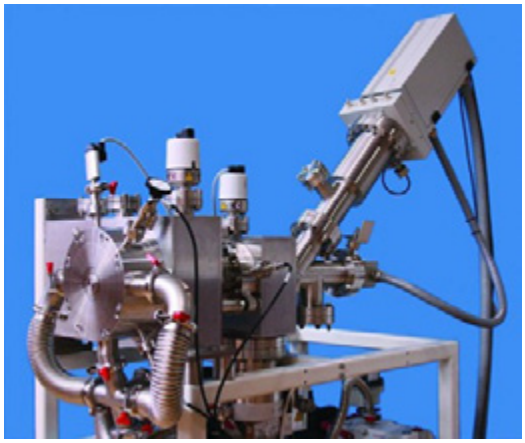
Hiden reveals molecular beam mass spectrometer

The tool is designed for reactive process monitoring

The Hiden HPR-60 mass spectrometer is a research tool designed specifically for direct analysis of ions, radicals and neutral species in reactive processes such as MOCVD.

It will be of interest to researchers in the fields of plasma and transient chemistry, reaction kinetics, catalytic processes.

The system typically operates in pressure regimes from 5 mbar to 5 bar, and mass spectrometer options provide for measurement of neutrals, positive ions, negative ions and ion energies, with choice of mass range up to 2500 amu.



Hiden HPR-60 system with EQP plasma ion monitor

The system samples direct from the process using a sequence of up to three pressure reduction stages with intermediate aligned beam skimmer cones, providing a sampling range from 5 mbar to 100 mbar for the two-stage system and to 5 bar with the third stage.

The configuration forms a supersonic molecular beam for direct, near collision-free transfer of sampled species direct to the UHV-operating mass spectrometer. The potential of each skimmer stage can be independently biased to enhance beam focussing and transmission of ionised species.

An integrated molecular beam chopper is available as a system option for automated simultaneous acquisition of foreground/background data, enabling real time display of the molecular beam intensity with instantaneous subtraction of the beam background signal.

Vacuum system operation is fully automated and systems are provided with integral over-pressure protection. A custom-engineering service is available for design of any required system-to-process interface.

Edwards abatement system for LEDs wins award

Plant Engineering China has recognised the Spectra-G 3000 in the "Environmental Health" category for its role in LED production

Edwards Group Limited has announced that its Spectra-G 3000 abatement system has won Plant Engineering China magazine's 2012 Best Product of the Year award in the Environmental Health category for its role in reducing pollution and costs of LED manufacturing.

Spectra-G300 system

"We are very pleased to be selected for this prestigious award," says Shao Wei, Global Market Sector Manager - LED at Edwards. "The Spectra-G 3000 allows global LED manufacturers to reduce the impact of their operations on the environment and, at the same time, lower their operating costs. It is great to see Edwards being recognised for its commitment to offering state-of-the-art technology with an environmental responsibility."

China's 12th Five-Year Plan focuses on reducing energy consumption and improving the environment. It provides preferential treatment for developing energy-efficient technology and also includes mandatory targets for carbon emissions, nitride pollution in water supplies and nitrogen oxide pollution in air.

The adoption of energy-efficient LEDs for general lighting and specialty applications, such as backlit flat panel displays for computers and televisions, is expected to contribute significantly to reductions in energy consumption and (indirectly) carbon emissions. However, large-scale LED manufacturing has the potential to generate nitride and NOx emissions that must be abated.

Edwards' Spectra-G 3000 system is an advanced gas abatement system specifically designed to handle the large flows of ammonia (NH3) and hydrogen (H2) found in the MOCVD processes used to manufacture LEDs. Using a combustion process, it converts these gases to harmless nitrogen (N2) and water vapour (H2O). Since the process uses no external water it completely eliminates nitride contamination of the water supply, and careful control of the combustion process keeps NOx emissions well below permitted levels. Combustion of hydrogen eliminates the risk of fire or explosion downstream in the manufacturing facility.

Edwards says the system also offers significant reductions in total cost of ownership as most of the energy is supplied by burning the ammonia and hydrogen from the MOCVD process. This greatly reduces the cost of fuel and the release of carbon from hydrocarbon fuels.

Air is used rather than water for post-combustion cooling, so the hot air can be passed through a heat-exchanger to capture and re-use the heat, further reducing the energy consumption and carbon footprint of the manufacturing facility. Finally, the system's robust design and the simplicity of the combustion process minimise maintenance costs.

Optical market still facing tough times

Firms in the LED and equipment market are still facing rapidly declining prices and waning demand and are finding it difficult to increase revenue and income. However, it's not all bad news - product development remains a bright spot

Rapidly declining pricing, softening demand and the continuing uncertainty of the global economy are creating challenges for manufacturers at all stages

of the optical industry supply chain.

Most of the companies that manufacture equipment, material and devices for LEDs, optoelectronic devices and photovoltaic devices are seeing declining revenue and income, or outright losses.

This is according to the Strategy Analytics report, "Compound Semiconductor Industry Review July – September 2012: Optoelectronics, Materials and Equipment" It captures financial announcements from companies such as Soitec, Aixtron, AXT, Hitachi Cable, JDSU, Finisar, Oclaro, Emcore, GigOptix, IQE, Kopin, Cree, OpNext, First Solar and Spire.

Despite declining financials at many of these companies, the report concludes that product development activities remain strong with the announcement of several new LED and higher data rate optical components.

"With a few notable exceptions like Dowa, First Solar and Cree, most of the other companies in this report struggled to increase revenue and income," observes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "Companies in the LED and equipment market are trying to address rapidly declining prices in conjunction with declining demand and they are finding it difficult to increase revenue and income in this environment."

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice adds, "Companies in the optical component segment of the supply chain are developing products for higher data rate networks, but most of the equipment orders at the front-end of the optical supply chain are going to research institutions rather than production expansions."

QuantumClean acquires Advent Cleaning Technology

The provider of high-purity outsourced process tool parts, cleaning and surface treatment to the solar and LED industries has added quartz fabrication to its portfolio

QuantumClean, has acquired Advent Cleaning Technology, Inc. (Advent) semiconductor parts cleaning business located in Carrollton, Texas.

The acquisition of Advent enhances QuantumClean's regional cleaning capabilities and adds quartz fabrication and repair to QuantumClean's already extensive portfolio of semiconductor parts refurbishment services.

"We are pleased to acquire Advent Cleaning Technology, long-recognised in the industry for their strong customer orientation and quality focus. Advent is a perfect fit with QuantumClean's strategy to continually increase its value to its semiconductor wafer fabrication, OEM and OPM customers through the offering of greater capabilities and convenience," comments Scott Nicholas , CEO & President of Quantum Global Technologies, LLC.

"With the Advent acquisition, QuantumClean now operates fifteen Advanced Technology Cleaning Centers and three world class ChemTrace microcontamination analytical laboratories in seven countries employing nearly 1,000 employees dedicated to providing the industry's most technologically advanced high-purity semiconductor parts cleaning and analytical services," Nicholas continues.

ChemTrace is a reference analytical testing laboratory primarily serving the semiconductor, solar and related industries by providing answers and solutions to its customers' micro-contamination related issues. Founded in 1993, ChemTrace also provides independent analytical verification of process tool part cleaning effectiveness for many of QuantumClean's semiconductor fab, OEM and OPM customers which have critical cleaning requirements.

Oxford Instruments hails plasma workshop a `great success`

Presentations included talks on Atomic Layer Deposition process and applications, an overview of plasma etch, PECVD & TEOS processes & nanoscale applications

The first workshop organised by Oxford Instruments Plasma Technology at MIT's Microsystems

Technology Laboratories (MTL), Cambridge, Massachusetts in December was attended by a wide audience.

It addressed the latest research and technologies in plasma etch and deposition, via technical presentations and discussions focussing on latest innovations, as well as a networking lunch.

Vicky Diadiuk, Associate Director, Operations, at MTL, comments, " This was an excellent workshop, and the talks presented a huge amount of very useful information, allowing our students and researchers to learn more about Atomic Layer Deposition and plasma processing from the experts, while also attracting participants from the wider technical community. Many of the attendees have reached out to tell me how much they learnt about the processes discussed. I think this is a really good way for Oxford Instruments to highlight the expertise of its staff."

"We've been hosting these successful seminars worldwide for several years, and were delighted that such recognised speakers as Prof. Erwin Kessels, Technical University Eindhoven and Vince Genova, Cornell University agreed to participate. Their input, together with talks from our own specialists combined to make an informative and interesting day", adds Stuart Mitchell, VP Sales for Oxford Instruments America Inc.

"These workshops provide an ideal opportunity for academic and industrial technologists to network and share ideas, and we are delighted to have held this joint workshop with the Microsystems Technology Laboratories," adds Mitchell.

Presentations included talks on Atomic Layer Deposition (ALD) process and applications; an overview of plasma etch, PECVD & TEOS processes, as well MEMS & nanoscale applications.

Advanced Photonix brings tetrahertz to Japan

The Terahertz manufacturing team shipped four systems in December

Advanced Photonix built and shipped a record number of terahertz systems in December 2012.

Two of the four systems shipped were part of a three system order previously announced for the Japanese market. The other two systems were part of the Appleton Paper strategic alliance.

On August 1st, 2012, Advanced Photonix announced the sale of three T-Gauge systems to the company's Japanese distributor for deployment on a manufacturing line providing 100 percent inspection and quality control of packaged products.

This is the first industrial deployment of terahertz in Japan.

The T-Gauge systems will inspect individual packages for contaminates or anomalies in a powder. This high-speed application was jointly developed by API and its distributor. The system will scan each individual package in five seconds using both imaging and waveform analysis to determine product quality.

On September 5th, 2012, Advanced Photonix announced a strategic alliance and the sale of two systems to Appleton Paper, a specialty coating developer and manufacturer of thermal, carbonless, security and specialty papers. Appleton will utilise terahertz energy to perform various critical measurements in order to provide inspection and quality control of current and newly developed coated products.

The ability of terahertz energy to penetrate non-conducting materials allows for the inspection of solid and liquid products that have already been packaged. The wide frequency content and high precision of the T-Gauge system provides sensitivity to both physical and chemical changes. Measurement of thickness, density, and certain material properties can be used to monitor the quality of the manufactured product.

"I would like to congratulate the Terahertz manufacturing team for building and shipping a record four systems in a single month," comments Richard Kurtz, Chief Executive Officer of Advanced Photonix. "This milestone achievement is indicative of our team's ability to accommodate growth expectations. As our work on the F-35 program is expected to conclude in the coming quarters, we will continue our transition from contract revenues to product revenues. We will always explore government contract work opportunistically, but

believe it will become a smaller portion of our Terahertz revenue as our commercial business increases."

Rubicon secures $25 million revolving credit facility

The financing to the sapphire substrate manufacturer strengthens its liquidity position

Rubicon Technology, Inc. has announced the closing of a three year $25 million secured revolving credit facility with Silicon Valley Bank.

"This undrawn credit facility bolsters Rubicon's strong liquidity position," says William Weissman, Chief Financial Officer of Rubicon Technology. "We believe it is prudent to establish this additional financial flexibility for the future."

Rubicon currently has no debt.

The terms and conditions of the credit facility will be described in the company's filings with the Securities and Exchange Commission.

New Kopin employee secures 400k shares of restricted stock

The firm's board has agreed to award Dashen Fan up to 400,000 shares of restricted common stock

Kopin Corporation, as required by NASDAQ Listing Rule 5635(c)(4), has granted restricted stock to Dashen Fan, a new employee, as a material inducement for Kopin to employ him.

The company stresses that Dashen Fan is not related to John C.C. Fan, Kopin's President and Chief Executive Officer.

Kopin's Board of Directors, including all of its independent directors, has agreed to award Dashen Fan up to 400,000 shares of restricted common stock as an inducement grant outside of Kopin's 2010 Equity Incentive Plan.

A total of 100,000 shares vest upfront and the remaining 300,000 shares vest based on the achievement of certain performance milestones. In the event that Fan is terminated or no longer an employee of Kopin, he is ineligible to continue to vest under this restricted stock award.

Could silicon substrates eclipse sapphire?

Maybe in the LED market. But opportunities for power amplifiers and tuneable capacitors and competing technologies may bring new volume applications to sapphire wafer manufacturers

Significant overcapacity and low LED substrate prices will affect the profitability and viability of many sapphire players in 2013 and beyond, but emerging applications could transform the industry.

According to the latest report by ReportsnReports.com, "Sapphire Substrates 2013", the sapphire material shortage experienced from 2010 to early 2011 created a window of opportunity for new entrants.

In the last two years, more than 80 companies announced their intention to enter the industry, bringing the potential number of players to over 130 with more than 50 of these potential new entrants located in China.

Coupled with slow demand from LED makers in 2012, this has created a very challenging environment with cores and wafers often selling at prices at or below manufacturing cost.

Revenues increased 15 percent in 2011 but are expected to drop 9 percent in 2012 due to lower Average Selling Prices. This will be despite volume increase and a favourableproduct mix with the percentage of PSS wafers increasing dramatically.

These difficult market conditions will trigger an industry rationalisation through consolidation and attrition that should take place in 2013 and 2014; activities that the Yole Finance business unit is monitoring closely.

In the long-term, as the environment remains extremely competitive, it is expected that the

industry will evolve towards a more vertically integrated model in order to limit margin stacking. A handful of tier-1 worldwide leaders should emerge from this rationalisation, along with smaller tier-2 regional players.

LED-on-Silicon is a major threat for sapphire makers

All major LED makers are currently exploring opportunities for transitioning from a sapphire-based technology platform to a silicon-based one ("LED-on-silicon"). This interest is driven by a potential cost savings of up to 60 percent at the die level.

But while significant progress has been made, the technology still faces hurdles.

It remains to be seen whether the leading proponents of LED-on-silicon, like Bridgelux/ Toshiba and Lattice Power, will be able to tackle all of the remaining challenges and transition to mass manufacturing in a cost-effective manner. Another new player in the market is Plessey Semiconductor who have not yet begun mass production, but this should hopefully come in the next year.

For most other LED companies, LED-on-silicon is often an important development axis, but not a necessary milestone on their manufacturing roadmap. The jury is still out, but in the meantime, investments in the large-diameter sapphire platform are often postponed pending the outcome of LED-on-silicon.

GaN could capture some niche markets thanks to higher performance and competitive system-level cost of ownership.

What's more, the Silicon on Sapphire (SoS) application could represent a nice upside for the happy few that enter the supply chain. Demand more than doubled in 2012 and could well do the same in 2013.

Major SoS company Peregrine has developed an Antenna Switch technology that has already achieved vast success in smart phones. The company benefits from strong macro trends in the cell phone market and is developing new components that could further increase not only SoS content per phone, but also wafer demand.

Opportunities for these new components (Power Amplifiers and tuneable capacitors), as well as for competing technologies developed by companies like Paratek (now part of cell phone maker RIM), may bring new volume applications to sapphire wafer manufacturers.

Aldrich reveals liquid-free preparation of metal organic frameworks

High purity MOF products prepared by the liquid-free process may be ideally suited as rare earth containing materials for sensors and detectors, electronic or magnetic materials

Researchers at Aldrich Materials Science have discovered an innovative way to design an important class of 3D hybrid structures; Metal Organic Frameworks (MOFs), under completely liquid-free conditions.

Metal organic materials are used in the manufacture of compound semiconductors.

The discovery also extends liquid-free preparation techniques to a large new class of 3D-structured materials and is expected to lead to new products with unique properties and suitability for applications currently unknown.

A report of the Aldrich-developed procedure was recently published in the journal, *Chemical Communications*. Niraj Singh, Meenakshi Hardi and Viktor Balema from the Aldrich Hard Materials Centre of Excellence demonstrated the synthesis of Y-MOF (MIL-78) using a room-temperature ball-milling process without a liquid grinding additive. In the process, yttrium hydride was ball-milled with solid high-melting trimesic acid to form Y-MOF (MIL-78).

Gaseous hydrogen was the only by-product observed in the process. The liquid-free synthesis process yields MOF products of high purity by preventing contamination from solvents and liquid residues.

Metal Organic Frameworks (MOFs) are an attractive class of highly ordered materials built by combining

multi-functional organic molecules (linkers) and metal ions into a 3D network. The well-defined, highly-ordered, and readily-controlled structure of MOFs can be exploited in a diverse range of applications including gas storage, separations, catalysis, sensors and drug delivery. The presence of modifiable organic linkers in the MOF structure enables tunability of function and customisation of end use.

Current routes to MOF materials typically rely on solution-based processes in which the organic linker and the metal source – a metal salt, carbonate or oxide - are partially or fully dissolved in an appropriate solvent and reacted. The reaction can occur in a tightly closed vessel at high temperature or by subjecting the solution to microwaves, ultrasound or electrochemical treatment.

Metal-organic framework materials can a liquid, which can be included as an additive with the initial solid-phase reaction mixture or generated in situ as a byproduct during the milling process. Although often asserted to be "solid-state," such processes necessarily involve liquid components, which can act as liquid micro-reactors that control the reaction process and promote the formation of MOFs by the conventional solution-based mechanism.

Until the discovery, it was uncertain whether MOF materials could be prepared in a completely liquid-free environment and whether new types of MOF materials and MOF materials of the purity required for many high-tech applications could be prepared in a cost-effective process.

"Excluding liquids from the preparation finally opens the way to making MOF materials whose properties are not influenced by the presence of contaminants and, therefore, may be quite different from those of conventional MOFs. Our approach also avoids the use of solvents, which are often harmful to the environment, difficult to remove from the extended 3D networks of the targeted MOF product materials, and detrimental to the performance of MOF materials in many applications," says Viktor Balema, Manager of the Aldrich Hard Materials Centre of Excellence.

Balema further notes that "Aldrich's process should enable generation of unique hybrid structures with non-conventional properties applicable in numerous areas of modern science and technology, which extend from energy generation and storage to electronics and bio-technology."

Prior to journal publication, Aldrich Materials Science filed a provisional patent application for the newly discovered procedure with the US Patent Office.

"This discovery exemplifies the work being done at the Hard Materials Centre of Excellence. Through this Centre along with the Polymer Centre of Excellence, we seek to enable innovation through new product additions to our materials portfolio, collaborations, technology licensing, custom research, process development and scale-up," comments Shashi Jasty, Director, Aldrich Materials Science.

Vienna University orders Riber MBE reactors

The reactors will be used for compound semiconductor microelectronics and optoelectronics research

Riber has sold two Compact 21 MBE machines to Vienna University of Technology, a material research laboratory in Europe.

The Compact 21 - 3 '' wafer systems are designed for the research on compound semiconductors for microelectronics or optoelectronics. MBE growth technology was selected as this platform is perfectly optimised when top performances of complex semiconductor heterostructures are needed.

These two new systems will enable Vienna University of Technology to increase his research capacities on new III-V and metal based structures. To extent the research capabilities and to grow ''incompatible'' material structures, the two MBE systems are connected together to maintain a full UHV environment all along the MBE processes.

Riber designs and produces MBE systems as well as evaporation sources and cells for the semiconductor industry. This high-technology equipment is essential for the manufacturing of compound semiconductor materials and new materials that are used in numerous consumer applications, such as new information technologies,

OLED flat screens and new generation solar cells.

Cambridge Centre for GaN orders tool to purify hydrogen in MOCVD reactor

The centre will use the tool to remove oxygen, moisture and carbon contamination to ensure a stable process regardless of source gas quality or flow rate in gallium nitride products

Power & Energy Inc. (P+E) , has received an order for a PE9000C Series purifier from The Cambridge Centre for Gallium Nitride at the University of Cambridge.

The micro-channel palladium purifier will be used to purify hydrogen for use in a new Aixtron MOCVD reactor. The research team is focused on the cutting edge of GaN research via collaboration with universities and industries throughout the world.

The compact 9000C Series removes oxygen, moisture and carbon contamination to parts-per-trillion levels to assure a stable process regardless of source gas quality or flow rate.

PE9000C Series Hydrogen Purifier

According to Colin Humphreys, the Director of The Cambridge Centre for Gallium Nitride, “We require the highest purity gases for our advanced GaN research, which is why we have chosen the palladium membrane technology in the 9000C Series purifier.”

This compact mass spectrometer uses a patent-pending method to concentrate impurities for analysis.

HEMS Hydrogen Analyser

HEMS has a 10 minute analysis cycle time and is self-calibrating.

Three models are available for applications such as semiconductor process control and bulk gas production.

Rubicon granted patent for ultra-flat high-throughput wafer lapping

The provider of sapphire substrates has secured a patent to ensure the platens facing the wafers are continuously self-conditioned and self-optimised

Rubicon Technology has had its patent application entitled, “Ultra-Flat, High-Throughput Wafer Lapping Process” accepted by the United States Patent and Trademark Office (USPTO).

The patent covers Rubicon’s process developed to perform grinding and polishing to achieve consistent, ultra-flat and defect-free surface quality for the high-volume production of large diameter sapphire wafers.

Rubicon’s customers in the LED and SoS/RFIC markets have very demanding requirements for the quality of sapphire wafers used in their applications. The patent addresses the quality and flatness challenges inherent in the production of sapphire wafers at larger diameters.

The patented ultra-flat, high-throughput lapping process enables Rubicon to achieve high levels of flatness and quality while maintaining the highest

levels of throughput in the production of large diameter sapphire wafers.

As wafers are lapped and polished, the platens facing the wafers become worn and deformed, leading to the deterioration of wafer quality. In the patented process, the platens are continuously self-conditioned and self-optimised to maintain high performance.

"Rubicon continues to build its patent portfolio and increase its technological leadership throughout the sapphire wafer manufacturing process," says Raja M. Parvez, President and CEO of Rubicon Technology. "This patent underscores our dedication to improving the large-diameter sapphire manufacturing process and improving the leading technology platform for the high-throughput production of high-quality large diameter sapphire wafers for our customers."

Agilent unveils platform for GaN device analysis

The firm's latest software includes the industry's standard gallium nitride device-modelling program. It delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes

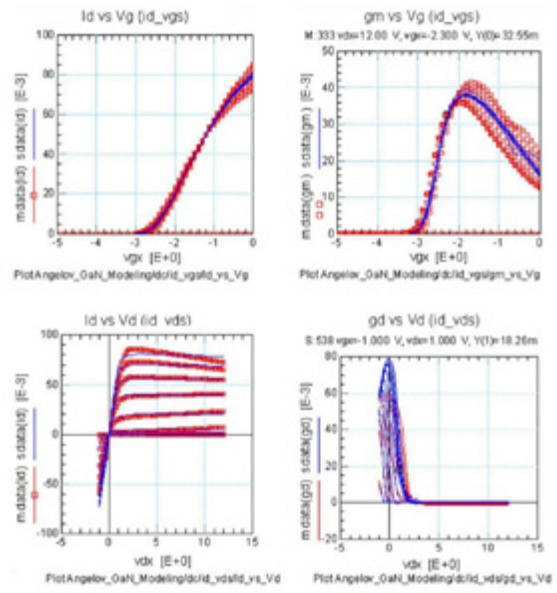
Agilent Technologies has launched a new release of its device modelling software platform, the Integrated Circuit Characterisation and Analysis Program (IC-CAP).

With IC-CAP 2013.01, Agilent introduces major improvements to its flagship product for high-frequency device modelling. One key improvement is turnkey extraction of the Angelov-GaN model, the industry standard compact device model for GaN semiconductor devices.

GaN technology is becoming commonplace in today's high-power RF communication circuits and automotive electronic components. Modelling these devices is challenging due to the impact of trapping and thermal effects on the device electrical characteristics.

Existing GaAs models have been used as a first attempt to model GaN devices, but they are not accurate enough. The Angelov-GaN model, developed by Professor Iltcho Angelov at Chalmers University of Technology, is quickly establishing itself as the industry solution to this dilemma.

Agilent's W8533 Angelov-GaN extraction package, which is part of the IC-CAP platform, was developed in conjunction with industry partners and validated on real GaN processes. It provides a dedicated software environment that allows users to perform the necessary measurements and extraction of the Angelov-GaN model.



Example of graphs from IC-CAP Angelov-GaN Extraction Package

Typical DC and network analysers are supported for making DC and S-parameter measurements and de-embedding. A convenient interface lets users execute a step-by-step extraction flow to obtain the model parameters. A turnkey flow provides quick start modeling of GaN devices. The package also enables complete customisation to optimise the flow to different technology flavours of GaN processes. Simulations are performed using Agilent's Advanced Design System.

IC-CAP 2013.01 also features a new Python programming environment that is up to 100 times faster for typical tasks such as parameter extraction, data analysis, instrument control and interface responsiveness. It enables better code organisation and provides an extensive set of libraries for calculations, instrument control and

statistical analysis. With IC-CAP Python, users gain major efficiency when developing their programs. Python programs are interoperable with existing programs, ensuring compatibility with ongoing IC-CAP projects.

"As the leading provider of RF device characterisation and modelling, Agilent continues to make bold improvements to our IC-CAP product," says Roberto Tinti, device modelling product manager with Agilent EEsof EDA. "This release represents a major milestone, as Python greatly improves an engineer's ability to learn and get the most out of IC-CAP. We continue to lead the way in high-frequency modelling with our Angelov-GaN extraction package."

Other new features in IC-CAP 2013 .01 include support of Smartspice simulations and support for gain compression and two-tone intermodulation distortion measurements with Agilent's PNA-X network analyser.

The firm says this is a critical capability since nonlinear device characterisation is essential in verifying model accuracy in real applications. Another part of the platform, IC-CAP WaferPro (a powerful automated on-wafer measurement solution), now features usability and user interface enhancements to facilitate test-plan development.

Agilent IC-CAP software is a device-modelling program that delivers powerful characterisation and analysis capabilities for today's semiconductor modelling processes. Providing efficient and accurate extraction of active device and circuit model parameters, IC-CAP performs numerous modelling tasks, including instrument control, data acquisition, graphical analysis, simulation and optimisation. It is used by semiconductor foundries and design houses to characterise foundry processes.

IC-CAP 2013.01 can be downloaded from the link: www.agilent.com/find/eesof-iccap-downloads-and-trials.

Praxair to hike gas prices and facility fees in 2013

The price of gases used in III-V MOCVD growth will be increased by between 15 and 30 percent in the US, Canada and Puerto Rico
Praxair and its divisions and subsidiaries are notifying bulk and packaged, industrial, electronics, specialty and medical gas customers in the United States, Canada and Puerto Rico of increases in prices effective January 1st, 2013, or as contracts permit.

Nitrogen, oxygen and carbon dioxide prices will increase by 15 percent, argon and hydrogen by 20 percent and helium by 30 percent.

Facility fees or monthly bulk product charges and cylinder rental rates and hardgoods will be stepped up by up to 15 percent. Price adjustments will vary as permitted by individual supply contracts.

These adjustments are due to persistent supply/demand imbalances for some products in the United States and Canada combined with increases in the cost of feedstock and other raw materials.

What's more, energy costs in the United States continue to increase, driven by state renewable energy requirements and associated utility transmission and distribution upgrades.

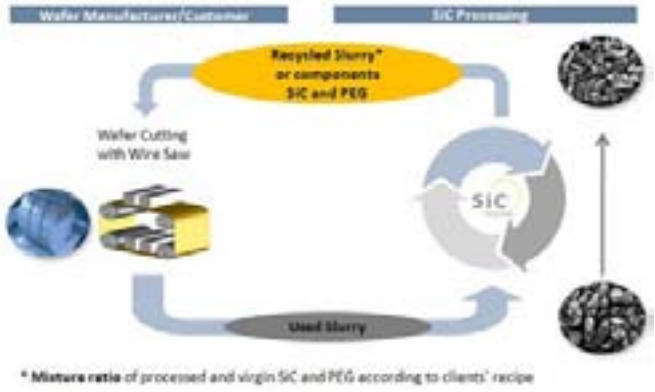
Praxair is one of the largest industrial gas companies in the world, with 2011 sales of $11 billion. The company produces, sells and distributes atmospheric, process and specialty gases used in MOCVD growth of III-V semiconductors.

SiC Processing AS flles for insolvency

The provider for the recovery of used slurry from the photovoltaic and semiconductor industries is following in the footsteps if its sole customer, REC Wafer Norway AS

The management board of SiC Processing AS, the subsidiary of SiC Processing GmbH in Norway, has agreed to petition for insolvency at the district court in Porsgrunn, Norway.

As announced on August 16th, its only customer REC Wafer Norway AS filed for insolvency in the summer of this year. Subsequently, SiC Processing AS has started a solvent winding-up procedure with the consent of its major creditors. Selected creditors have now decided to not maintain their consent, which is required for a solvent winding-up.



Financial consequences for SiC Processing GmbH, its creditors or creditors of its other subsidiaries beyond the cases mentioned in the ad-hoc announcement of 16th August 2012 are currently not foreseen.

With approximately 755 employees worldwide, SiC Processing GmbH is located in 5 countries all over the world with production sites in Germany, China and US and a sales office in Italy. Production sites in Norway were closed down in mid 2012. The founder family holds a 25 percent stake beside the majority shareholder Nordic Capital Fund VII.

Controlling GaN-on-silicon(001) growth with insitu monitoring

Laytec has reported EpiCurve TT results obtained during the growth of gallium nitride HEMTs on Si(001) substrates

The growth of GaN on Si(111), especially for LEDs, is quite well known and relatively controllable.

Cooldown-assisted layer cracking as a result of high tensile stress can be prevented and crystal quality can be enhanced by sophisticated interlayers. Many institutions are using LayTec‘s EpiCurve TT tool with advanced curvature resolution to grow high quality GaN devices on large scale (111) silicon substrates.

Now, this experience is being transferred to growth on Si(001) and Si(110) substrates. This is because GaN based power electronics can be easily integrated with standard silicon electronics (CMOS). What’s more, like Si(111), these substrates are also available in large sizes of up to 300 mm.

In October 2012, Jonas Hennig of Otto-von-Guericke Universität Magdeburg in Germany reported results on high performance GaN HEMT structures grown on Si(001). The structures incorporated highly optimised interlayers to control stress and defect density.

The results were presented at the International Workshop on Nitride Semiconductors in Japan.

According to Hennig, *in-situ* growth monitoring by Epi-Curve TT is a great help for their strain engineering.

The well pronounced Fabry-Perot oscillations at 633 nm (red) and 950 nm (blue) in correlation with the smooth development of the curvature show the high quality of the GaN. What›s more, during the growth of interlayers, when the temperature is being reduced, an abrubt increase in curvature can be observed as shown in Figure 1 below.

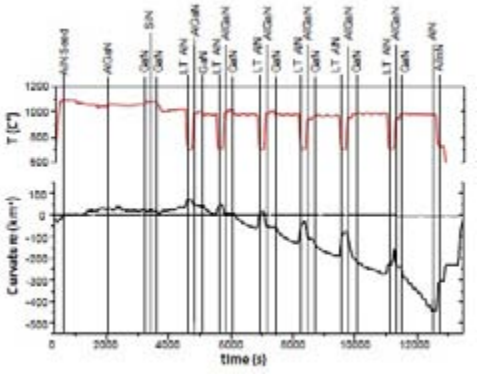


Figure 1: In-situ measurements of temperature (red) and curvature (black)by EpiCurve TT during GaN on Si(001) growth.

The three combined reflectance signals help to determine the growth rates and allow adjustment of the growth parameters. In addition, the 405 nm reflectance (the black line in Figure 2 below), provides information on the structural interface quality.

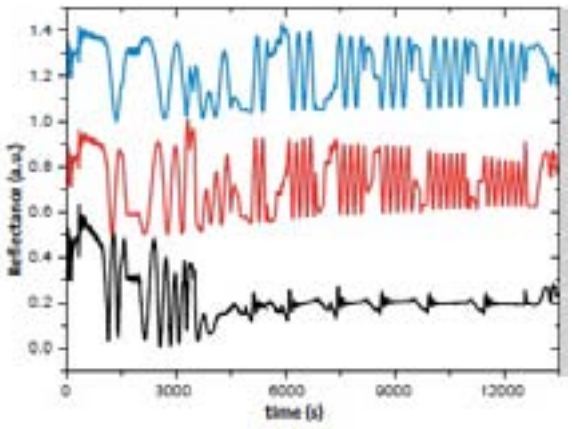


Figure 2: In-situ reflectance measurements by EpiCurve TT at three wavelengths:

blue – 950 nm, red – 633 nm, black - 405nm

The work at Otto-von-Guericke University and other institution which use LayTec's *in-situ* tools for silicon applications shows that the quality of GaN-on-silicon can be significantly improved by advanced curvature monitoring in combination with multiple wavelength reflectance.

China uses Aixtron to move into GaN power electronics

Dynax Semiconductor is to receive its first Aixtron production system to manufacture gallium nitride on silicon carbide (SiC) and silicon substrates

Chinese firm, Dynax Semiconductor Inc. has placed its first purchase order for an Aixtron Close Coupled Showerhead (CCS) CRIUS MOCVD system.

Aixtron CCS system

The reactor will be used to produce GaN and related nitride semiconductor epitaxial layers on SiC and silicon substrates for microwave and power devices.

Aixtron says it will be the first system in China dedicated to GaN electronics.

After installation and commissioning the system is now ready to produce high quality GaN epi-wafers.

"This is an important step for us", NaiQian Zhang, President and CEO of Dynax Semiconductors, comments. "High power and high efficiency GaN electronic devices are the key components for next generation power management and data communications. This disruptive technology will help us achieve a sustainable society. The Aixtron reactor is a proven system for this application".

Frank Wischmeyer, Vice President and Program Manager Power Electronics at Aixtron, says, "The Dynax technical team already has extensive experience with Aixtron's CCS technology. We are looking forward to supporting the customer with our expertise on accelerating the GaN power device market introduction in China."

Compared to conventional silicon devices, GaN electronic devices provide superior performance in RF and power electronic applications in terms of efficiency and power density.

But two major challenges have to be met.

Due to the strong lattice mismatch between GaN and foreign substrates, GaN has to be grown in a special process.

To compete with silicon devices, manufacturing costs have to be as low as possible which requires MOCVD technology to provide high uniformity and reproducibility.

Dynax Semiconductor Inc., Suzhou, was founded in 2011 to manufacture GaN electronic devices. The company is based in Kunshan, Jiangsu province in east China. Dynax produces electronic devices for electronics, data communications, automotives, and motor control markets.

Pfeiffer Vacuum expert honoured for X-ray laser innovation

X-ray laser research has advanced the analysis of compound semiconductors and many other materials

Christoph Bostedt has been awarded the Röntgen Prize of the Justus-Liebig University of Gieß

Third from right is Christoph Bostedt

For over fifty years, Pfeiffer Vacuum, together with the Erich-Pfeiffer Foundation and the Ludwig-Schunk Foundation, has sponsored the Röntgen Prize for young scientists in the field of radiation physics.

Manufacturing processes for solar cells, semiconductors and DVDs are a few examples of applications for vacuum technology.

Vacuum plays a major role in research & development and environmental technology, as well as in the analytical and automotive industries. It is also used in MOCVD growth.

Bostedt is currently a researcher at Stanford Linear Accelerator Laboratory in the USA, where he is a team leader in the Linear Coherent Light Source (LCLS) in the field of nuclear and molecular physics.

Bostedt was awarded the Röntgen Prize for his research in innovative X-ray lasers. His work with the free-electron lasers FLASH and LCLS is especially highlighted. He was able to also take advantage of vacuum solutions by Pfeiffer Vacuum in his scientific work.

X-ray lasers, which are much brighter and have a much shorter pulse duration than other sources, have opened up a large range of new experiments. They also have a high repetition rate.

This has created a very large volume of experimental data from such sources. For example the CXI beamline at LCLS can produce ten times more data than the ATLAS detector at LHC during one year of continuous operation.

The tiny wavelength of X-rays allows us resolve the arrangement of atoms in many materials such as compound semiconductors.

Pfeiffer Vacuum provides hybrid and magnetically levitated turbopumps. The firm's product portfolio comprises backing pumps, measurement and analysis devices, components as well as vacuum chambers and systems.

Deli Optoelectronics opts for Veeco MOCVD tools

The newly formed firm will use the reactors to manufacture III-nitride HB-LED wafers

Guangdong Deli Optoelectronics Co., Ltd, has ordered multiple TurboDisc K465i MOCVD systems to support its high brightness LED manufacturing ramp.

Guangdong Deli Optoelectronics is a privately held company located in Jiangmen.

Mai Qinghua, President of Deli Optoelectronics, comments, "We are excited to select Veeco's K465i systems for our new production facility which will open in the spring of 2013. We chose Veeco over its competitors because of the company's demonstrated market leadership in MOCVD and production-proven technology. Veeco's systems will provide us the lowest cost of ownership to help us achieve great success in the LED market."

Jeff Hawthorne, Veeco's Senior Vice President, MOCVD, adds, "It is gratifying to be chosen by Deli Optoelectronics as they make their first foray into the LED industry. Our tools have supported many of China's LED leaders, so we look forward to providing this new customer with state-of-the-art

equipment, engineer training and excellent support and service."

Deli Optoelectronics (a sub-company of DELIXI), headquartered in Wenzhou, specialises in the manufacturing of electric power transmission and distribution appliances. DELIXI produces a broad range of high and low voltage switchgear sets and components.

InGaAs '4-D' transistor could be the future for computers

Indium gallium arsenide is one of the several promising semiconductors being studied to replace silicon

A new type of transistor shaped like a Christmas tree has arrived just in time for the holidays, but the prototype won't be nestled under the tree along with the other gifts.

"It's a preview of things to come in the semiconductor industry," says Peide "Peter" Ye, a professor of electrical and computer engineering at Purdue University.

Researchers from the universities of Purdue and Harvard created the transistor, which is made from a material that could replace silicon within a decade.

Each transistor contains three tiny nanowires made not of silicon, like conventional transistors, but from InGaAs. The three nanowires are progressively smaller, yielding a tapered cross section resembling a Christmas tree.

The research builds on previous work in which the team created a 3-D structure instead of conventional flat transistors. The approach could enable engineers to build faster, more compact and efficient integrated circuits and lighter laptops that generate less heat than today's.

New findings show how to improve the device performance by linking the transistors vertically in parallel.

"A one-story house can hold so many people, but more floors, more people, and it's the same thing with transistors," Ye comments. "Stacking them results in more current and much faster operation for high-speed computing. This adds a whole new dimension, so I call them 4-D."

The findings will be detailed in two papers to be presented during the International Electron Devices Meeting taking place between Dec 8th and 12th in San Francisco. One of the papers has been highlighted by conference organisers as among "the most newsworthy topics and papers to be presented."

The newest generation of silicon computer chips, introduced this year, contain transistors having a vertical 3-D structure instead of a conventional flat design. However, because silicon has a limited "electron mobility" - how fast electrons flow - other materials will likely be needed soon to continue advancing transistors with this 3-D approach, Ye adds.

Transistors contain critical components called gates, which enable the devices to switch on and off and to direct the flow of electrical current. Smaller gates make faster operation possible. In today's 3-D silicon transistors, the length of these gates is about 22 nanometres (nm), or billionths of a metre. The 3-D design is critical because gate lengths of 22 nm and smaller do not work well in a flat transistor architecture. Engineers are working to develop transistors that use even smaller gate lengths; 14 nm are expected by 2015, and 10 nm by 2018.

However, size reductions beyond 10 nm and additional performance improvements are likely not possible using silicon, meaning new materials will be needed to continue progress, Ye says. Creating smaller transistors also will require finding a new type of insulating, or "dielectric" layer that allows the gate to switch off. As gate lengths shrink smaller than 14 nm, the dielectric used in conventional transistors fails to perform properly and is said to "leak" electrical charge when the transistor is turned off.

Nanowires in the new transistors are coated with a different type of composite insulator, a 4 nm thick layer of lanthanum aluminate with an ultrathin, half-nanometre layer of aluminium oxide. The new ultrathin dielectric allowed researchers to create transistors made of InGaAs with 20 nm gates, which

is a milestone, Ye continues.

The work, based at the Birck Nanotechnology Center in Purdue's Discovery Park, was funded by the National Science Foundation and the Semiconductor Research Corp.

Temescal's electron beam metallisation process slashes costs

The firm's process for lift-off compound semiconductor applications improves uniformity. It is also claimed to deliver up to 40 percent reduction in material consumption

The Temescal Division of Ferrotec Corporation, says it has made a major process breakthrough in electron beam metallisation.

The firm says its Auratus Deposition Process Enhancement Methodology improves wafer-coating processes dramatically, producing near-perfect uniformity while delivering up to 40 percent reduction in material consumption. This results in significant cost savings on process materials like gold and platinum compared to traditional box coaters.

Traditionally, electron beam evaporation takes place inside of box-shaped stainless steel vacuum chambers using a high voltage electron beam to vaporise materials like gold or platinum. Once the material has been vaporised, it forms a flux cloud above the electron beam gun. This results in a thin film coating condensing on the wafers held in an assembly in the upper portion of the chamber.

While this process is considered mature, traditional deposition methods have not fully considered optimising the vapour cloud from the perspective of maximising efficiency in lift-off process collection.

The Auratus methodology reinterprets electron beam evaporation by focusing on optimising vapour cloud utilisation.

"As an industry leader in electron beam deposition, our customers turn to Temescal for our expertise and knowledge of the vapour cloud and both thermal and film uniformity-based results," says Gregg Wallace, managing director of Ferrotec's Temescal division.

"With the Auratus process enhancement methodology, we have re-envisioned electron beam deposition with an emphasis on multiple metal uniformity and collection efficiency. The results are incredible, with near-perfect uniformity, increased precision across a wide range of metals, and up to 40 percent cost savings on process materials, dramatically reducing cost of ownership."

Auratus is a proprietary optimisation methodology for lift-off electron beam evaporative coating that incorporates patent pending technology to achieve unprecedented levels of uniformity, precision, and collection efficiency.

It enables customers to coat wafers with near perfect uniformity, resulting in more consistent, better quality products and fewer defects. Temescal's Auratus methodology also has the capability to increase the effective deposition rate, enabling customers to increase throughput.

Temescal's Auratus process enhancement methodology is only available on select Temescal systems.

KLA-Tencor unveils LED wafer inspector

The ICOS WI-2280 system is designed to provide manufacturers with greater flexibility, reduced cost of ownership and improved efficiency

KLA-Tencor Corporation has revealed its next-generation LED patterned wafer inspection tool, the ICOS WI-2280.

ICOS WI-2280

The tool is designed specifically for defect inspection and 2D metrology for LED applications.

But the ICOS WI-2280 also provides enhanced inspection capabilities and increased flexibility for power semiconductor wafers spanning two inches to eight inches in size.

The ICOS WI-2280 is KLA' fourth generation LED wafer inspection system and is built on its WI-22xx platform, delivering sensitivity with increased throughput.

What's more, the tool supports handling of whole wafers in carriers and diced wafers in hoop ring or film frame carriers to accommodate multiple media with minimal equipment changeover time.

The WI-2280 also features an enhanced rule-based binning defect classification and recipe qualification engine, enabling manufacturers to achieve faster yield learning during production ramps, as well as improve process control and process tool monitoring strategies in their manufacturing process.

"Increasingly, LED manufacturers are demanding improved detection and classification of yield relevant defects of interest, which enables them to take faster corrective actions to improve their yields at higher inspection throughput. There is also a growing need to boost productivity by enabling faster production recipe creation," says Jeff Donnelly, group vice president, Growth and Emerging Markets (GEM) at KLA-Tencor.

"The ICOS WI-2280 addresses critical market requirements, ultimately enabling LED manufacturers to achieve better lumens per watt and lumens per dollar performance. We remain committed to advancing our industry-leading ICOS product line to meet the LED community's emerging needs," continues Donnelly.

The ICOS WI-2280 includes flexible advanced optical modes with dedicated image processing. This enables a high defect capture rate and recipe robustness against varying process backgrounds.

The tool can also classify defects uniquely and has an advanced recipe tuning engine and enhanced metrology capability.

Front-end to back-end-of-line connectivity analysis is also possible, delivering a single platform for defect source analysis. KLA says the system has an easy-to-use inline or offline reclassification engine. This enables post-inspection yield improvements for enhanced productivity

In addition to LED application environments, compound semiconductor and power device markets can leverage the ICOS WI-2280 tool for back-end-of-line and post-dicing outgoing quality control or binning; front-end-of-line patterned wafer inspection for baseline yield improvement, rework, excursion control or overlay; and 2D surface inspection and metrology.

The ICOS WI-2280 also works in conjunction with KLA-Tencor's Candela LED unpatterned wafer inspection system and Klarity LED automated analysis and defect data management system to provide manufacturers with end-to-end inspection coverage.

Novel Devices

III-Vs improve integrated circuit battery life tenfold

Early results using compound semiconductors and processes achieve a milestone towards low-power tunnel transistor electronics

Researchers have demonstrated that using new methods and materials for building integrated circuits can reduce power.

This extends battery life to 10 times longer for mobile applications compared to conventional transistors.

The consortium of researchers was composed of scientists from Rochester Institute of Technology (RIT), SEMATECH and Texas State University.

The key to the breakthrough is a tunnelling Field Effect Transistor (FET). The FET includes GaAs, In0.53Ga0.47As, InAs, InAs0.9Sb0.1/Al0.4Ga0.6Sb

and InAs/GaSb.

Transistors are switches that control the movement of electrons through material to conduct the electrical currents needed to run circuits. Unlike standard transistors, which are like driving a car over a hill, the tunnelling FET is more like tunnelling through a hill, says Sean Rommel, associate professor of electrical and microelectronic engineering.

Sean Rommel

"The tunnelling field effect transistors have not yet demonstrated a sufficiently large drive current to make it a practical replacement for current transistor technology," Rommel adds, "but this work conclusively established the largest tunnelling current ever experimentally demonstrated, answering a key question about the viability of tunnelling field effect transistor technology."

Rommel worked with David Pawlik, Brian Romanczyk and Paul Thomas, three graduate students in the microelectronic engineering and microsystems engineering programs at RIT. Along with colleagues from SEMATECH and Texas State University, the team presented the breakthrough findings at the International Electron Devices Meeting in San Francisco this past December.

In order to accurately observe and quantify these current levels, a fabrication and testing procedure was performed at RIT. Pawlik developed a process to build and test vertical Esaki tunnel diodes smaller than 120 nanometres in diameter, Rommel explains.

This procedure allowed the researchers to measure hundreds of diodes per sample. Because of the nanometre-scale devices tested, the researchers were able to experimentally observe currents substantially larger than any previously reported tunnelling currents.

Esaki tunnel diodes, discovered in 1957 and the first quantum devices, were used to create a map showing output tunnel currents for a given set of material systems and parameters. For the first time, researchers have a single reference to which they can compare results from the micro- to the mega-ampere range, Rommel adds.

"This work may be used by others in designing higher performance tunnelling field effect transistors which may enable future low power integrated circuits for your mobile device," he says.

The National Science Foundation, SEMATECH and RIT's Office of the Vice President of Research sponsor the team's work.

"SEMATECH, RIT and Texas State have made a significant breakthrough in the basic materials for the sub 10 nm node with this work," comments Paul Kirsch, director of SEMATECH's Front End Processes. "The research that was presented at the International Electron Devices Meeting on III-V Esaki tunnel diode performance resolves fundamental questions on the viability of tunnelling field effect transistors and provides a practical basis for low-voltage transistor technologies."

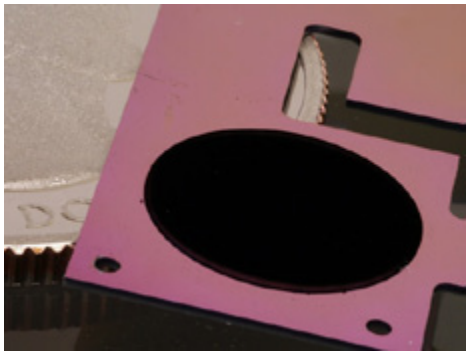
The team's findings in the area of developing high performance, low-power electronic devices are also detailed in the paper, "Benchmarking and Improving III-V Esaki Diode Performance with a Record 2.2 MA cm2 Current Density to Enhance Tunnelling Field-Effect Transistor Drive Current."

Simplifying laser power measurements for telecoms

NIST's prototype carbon nanotube device is a silicon chip topped with circular mats of carbon nanotubes standing on end

NIST has demonstrated a chip-scale instrument made of carbon nanotubes that may simplify absolute measurements of laser power.

The device is especially suited to transmitting light signals used in optical fibres in telecommunications networks.



The circular patch of carbon nanotubes on a pink silicon backing is one component of NIST's new cryogenic radiometer, shown with a quarter for scale. Gold coating and metal wiring has yet to be added to the chip. The radiometer will simplify and lower the cost of disseminating measurements of laser power. (Credit: Tomlin/NIST)

The prototype device, a miniature version of an instrument called a cryogenic radiometer, is a silicon chip topped with circular mats of carbon nanotubes standing on end.

NIST says the mini-radiometer builds on its previous work using nanotubes, the world's darkest known substance, to make an ultra efficient, highly accurate optical power detector.

"This is our play for leadership in laser power measurements," project leader John Lehman says. "This is arguably the coolest thing we've done with carbon nanotubes. They're not just black, but they also have the temperature properties needed to make components like electrical heaters truly multifunctional."

National metrology institutes around the world measure laser power by tracing it to fundamental electrical units. Radiometers absorb energy from light and convert it to heat. Then the electrical power needed to cause the same temperature increase is measured.

NIST researchers found that the mini-radiometer accurately measures both laser power (brought to it by an optical fibre) and the equivalent electrical power within the limitations of the imperfect experimental setup. The tests were performed at a temperature of 3.9 K, using light at the telecom wavelength of 1550nm.

The tiny circular forests of tall, thin nanotubes called VANTAs ("vertically aligned nanotube arrays") have several desirable properties. More importantly, they uniformly absorb light over a broad range of wavelengths and their electrical resistance depends on temperature.

The versatile nanotubes perform three different functions in the radiometer.

One VANTA mat serves as both a light absorber and an electrical heater, and a second VANTA mat serves as a thermistor (a component whose electrical resistance varies with temperature).

The VANTA mats are grown on the micro-machined silicon chip, an instrument design that is easy to modify and duplicate. In this application, the individual nanotubes are about 10nm in diameter and 150μm long.

By contrast, ordinary cryogenic radiometers use more types of materials and are more difficult to make. They are typically hand assembled using a cavity painted with carbon as the light absorber, an electrical wire as the heater, and a semiconductor as the thermistor.

Also, these instruments need to be modelled and characterised extensively to adjust their sensitivity, whereas the equivalent capability in NIST's mini-radiometer is easily patterned in the silicon.

NIST plans to apply for a patent on the chip-scale radiometer. Simple changes such as improved temperature stability are expected to greatly improve device performance.

Future research may also address extending the laser power range into the far infrared, and integration of the radiometer into a potential multipurpose "NIST on a chip" device.

More details of this work are described in the following articles:

"Carbon nanotube electrical-substitution cryogenic radiometer: initial results," by N.A. Tomlin *et al* in*Optics Letters*, Vol. 38, No. 2. Jan. 15, 2013.

NIST Tech Beat article, "Extreme Darkness: Carbon Nanotube Forest Covers NIST's Ultra-dark Detector," at www.nist.gov/pml/div686/dark_081710.cfm.

and

NIST Tech Beat article, "Prototype NIST Device Measures Absolute Optical Power in Fiber at Nanowatt Levels," at www.nist.gov/pml/div686/radiometer-122011.cfm.

Microwave GaN-on-Si HEMTs compatible with non-gold metal stack

The devices are believed to exhibit the lowest specific contact resistivity (rc) ever reported for CMOS-compatible non-gold ohmic contacts for conventional gallium nitride HEMTs on a silicon substrate

Researchers from Nanyang Technological University, Singapore have demonstrated 0.15 μm gate-length AlGaN/GaN high-electron-mobility transistors (HEMTs) with direct-current and microwave performances.

The scientists, led by Professor G. I. Ng, say that this is the first microwave performance GaN-on-silicon HEMTs with improved ohmic contact using complementary metal-oxide-semiconductor (CMOS)-compatible non-gold metal stack.

The silicon/tantalum (Si/Ta)-based ohmic contact exhibited the lowest contact resistance (*Rc* = 0.24 Ω-mm) ever reported thus far with as smooth surface morphology.

This work demonstrates the feasibility of achieving high performance GaN-on-silicon HEMTs using a non-gold metal stack approach which is compatible to the CMOS process in large-volume silicon manufacturing lines.

The fabricated GaN HEMTs exhibited maximum drain current density (*IDmax*) of 830 mA/mm, a maximum extrinsic transconductance (*gmmax*) of 250 mS/mm, and a threshold voltage (*Vth*) of -3.75 V. The measured current gain cut-off frequency*fT* and maximum oscillation frequency *fmax* are 39 GHz.

The devices also achieved a breakdown voltage of 90 V with a minimum drain current collapse of less than 10 percent for a gate-drain spacing of 1.7 μm. The device Johnson's figure of merit (J-FOM =*fT*×*BV*gd) is in the range between 3.51 THz.V to 3.83 THz.V which is comparable to other reported GaN HEMTs on silicon with a conventional III-V gold-based ohmic contact process.

The GaN HEMT structure was grown by MOCVD with a 2-nm thick GaN cap layer, 18-nm thick Al0.26Ga0.74N barrier, 800-nm thick GaN buffer and 1.4-μm thick transition layer on 4 inch silicon (111) (resistivity > 6000 Ω-cm).

The grown structure exhibited room temperature 2-dimensional electron gas (2-DEG) mobility of 1450 cm2/V.s and sheet carrier density of 1.1x1013 cm-2. An optimised Ta/Si-based ohmic contact metal scheme (Ta/Si/Ti/Al/Ni/Ta) revealed repeated low *Rc* value of 0.24 Ω-mm (standard deviation of 0.07 Ω-mm) out of 3 separate runs with an average specific contact resistivity (*r*c) of 1.25x10-6 Ωcm2.

This is believed to be the lowest ever reported for CMOS-compatible non-gold ohmic contacts for conventional GaN HEMTs on silicon and it is also lower than that of recessed ohmic contacts.

With reference to the conventional gold-based ohmic contact [Figure 1(a)], the CMOS-compatible non-gold ohmic metal stack provides a smooth surface morphology with good edge definition [Figure 1 (b)].

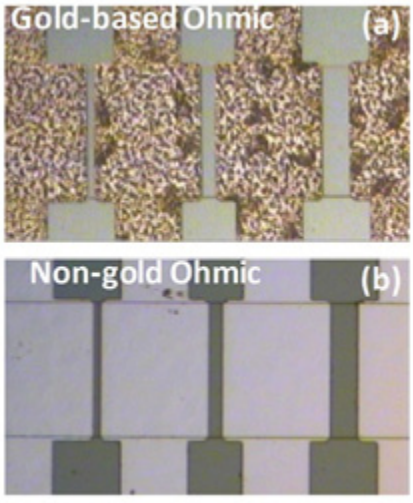


Figure 1 (a) Conventional III-V gold-based Ohmic contact with rough morpholoty, (b) Non-gold Ohmic contact with smooth surface morphology

This simple ohmic scheme also avoids the need to use other complicated techniques such as an ohmic recess or a regrown ohmic contact, which will complicate the manufacturing process. The fabricated devices have also exhibited very low current collapse (less than 10 percent) at gate- and drain-quiescent biases (*Vgs0* = -8 V, *Vds0* = 10 V) [Figure 1 (c)]. Further device improvement can be realised by optimising the GaN HEMT epi-structure and by reducing the device parasitics.

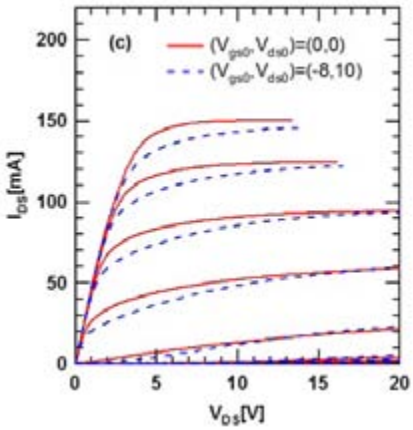


Figure 1 (c) Pulsed (pulse width = 200 ns; pulse period = 1 ms) IDS-VDS characteristics of fabricated GaN HEMTs on silicon using CMOS compatible non-gold metal stack.

This research work is supported by SERC-A*STAR under the TSRP program grant No.102-169-0126.

Further details of this research are described in the paper, "Demonstration of Submicron-Gate AlGaN/GaN High-Electron-Mobility Transistors on Silicon with Complementary Metal–Oxide–Semiconductor-Compatible Non-Gold Metal Stack," by S. Arulkumaran, G. I. Ng, S. Vicknesh *et al*, in*Applied Physics Express 6*, 016501 (2013). DOI:10.7567/APEX.6.016501

SiC could eclipse diamond in quantum computers

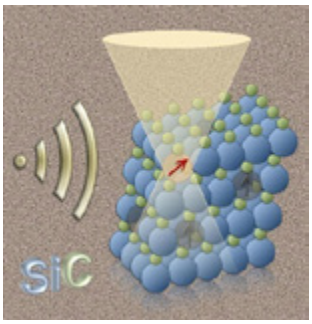
By creating a silicon vacancy defect in silicon carbide, scientists have generated additional energy levels in the so band gap for use in supercomputers

Researchers from the University of Würzburg have modified SiC crystals to exhibit new and surprising properties.

This makes them interesting with regard to the design of high-performance computers or data transmission.

SiC crystals consist of a regular lattice formed by silicon and carbon atoms. At present, these semiconductors are extensively used in micro and optoelectronics. They are particularly suited for used in high temperature applications in power semiconductors.

Now physicists from Saint Petersburg and the University of Würzburg have succeeded in manipulating SiC in a way so it can be used in novel, super-fast quantum computers.



A combination of light and radio waves can be used to store and retrieve information in silicon vacancy defects. (Graphics: Georgy Astakhov)

A defect in the crystal

"We have removed a silicon atom from the crystal lattice, thus creating a silicon vacancy defect," Georgy Astakhov says, explaining the method applied by the physicists. Astakhov is a research fellow at the Department for Experimental Physics VI of the University of Würzburg.

To the researchers' surprise, this crystallographic defect gives the material interesting new properties.

In order for the semiconductor to emit light, its electrons must be raised to a higher energy level by means of energy-rich light, for instance. The silicon vacancy defect leads to the generation of additional energy levels in the so-called band gap.

Stepladder for electrons

Vladimir Dyakonov, chair of the Department for Experimental Physics VI, explains the process with a simple analogy; "In a regular, perfectly structured silicon carbide crystal, the electron must overcome a big hurdle with only one step. This requires a lot of energy. Due to the defect, the electron is provided with a ladder. It can clear the hurdle with two steps, requiring less energy."

When the electrons "fall back" from the higher energy level to the lower one, this type of silicon carbide emits infrared rather than ultraviolet light. According to Astakhov, such light is better suited to transfer information in an optical fibre. "This requires wavelengths in the infrared range," the physicist says.

Application in a quantum computer

The modified SiC is particularly promising for another application – as a semiconductor and storage medium in novel quantum computers. "Since their invention, transistors have shrunk from several tens of micrometers to approximately 10nm, i.e. about one thousandth of their original size," Astakhov notes.

If the miniaturisation continues at this speed, transistors would have to consist of one individual atom in ten years' time. At this scale, however, special physical laws apply, namely the laws of quantum mechanics.

The computers of today process information with the binary system (0/1): Electricity flows or it does not. A quantum computer processes information in the form of so-called qubits. These can be based on the spin of electrons. In simplified terms, the spin represents their angular momentum. It can point in several directions, for which reason it can represent much more information than a classical bit.

The information lies in the defect

"In this field of research, a lot of attention has been paid to the colour centres in diamond, which exhibit defects that are similar to those of our silicon carbide," says Astakhov.

Their qubits can be easily addressed, changed or read even at room temperature. However, the diamond production technology is not nearly as advanced as that of silicon semiconductors. "For this reason, there is a worldwide hunt for quantum systems that combine the advantages of diamond and silicon within one material," Astakhov explains.

The Würzburg physicists believe SiC with a vacancy defect to be a suitable candidate for this purpose. "The missing atom also has as a consequence that the crystal lattice lacks an electron, which in turn is equivalent to the spin that can be used as information carrier in a quantum computer," Dyakonov explains. What's more, the SiC technology is fairly well developed. LEDs, transistors, micro-electro-mechanical components or sensors made from this material are already on the market.

Exposing the material to light and radio waves

The Würzburg physicists conducted their experiments in collaboration with researchers from Saint Petersburg. By "hitting" the silicon crystals simultaneously with light and radio waves, they were able to manipulate the spins in a targeted way, enabling them to store and retrieve information at will.

What the physicists are particularly enthusiastic about is the fact that the silicon vacancy qubits in a densely packed crystal behave almost like atoms with well-defined, very sharp optical resonances. "This is very unusual," Astakhov adds.

"This is a new research field where experimental data of other study groups are still scarce at the moment. However, the reviewers looked favourably on our experiments and immediately recommended our manuscript for publication. We are very curious to know how the scientific community will react to our study," Astakhov reveals. The first reaction has already materialised; Astakhov has been invited to present his results at the Quantum Science Symposium in Cambridge.

Spin quantum computers not only require the ability to process information, but also to store

the information for as long as possible. This is still a problem at this point, since the stray field of adjacent nuclei can gradually erase the information stored in the defects.

Therefore, the researchers from Würzburg and Saint Petersburg plan as a next step to produce SiC crystals that are formed from a silicon isotope without a magnetic moment. “We know that spin-free isotopes of silicon and carbon atoms exist,”concludes Astakhov. A SiC crystal exclusively consisting of such isotopes should therefore be capable of storing the information over a long period of time.

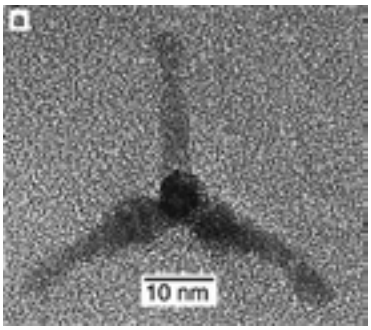
Further details of this work have been published in the paper, “Resonant addressing and manipulation of silicon vacancy qubits in silicon carbide”, by D. Riedel, *et al* in *Physical Review Letters*, 109, 226402 (2012). DOI:10.1103/PhysRevLett.109.226402

QMC commercial II-VI QD manufacturing technology awarded

The firm has been honoured for its commercially viable technology that enables large-scale production of highly efficient inexpensive QDs

Frost & Sullivan has bestowed Quantum Materials Corporation (QMC) with the 2012 North American Frost & Sullivan Award for Enabling Technology.

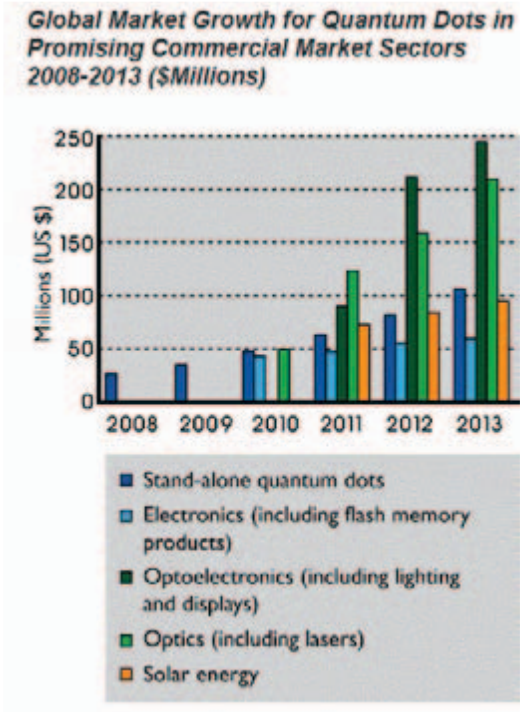
QMC’s technology, employing an innovative tetrapod quantum dot (QD) continuous-flow chemistry process addresses the major challenges - low production and corresponding high manufacturing cost - that have held back the wide-spread adoption of QD technology by major industries.



QMC II-VI tetrapod quantum dot

QMC’s process enables bulk manufacturing (95 percent to 97 percent full tetrapod yield) of highly efficient tetrapod-shaped QDs that have 4 arms on the QD core to enable better electrical conductivity compared to current QD technology.

The structure and size of the resulting Tetrapod QDs are highly uniform, which enables the narrow bandwidth light extraction accuracy of QMC’s quantum dots to be significantly higher than QDs manufactured through batch colloidal synthesis.



“Characteristics such as high quantum yield, smaller size and high band gap tunability make QDs an ideal platform technology for many emerging applications, such as solar energy, sensors, solid state lighting, quantum computers, and QD lasers,” says Frost & Sullivan Research Analyst Shyam Krishnan. “However, manufacturing inefficiencies of complicated, expensive synthesis processes have

limited their adoption."

QMC manufactures unique Tetrapod QDs using a technology licensed from William Marsh Rice University. QMC's QD synthesis process allows for mass-production in a very cost-efficient and "green" manner while competitors use industry-standard dual-injection colloidal synthesis, which is expensive, uses toxic chemicals and is generally not viable for commercialising large-scale applications.

In short, QMC's technology has eliminated most of the industrial challenges facing large-scale adoption of QD technology. Moreover, the company's unique synthesis eliminates conventionally used solvents, replacing them with cheaper and less toxic solvents that reduce the cost and improve the effectiveness of the process.

"A major advantage of QMC's Tetrapod QD manufacturing technique is its flexibility; it can fabricate Tetrapod QDs from 12 different elements, which allows for RoHS compliance," observes Krishnan. "The process also allows for the width and length of the Tetrapod QD's arms to be fine-tuned for any desired application. For example, short QD arms for biotech applications, and longer QD arms to improve electron transport in solar cells."

QMC is mainly focusing on developing products through collaboration and joint ventures. But the firm also plans to make available research quantities to nanotech oriented universities at a substantially lower price and also focus on R&D units for electronic device manufacturers.

With this approach, QMC will be able generate goodwill among market players. Hence, QMC's QD technology is poised for strong adoption in diverse fields, such as lighting, displays, solar energy, sensors, optoelectronics, and flexible electronics.

Improving polar InN surfaces

Using a simple nitridation process, it is now possible to grow up to 25nm thick polar InN films with the surface Fermi level close to the valence band maximum. Substrates used include silicon (111) and GaN (0001)

A Finnish-Russian-Swedish collaboration is claiming that it has used ammonia nitridation to produce the first polar InN with the surface Fermi level near the valence-band maximum.

In the past, the growth of polar InN films has been hindered due to metallic indium clusters, formed readily during growth, and unintentional *n*-type conductivity of nominally undoped films. These include surface electron-accumulation layers via the Fermi level pinning into the conduction band.

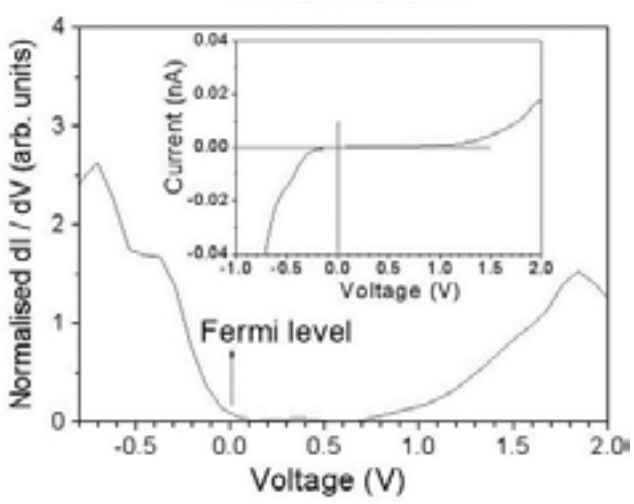
These issues have hampered, for example, the realisation of *p*-type InN layers. This makes it difficult to grow *p*-*n* junctions in InN layers, which are needed in devices such as those used in solar, power electronic and LED applications.

A team from the Institute of Solid State Theory, Friedrich Schiller University and the European Theoretical Spectroscopy Facility, all based in Germany, using *ab initio* calculations, recently predicted the Fermi level position for InN [1]. Furthermore, researchers at Ritsumeikan University in Japan and Seoul National University, Korea have shown that the plasma nitridations during growth stops transform even large indium clusters into two-dimensional InN islands, improving InN quality [2].

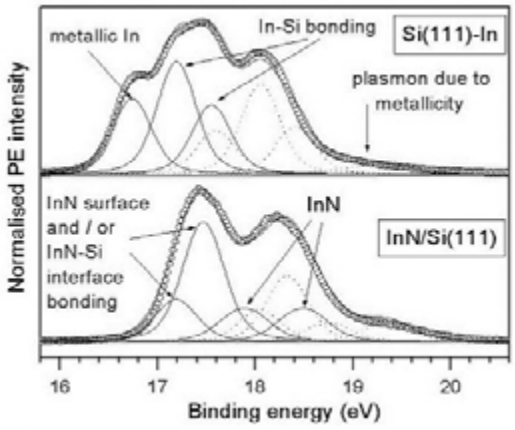
Now researchers, led by a team at the University of Turku in Finland, have shown that high electron concentrations can be avoided, which is promising for making *p*-type InN films.

They initially grew InN films on silicon (111) and GaN (0001) substrates by the nitridation of the indium-covered semiconductor surfaces with ammonia (NH3) or cracked N2 gas.

Following this treatment, the scientists found it was possible to grow up to 25nm thick polar InN films with the surface Fermi level close to the valence band maximum. In other words, they avoided the presence of electron accumulation layers. The plot below shows the Fermi level obtained using Scanning Tunnelling Spectroscopy (STS).



Analysis of current-voltage curves, measured by STS from well-defined surface areas, reveal that the surface Fermi level locates close to the valence-band maximum

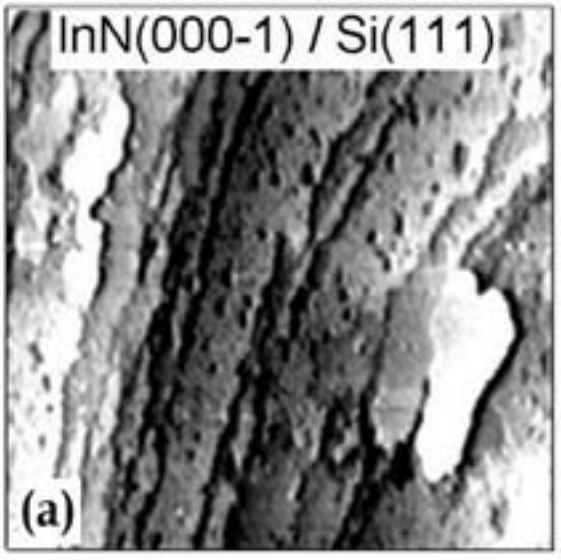


Synchrotron-radiation In 4d core-level photoelectron spectra show that the nitridation transform metallic indium to InN

The substrate temperature during the nitridation was found to be one of the most crucial parameters in the formation of InN (000-1) films with the Fermi level near the valence-band maximum.

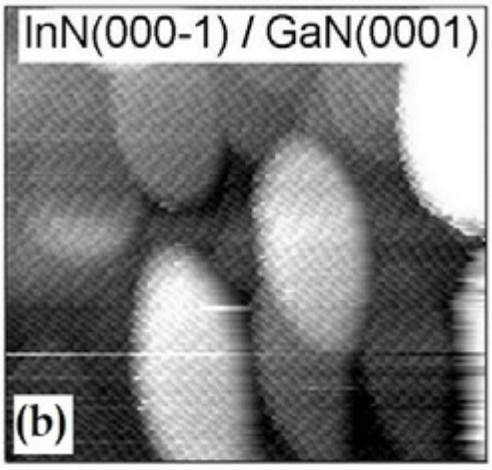
Indium was evaporated from a heated tantalum envelope onto the substrates, which were kept at room temperature before nitridations. The NH3 pressure was about 5 x 10-5 mbar during the nitridation. Temperature of indium-covered silicon (111) substrates was 400 - 450 °C during the nitridation, and the temperature for indium-covered GaN (0001) pieces was 530 - 580 °C, just below the decomposition temperature of InN.

The silicon (111) substrates were flash heated at about 1200 °C. STM indicates a smooth, well-defined (7x7)-reconstructed surface.



STM image showing two-dimensional nature of InN (000)/Si (111) sample (~ 800 nm x 800 nm)

To clean HVPE-grown *n*-type GaN (0001) substrate pieces, they were heated to around 600 °C in the NH3 atmosphere to get a sharp (1 x 1) diffraction.



STM image showing two-dimensional nature of InN (000)/GaN (0001) sample (~450nm x 450nm)

Further details of this work have been published in the paper, “Formation of polar InN with surface Fermi level near the valence band maximum by means of ammonia nitridation” by J. Dahl *et al* in*Physical Review B,* 86, 245304 (2012). DOI: 10.1103/PhysRevB.86.245304

References:

[1] A. Belabbes, J. Furthmüller, and F. Bechstedt, Phys. Rev. B 84, 205304 (2011)

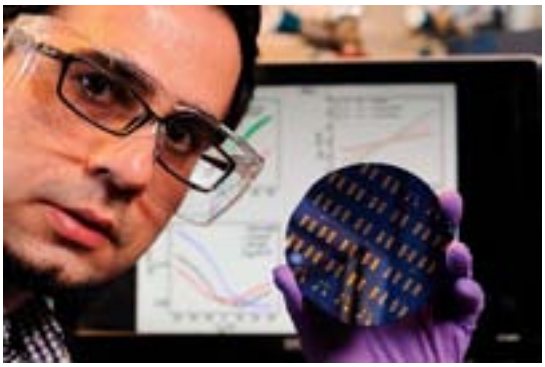
[2] T. Yamaguchi and Y. Nanishi, Appl. Phys. Expr. 2, 051001 (2009).

Using monolayers to create p-n junctions in graphene

New developments using graphene are suited for use in field-effect transistors. But if researchers are able to lower the temperature, they may be able to use graphene in optoelectronic products

The electronic properties of graphene films are directly affected by the characteristics of the substrates on which they are grown or to which they are transferred.

Researchers are taking advantage of this to create graphene *p-n* junctions by transferring films of the promising electronic material to substrates that have been patterned by compounds that are either strong electron donors or electron acceptors.



Georgia Tech postdoctoral fellow Hossein Sojoudi holds a wafer containing graphene p-n junctions, while the screen display in the background shows electrical data measured in the devices. (Credit: Gary Meek)

A low temperature, controllable and stable method has been developed to dope graphene films using self-assembled monolayers that modify the interface of graphene and its support substrate. Using this concept, a team of researchers at the Georgia Institute of Technology has created graphene *p-n* junctions - which are essential to fabricating devices - without damaging the material's lattice structure or significantly reducing electron/hole mobility.

The graphene was grown on a copper film using CVD, a process that allows synthesis of large-scale films and their transfer to desired substrates for device applications. The graphene films were transferred to silicon dioxide substrates that were functionalised with the self-assembled monolayers.

"We have been successful at showing that you can make fairly well doped p-type and n-type graphene controllably by patterning the underlying monolayer instead of modifying the graphene directly," says Clifford Henderson, a professor in the Georgia Tech School of Chemical & Biomolecular Engineering. "Putting graphene on top of self-assembled monolayers uses the effect of electron donation or electron withdrawal from underneath the graphene to modify the material's electronic properties."

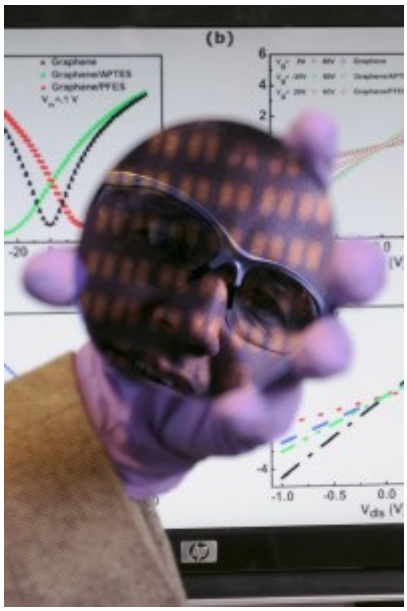
Creating *n*-type and *p*-type doping in graphene , which has no natural bandgap, has led to development of several approaches. Scientists have substituted nitrogen atoms for some of the carbon atoms in the graphene lattice, compounds have been applied to the surface of the graphene, and the edges of graphene nanoribbons have been modified. However, most of these techniques have disadvantages, including disruption of the lattice – which reduces electron mobility – and long-term stability issues.

"Any time you put graphene into contact with a substrate of any kind, the material has an inherent tendency to change its electrical properties," Henderson says. "We wondered if we could do that in a controlled way and use it to our advantage to make the material predominately n-type or p-type. This could create a doping effect without introducing defects that would disrupt the material's attractive electron mobility."

Using conventional lithography techniques, the researchers created patterns from different silane materials on a dielectric substrate, usually silicon oxide. The materials were chosen because they are either strong electron donors or electron acceptors. When a thin film of graphene is placed over the patterns, the underlying materials create charged sections in the graphene that correspond to the patterning.

"We were able to dope the graphene into both *n*-type and *p*-type materials through an electron donation or withdrawal effect from the monolayer," Henderson explains. "That doesn't lead to the substitutional defects that are seen with many of the other doping processes. The graphene structure itself is still pristine as it comes to us in the transfer process."

The monolayers are bonded to the dielectric substrate and are thermally stable up to 200 degrees Celsius with the graphene film over them, Sojoudi, a postdoctoral fellow working on the project, notes. The Georgia Tech team has used 3-Aminopropyltriethoxysilane and perfluorooctyltriethoxysilane for patterning. In principle, however, there are many other commercially-available materials that could also create the patterns.



Clifford Henderson's face is reflected in a wafer containing graphene p-n junctions. The screen in the background shows electrical data measurements. (Credit: Gary Meek)

"You can build as many *n*-type and *p*-type regions as you want," Sojoudi says. "You can even step the doping controllably up and down. This technique gives you ontrol over the doping level and what the dominant carrier is in each region."

The researchers used their technique to fabricate graphene *p-n* junctions, which was verified by the creation of field-effect transistors (FETs). Characteristic I-V curves indicated the presence of two separate Dirac points, which indicated an energy separation of neutrality points between the *p*and *n* regions in the graphene, points out Soujoudi.

The group uses CVD to create thin films of graphene on copper foil. A thick film of PMMA was spin-coated atop the graphene, and the underlying copper was then removed. The polymer serves as a carrier for the graphene until it can be placed onto the monolayer-coated substrate, after which it is removed.

Beyond developing the doping techniques, the team is also exploring new precursor materials that could allow CVD production of graphene at temperatures low enough to permit fabrication directly on other devices. That could eliminate the need for transferring the graphene from one substrate to another.

A low-cost, low-temperature means of producing graphene could also allow the films to find broader applications in displays, solar cells and organic LEDs, where large sheets of graphene would be needed.

"The real goal is to find ways to make graphene at lower temperatures and in ways that allow us to integrate it with other devices, either silicon CMOS or other materials that couldn't tolerate the high temperatures required for the initial growth," Henderson says. "We are looking at ways to make graphene into a useful electronic or optoelectronic material at low temperatures and in patterned forms."

Further details of this work has been published in the paper, «Creating Graphene *p-n* Junctions Using Self-Assembled Monolayers," by Sojoud *et al* in ACS Applied Materials & Interfaces, dx.doi.org/10.1021/am301138v and the publication, "Facile Formation of Graphene P-N Junctions Using Self-Assembled Monolayers" by Baltazar *et al* in The Journal of Physical Chemistry C, dx.doi.org/10.1021/jp3045737.

Funding for the research came from the National Science Foundation, through the Georgia Tech MRSEC and through separate research grants.

Qualcomm & Sharp To Invigorate LCD Displays

The displays will incorporate Sharp's IGZO (Indium Gallium Zinc Oxide) technology and be built utilising existing LCD manufacturing infrastructure, and Qualcomm's equity investment in Sharp.

Qualcomm is expanding its display technology agreement between its subsidiary Pixtronix, Inc. and Sharp Corporation to develop and commercialise high-quality colour, low-power MEMS displays.

As a result of the equity investment, Qualcomm will become a minority shareholder in Sharp.

Qualcomm's equity investment in Sharp and the expanded joint development agreement build upon the existing work between Sharp and Pixtronix; the two companies have been engaged in development activities for the last year and a half.

The goal of this joint effort is to accelerate commercialisation of Pixtronix's low power MEMS displays utilising Sharp's IGZO technology.

The equity investment by Qualcomm will take place in stages and the consummation of the transaction is subject to certain contingencies.

"As one of the leading electronics companies in the world, Sharp has an established industry brand and is a recognised leader in the development and commercialisation of new innovative display technologies," says Derek Aberle, executive vice president and group president of Qualcomm.

"Expanding our existing relationship with Sharp to jointly commercialize new MEMS display technologies will help both companies realise their shared goal of driving high performance, lower power displays for a variety of devices, including smartphones and tablets."

"Sharp has brought many innovations to the display industry, including the world's first commercialisation of IGZO technology in LCD displays this year," adds Yoshisuke Hasegawa, executive managing officer of Sharp Corporation. "Sharp is targeting to accelerate the commercialisation of MEMS displays by combining Sharp's cutting-edge IGZO technology and Pixtronix's MEMS display technology."

InGaAs MOSFETs could beat Moore's Law

Indium gallium arsenide transistors could snatch silicon's crown

Silicon's crown could be under threat. The semiconductor's days as the king of microchips for computers and smart devices could be numbered, thanks to the development of the smallest transistor ever to be built from III-V semiconductor InGaAs.

Last week, researchers at Purdue University announced a new type of transistor shaped like a Christmas tree, where each transistor contains three tiny nanowires made of InGaAs.

So III-Vs replacing silicon seems to be a hot research topic, with InGaAs being one of the main contenders.

Now scientists at MIT's Microsystems Technology Laboratories, have also created a compound transistor, which performs well despite being just 22nm length. This makes it a promising candidate to eventually replace silicon in computing devices, says co-developer Jesús del Alamo, the Donner Professor of Science in MIT's Department of Electrical Engineering and Computer Science (EECS), who built the transistor with EECS graduate student Jianqian Lin and Dimitri Antoniadis, the Ray and Maria Stata Professor of Electrical Engineering.

To keep pace with our demand for ever-faster and smarter computing devices, the size of transistors is continually shrinking, allowing increasing numbers of them to be squeezed onto microchips. "The more transistors you can pack on a chip, the more powerful the chip is going to be, and the more functions the chip is going to perform," del Alamo says.

But as silicon transistors are reduced to the nanometre scale, the amount of current that can be produced by the devices is also shrinking, limiting their speed of operation. This has led to fears that Moore's Law - the prediction by Intel founder Gordon Moore that the number of transistors on microchips will double every two years - could be about to come to an end, del Alamo says.

To keep Moore's Law alive, researchers have for some time been investigating alternatives to silicon, which could potentially produce a larger current even when operating at these smaller scales. One such material is the compound InGaAs, which is already used in fibre-optic communication and radar technologies, and is known to have extremely good electrical properties, del Alamo says.

But despite recent advances in treating the material to allow it to be formed into a transistor in a similar way to silicon, nobody has yet been able to produce devices small enough to be packed in ever-greater numbers into tomorrow's microchips.

Now del Alamo, Antoniadis and Lin have shown it is possible to build a nanometre-sized metal-oxide semiconductor field-effect transistor (MOSFET) - the type most commonly used in logic applications such as microprocessors - using the material. "We have shown that you can make extremely small indium gallium arsenide MOSFETs with excellent logic characteristics, which promises to take Moore's Law beyond the reach of silicon," del Alamo says.

Transistors consist of three electrodes: the gate, the source and the drain, with the gate controlling the flow of electrons between the other two. Since space in these tiny transistors is so tight, the three electrodes must be placed in extremely close proximity to each other, a level of precision that would be impossible for even sophisticated tools to achieve. Instead, the team allows the gate to "self-align" itself between the other two electrodes.

A cross-section transmission electron micrograph of the fabricated transistor. The central inverted V is the gate. The two molybdenum contacts on either side are the source and drain of the transistor. The channel is the InGaAs light colour layer under the source, drain, and gate. (Image courtesy of the researchers)

The researchers first grow a thin layer of the material using MBE, a process widely used in the semiconductor industry in which evaporated atoms of indium, gallium and arsenic react with each other within a vacuum to form a single-crystal compound.

The team then deposits a layer of molybdenum as the source and drain contact metal. They then "draw" an extremely fine pattern onto this substrate using a focused beam of electrons - another well-established fabrication technique known as electron beam lithography.

Unwanted areas of material are then etched away and the gate oxide is deposited onto the tiny gap. Finally, evaporated molybdenum is fired at the surface, where it forms the gate, tightly squeezed between the two other electrodes, del Alamo says. "Through a combination of etching and deposition we can get the gate nestled [between the electrodes] with tiny gaps around it," he says.

Although many of the techniques applied by the MIT team are already used in silicon fabrication, they have only rarely been used to make compound semiconductor transistors. This is partly because in applications such as fibre-optic communication, space is less of an issue.

"But when you are talking about integrating billions of tiny transistors onto a chip, then we need to completely reformulate the fabrication technology of compound semiconductor transistors to look much more like that of silicon transistors," del Alamo says.

The team presents its work this week at the International Electron Devices Meeting in San Francisco.

Their next step will be to work on further improving the electrical performance, and hence the speed of the transistor by eliminating unwanted resistance within the device. Once they have achieved this, they will attempt to further shrink the device, with the ultimate aim of reducing the size of their transistor to below 10nm in gate length.

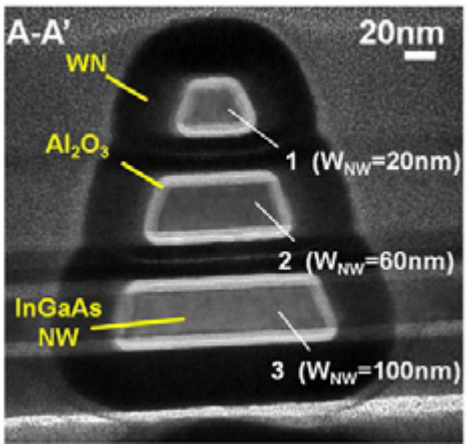
Matthias Passlack, of Taiwanese semiconductor manufacturer TSMC, says del Alamo's work has been a milestone in semiconductor research. "He and his team have experimentally proven that indium arsenide channels outperform silicon at small-device dimensions," he says. "This pioneering work has stimulated and facilitated the development of CMOS-compatible, III-V-based-technology research and development worldwide."

The research was funded by DARPA and the Semiconductor Research Corporation.

InGaAs `4-D` transistor could be the future for computers

Indium gallium arsenide is one of the several promising semiconductors being studied to replace silicon

A new type of transistor shaped like a Christmas tree has arrived just in time for the holidays, but the prototype won't be nestled under the tree along with the other gifts.



This image taken with a transmission electron microscope shows the cross section of a new type of transistor shaped like a Christmas tree that was created by researchers at Purdue and Harvard universities. The transistor is made from tiny nanowires of a material called InGaAs, which could replace silicon within a decade. (Purdue University image)

"It's a preview of things to come in the semiconductor industry," says Peide "Peter" Ye, a professor of electrical and computer engineering at Purdue University.

Researchers from the universities of Purdue and Harvard created the transistor, which is made from a material that could replace silicon within a decade.

Each transistor contains three tiny nanowires made not of silicon, but from InGaAs. The three nanowires are progressively smaller, yielding a tapered cross section resembling a Christmas tree.

The research builds on previous work in which the team created a 3-D structure instead of conventional flat transistors. The approach could enable engineers to build faster, more compact and efficient integrated circuits and lighter laptops that generate less heat than today's.

New findings show how to improve the device performance by linking the transistors vertically in parallel.

"A one-story house can hold so many people, but more floors, more people, and it's the same thing with transistors," Ye comments. "Stacking them results in more current and much faster operation for high-speed computing. This adds a whole new dimension, so I call them 4-D."

The findings will be detailed in two papers to be presented during the International Electron Devices Meeting taking place between Dec 8th and 12th in San Francisco. One of the papers has been highlighted by conference organisers as among "the most newsworthy topics and papers to be presented."

The newest generation of silicon computer chips, introduced this year, contain transistors having a vertical 3-D structure instead of a conventional flat design. However, because silicon has a limited "electron mobility" - how fast electrons flow - other materials will likely be needed soon to continue advancing transistors with this 3-D approach, Ye adds.

Transistors contain critical components called gates, which enable the devices to switch on and off and to direct the flow of electrical current. Smaller gates make faster operation possible. In today's 3-D silicon transistors, the length of these gates is about 22 nanometres (nm), or billionths of a metre.

The 3-D design is critical because gate lengths of 22 nm and smaller do not work well in a flat transistor architecture. Engineers are working to develop transistors that use even smaller gate lengths; 14 nm are expected by 2015, and 10 nm by 2018.

However, size reductions beyond 10 nm and additional performance improvements may not be possible using silicon, meaning new materials will be needed to continue progress, Ye says.

Creating smaller transistors also will require finding a new type of insulating, or "dielectric" layer that allows the gate to switch off. As gate lengths shrink smaller than 14 nm, the dielectric used in conventional transistors fails to perform properly and is said to "leak" electrical charge when the transistor is turned off.

"Nanowires in the new transistors are coated with a different type of composite insulator, a 4 nm thick layer of lanthanum aluminate with an ultrathin, half-nanometre layer of aluminium oxide. The new ultrathin dielectric allowed researchers to create transistors made of InGaAs with 20 nm gates, which is a milestone," Ye points out.

The work, based at the Birck Nanotechnology Centre in Purdue's Discovery Park, was funded by the National Science Foundation and the Semiconductor Research Corporation.

InGaAs '4-D' transistor could be the future for computers

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