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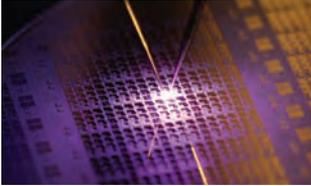
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Volume 19 Issue 6 2013

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Better electron blocking in UV LEDs



Bismuth promises ultra-cool lasers



In-situ monitoring aids cell growth



Full-colour lamps with violet LEDs



A third way for MOCVD design



## Strippers

Combining speed with green credentials

inside **CS** COMPOUND SEMICONDUCTOR

News Review, News Analysis, Features, Research Review and much more.

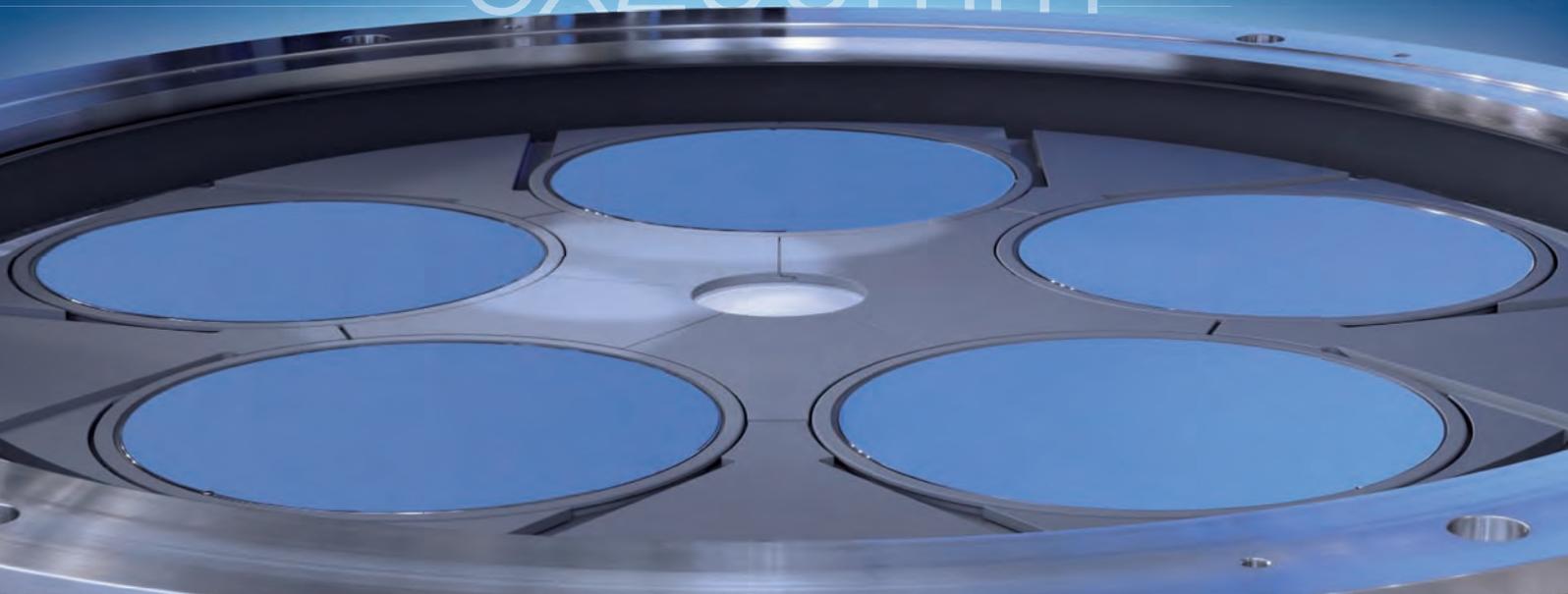
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# editorial view

by Dr Richard Stevenson, Editor

## Transforming telecom lasers

THERE ARE MANY PATHS you can go down when striving to improve device performance.

One option is to keep it simple and try to improve the quality of the production processes, such as optimising the growth of the epiwafer. This can pay dividends, particularly if the class of device is not well established.

If you are up for more of a challenge, you can try to boost performance by altering chip design. Such an effort, which can be supported by simulations, could involve modifying the device architecture, such as increasing the doping in one layer.

But by far the most radical route is to dispense with a mature material system, and adopt one that is yet to be tried and tested. That's what a team of European researchers is doing, developing telecom lasers based on bismuth alloys, rather than InP. This effort has had to start from scratch, developing models to understand device behaviour and establishing appropriate growth conditions before it is even possible to try and fabricate the first devices (see feature on p53 for details).

The rewards for these trailblazing researchers could be huge. InP laser efficiency is impaired by Auger recombination, and this inherent interaction generates lots of heat. But with bismuth alloys, the spin-off splitting energy can rule out the possibility of Auger recombination if the bismuth content in the alloy exceeds



10 percent. The promise of telecom lasers that are free from cooling is incredibly appealing. It's not just the potential to cut costs by eliminating the need for coolers – it's the substantial energy savings that could result.

That's because internet traffic is rocketing, due to uptake of smartphones and internet TV, and if energy-saving measures are not introduced, this traffic could start to be responsible for a significant proportion of the world's carbon footprint. So I, for one, hope that this group of pioneers succeed in their efforts.

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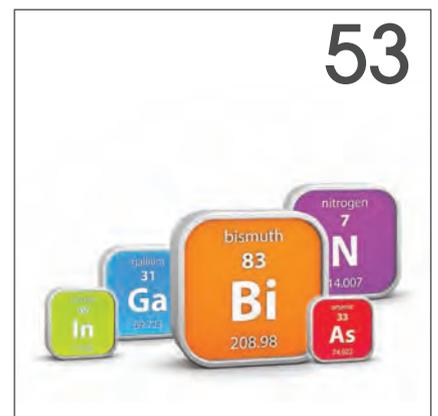
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## features



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## 27 Replacing halogen lamps

Inferior light quality holds back the sales of most LED-based replacements for halogen lamps in casinos, hotels, high-end retailers and cruise ships. But that's not the case for Soraa's lighting products, which produce full-spectrum emission with a violet LED exciting red, green and blue phosphors.

## 30 Simplify air quality monitoring

Conventional sensors for assessing the air quality in buildings are wired into the mains, making them expensive to install and reposition. But portability and battery powering is possible with Gas Sensing Solutions' modules that feature mid-infrared LEDs and photodetectors.

## 36 Building brighter, cheaper LEDs

The gases and chemicals that are consumed during the manufacturing of LEDs make a considerable contribution to device costs. But savings are possible by switching to a new MOCVD design with a flared chamber profile that not only trims gas consumption by up to 40 percent but also shortens the growth interruption between layers, leading to improved multiple quantum well quality.

## 44 Boosting triple-junction yield with *in-situ* monitoring

*In-situ* monitoring provides a great deal of valuable information for developers and producers of multi-junction solar cells. It can determine interface quality; the thickness, doping level and composition of every layer; and wafer bow.

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A novel, water-based stripper offers a fast, environmentally friendly approach to high quality removal of photoresist and the carrying out of metal lift-off.

## 53 An elemental change to laser design

Today's telecom lasers are plagued with Auger-related losses, which drive down efficiency and make device cooling mandatory. The solution: Switch to an active region with alloys featuring a bismuth content of more than 10 percent.

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Magazine & Front Cover designed by Mitch Gaynor

# IHS: LED manufacturers to continue oversupplying

DESPITE A MAJOR SURPLUS in the LED market, top suppliers are increasing their capital spending and production. That's because of government incentives enabling firms to cash in on an expected boom in the lighting business.

Global shipments of MOCVD, tools that are essential for LED manufacturing are expected to rise by 17 percent in 2013, according to Alice Tao, senior analyst, LEDs and lighting for IHS.

This will be the first annual growth for the MOCVD market since 2011, and will represent a major turnaround from the 70 percent plunge of 2012.

At the same time that growth is being projected, factory utilisation rates are increasing for major LED companies in Asia. In South Korea, for instance, utilisation rose to about 75 percent in the second quarter, up from 60 percent in 2012. Meanwhile, utilisation for some Taiwanese and Chinese companies reached 90 percent in the second quarter. The spending and boosting

of utilisation rates alike are occurring despite a glut of supply that has plagued the market since 2010. The surplus started when LED suppliers made major investments in capacity in 2010 and 2011, stemming from the efforts of local governments in China to subsidize MOCVD purchasing.

Governments are helping fund the procurement of MOCVD by to 80 percent of the total price of the equipment. Many of these companies also are increasing production in the belief that they can capitalize on upcoming fast growth in the market for LEDs used in lighting.

"The global market for LED lighting is expected to double during the next three years," noted Tao. "The prospect of this massive growth is irresistible to LED suppliers, who don't want to be caught short of supply during this expected boom. But given the rising investments in manufacturing equipment, the acute LED oversupply already in existence is expected to continue through 2016."



The supply of LEDs, measured in terms of manufactured die, is expected to exceed demand by 69 percent in 2013 and in 2014. The glut will decline slightly to 61 percent in 2015 and then to 40 percent in 2016.

Major LED suppliers include San'an, Elec-tech of China, Samsung and Seoul Semiconductor of South Korea, Epistar of Taiwan, and other companies including Philips Lumileds of the United States and German firm Osram.

## Natural disasters cause GaAs substrate market to flounder

SLOW GROWTH in the GaAs device market in 2012, coupled with new developments and competitive technologies in cellular power amplifiers dropped demand for semi-insulating GaAs bulk substrates.

Wafer pricing is returning to normal levels after a pricing spike caused by the 2011 earthquake and tsunami in Japan. This, coupled with falling demand drove market revenue to double digit declines.

The recently released Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) spread sheet model and Forecast and Outlook report, "Semi-Insulating GaAs Substrate Markets: 2012-2017", forecasts that total demand for semi-insulating (SI) GaAs bulk substrates from manufacturers such as Freiburger Compound Materials (FCM), Hitachi Cable, AXT, Sumitomo and Dowa fell by nearly 10 percent from 2011 levels.



The report estimates that this demand resulted in roughly \$193 million in revenues in 2012. The forecast indicates demand will return to slow growth and reach nearly 32300 ksi in 2017. The slow growth in demand, coupled with substrate pricing dropping to more normal pricing profiles will cause revenue to decline to an estimated \$189 million in 2017.

"The GaAs device market struggled to a small gain in 2012. This and the on going conversion to multi-band cellular PAs that replace several single-band devices both

conspired to reduce GaAs bulk substrate demand", notes Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs).

He adds, "As multi-band PA architectures become even more prevalent in cellular architectures and silicon-based technologies continue to gain market share, this segment will be challenged to find growth."

Asif Anwar, Director in the Strategy Analytics Strategic Technologies Practice (STP) continues, "The disruptions in the GaAs bulk substrate supply chain caused by the Japanese earthquake and tsunami in 2011 seem to be working their way out of the system. While this is good for the companies involved, the effect has been to drop substrate pricing back to pre-earthquake levels and this, coupled with lower demand has decreased substrate revenue substantially."

# IQE qualifies its CPV epiwafers

IQE'S MATERIAL has been qualified for production-ready, high-volume manufacturing by its strategic partner Solar Junction. Solar Junction, a developer of high efficiency multi-junction solar energy cells for the CPV market, has successfully completed the process transfer and full qualification of IQE's epitaxial materials for high-volume manufacturing.

This qualification is a major milestone which has required extensive validation of IQE's manufacturing processes, product quality and reliability in delivering material with cutting edge solar efficiency.

Solar Junction is now production-ready and at an advanced stage in qualifying its cells with the leading global CPV systems manufacturers. Solar Junction expects to receive initial high-volume orders over the coming months. As a result of the joint development agreement in February between Amonix and Solar Junction, Amonix, worldwide installer of CPV systems, is already testing solar cells produced with IQE epitaxy and observing improved performance.

Jeff Allen, Vice President of Business Development at Solar Junction, said: "The qualification of our production-ready 42 percent median efficiency solar cells produced by IQE and our new fabrication line could not have come at a better time for Solar Junction and the CPV market.

"Solar Junction's key customers are highly impressed with the 2+ percent cell efficiency advantage over our competitor's cells, which translates to an estimated reduction in total installed CPV system cost of approximately 5 percent.

"The rapid adoption of our technology in the U.S., China and Middle East will propel Solar Junction to market leadership in CPV."

A recent independent industry report estimates the target market for CPV is expected to exceed 5GW over the next few years, with more than 750MW to be installed by 2015.

Initial deployment will be in Southwestern U.S., Southern Europe around the Mediterranean, Middle East and Northern Africa (MENA), Southern Africa, Chile, Australia and China. Vijit Sabnis, Chief Executive of Solar Junction said: "The successful qualification is attributable to the close partnership of the team responsible, from Solar Junction and IQE, over the past twelve months.

"The IQE epitaxial materials are fabricated at Solar Junction's 4-inch and 6-inch production facility, partially funded by the U.S. Department of Energy SUNPATH contract, in Silicon Valley. Solar cells are currently out for independent third-party verification of efficiency results with performance anticipated to be equivalent to that produced by our internal pilot line."

Solar Junction's successful qualification continues to demonstrate the value of its dilute nitride materials, which uniquely provides CPV system manufacturers the foundation to deliver the most efficient conversion of solar to electrical energy.

In October 2012, Solar Junction achieved a World record 44 percent efficiency for a standard 3J cell at a concentration of 942 suns.

Drew Nelson, IQE Chief Executive, said: "The successful qualification of IQE's production scale epiwafers for CPV marks a key milestone in bringing Solar Junction's advanced technology to market. What has been particularly impressive is that median efficiencies from our large volume 4-inch and 6-inch platforms are at least as good as having been previously achieved in small scale demonstrations.

"The performance and manufacturing advantages of Solar Junction's 3J solar cell technology will accelerate adoption of CPV and position IQE to become the key epiwafer supplier to the global utility scale CPV solar market.

"These achievements demonstrate the success of our strategy to invest in Solar Junction and enter into an exclusive, worldwide license for the technology."

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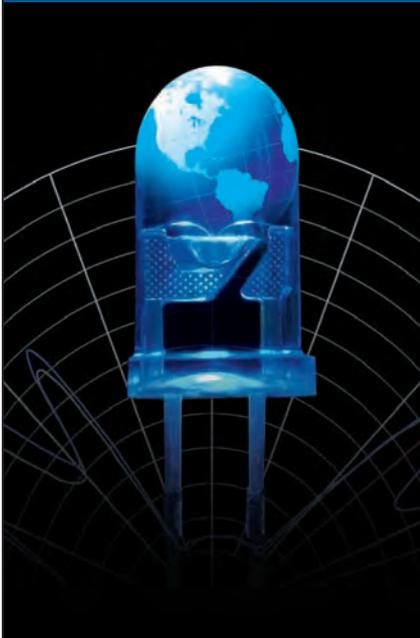
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# Doped tungsten doubles lifetime in sapphire growth

PLANSEE USES the creep-resistant tungsten material 'WVM' to manufacture heaters for sapphire growth. These have more than twice the service life of conventional tungsten heaters.

Sapphire growth takes place at high temperatures of approximately 2100 °C. In the Kyropoulos process, rod heaters made from pure tungsten are generally used.

These often have to be replaced after just a few cycles. This is due to the high level of embrittlement and deformation. It can sometimes be so extreme that the heater rods touch the shielding and cause short-circuits. To meet the needs of single crystal growth applications, Plansee has further developed a material that has already earned the plaudits of the lighting industry for its behaviour at high temperatures.

The material consists of pure tungsten with very low quantities (30-70 ppm) of potassium. The creep resistance of this material is several times better than that of pure tungsten. This capability was recently confirmed by a sag test performed by Plansee's materials engineers.

The scientists at Plansee simulated the use of its novel material at high temperatures and under various mechanical loads. The sag test proved that WVM sags four times less than pure



tungsten. This is because potassium leads to a more stable and coarser crystalline structure than pure tungsten. This property also has a positive influence on the material's creep resistance. The graph below compares the sag for pure tungsten and WVM.

Samples used in the analysis obtained from the graph above were tested at 2100 °C, for 6 hours with a bending stress of 22 MPa.

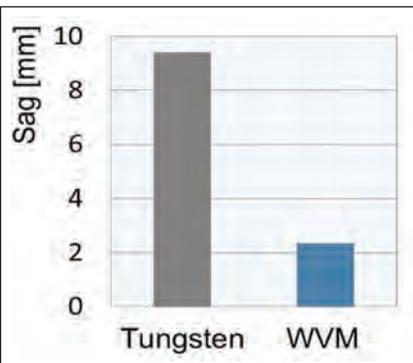
Plansee says rod heaters, mesh heaters, and sheet heaters made from WVM provide excellent dimensional stability, especially when it comes to high-temperature processes such as sapphire growth.

While conventional tungsten heaters have to be replaced after just a few cycles, WVM heaters are claimed to easily last for 2 to 3 times as long.

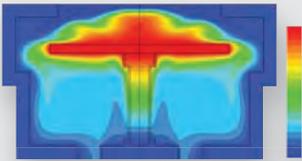
Rod type heater used in sapphire growth At 99.97 percent, the purity of WVM is the same as that of pure Plansee tungsten. The potassium content in WVM is firmly bound in the material. As a result, it will not contaminate the furnace atmosphere. The material is suitable for use in extremely sensitive high-vacuum processes in the same way as pure tungsten.

But when it comes to sapphire growth, Plansee believes it is able to offer more than hot zones with particularly durable heaters. The company also produces the corresponding pressed-sintered tungsten crucibles. These high purity crucibles have an ultra-smooth surface.

The sapphire can be extracted without difficulty from the crucible without any damage to the crucible surface. And the smooth surface is less susceptible to corrosion in contact with the sapphire melt. With their high and homogenous density of over 93 % the crucibles are non-deformable even at high and rapidly changing temperatures.



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# Raw material global demand doubles as LED market booms

GLOBAL DEMAND for precursor, a material used in manufacturing of LEDs, is set to more than double from 2012 to 2016, as the market for LED lighting booms, according to a new report entitled "Precursor for LED MOCVD—Market and Industry Analysis," from Displaybank, now part of IHS.

The market for precursor used in the metal-organic chemical vapour deposition (MOCVD) manufacturing process for making LEDs will rise to 69 tons in 2016, up a notable 114 percent from 32 tons in 2012, as presented in the figure. "The boom in the precursor market reflects the rising operating rate of

MOCVD as the LED lighting market grows," said Richard Son, senior LED analyst at IHS.

Precursor is a core material that ensures the optimal light efficiency for each LED epi layer. It is used in the MOCVD process, which is the most important process in manufacturing LED chips.

Major precursors include trimethylgallium (TMGa), trimethylindium (TMIn), trimethyl aluminum (TMA), triethylgallium (TEGa) and C2Mg2. Among these, TMGa is the most widely used and commands about 94 percent of total demand.



Global shipments of MOCVD equipment are on the rise, with shipments expected to climb by 17 percent in 2013. The largest buyers of MOCVD equipment—South Korea, Taiwan and China—account for about 80 percent of the global demand of precursors.

China, which is generating the highest growth in installation of MOCVD equipment among the three countries, is expected to make up 45 percent of the global demand of precursors in 2016.

In the nascent stage of the LED market, Dow Chemical Co. was the unrivalled leader in the precursor market.

However, with the recent growth in precursor demand, new players have been investing in R&D and manufacturing facilities while aggressively breaking into the market with low prices for similar-quality product.

Such developments will intensify competition further among precursor makers.

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# Alta Devices enables unmanned aircrafts to fly in the sun

DURING A KEYNOTE at the recent small unmanned systems business expo in San Francisco, California, Alta Devices' CEO, Christopher Norris, explained that small unmanned aerial vehicles (UAV) are no longer constrained to short-range or limited flight times. They are now able to fly as long as the sun is shining.

This is expected to have tremendous economic value for agricultural, public safety, wildfire mapping, search and rescue, law enforcement, industrial applications, and many others.

In the past, solar solutions for powering these vehicles were either too heavy or could not produce enough power for long-range flight, or both. However, a small UAV outfitted with Alta Devices' mobile power technology can produce enough power, while adding practically no weight, to fly indefinitely under the sun.

Alta Devices manufactures one of the world's thinnest, most flexible, and most efficient solar materials from III-V compound semiconductors. It can be used on anything that moves, can be carried, or worn, to generate substantial power from light.

In the case of a typical small UAV with a 9-foot wingspan, Alta's material can generate roughly 125W of power and weigh about 125g. In many cases, this is enough power to sustain flight and keep an on-board power source fully charged. Chris Norris, Alta Devices president and CEO explains, "A broad range of civil



unmanned systems will benefit from extended range and endurance. For example, when a UAV is used to map a wildfire, or on a human search and rescue mission, it is critical to have flight times that are as long as possible."

And for agricultural use, the ability to extend the range of a UAV and shorten the task of monitoring a large area by avoiding stops to recharge, has significant economic benefit to the farming community.

According to a report published by the Association for Unmanned Vehicle Systems International (AUVSI), precision agriculture and public safety represent over 90 percent of the potential for civil UAS use and will result in an economic benefit to the United States of 82 billion dollars between 2015 and 2025.

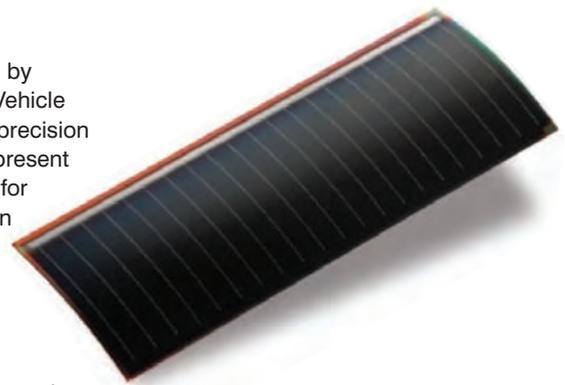
Gretchen West, executive vice president, Association for Unmanned Vehicle Systems International (AUVSI) explains, "Efficiency and endurance is the holy grail for unmanned systems. Enabling all-day flight times for small

UAVs will change the game for civil use and represents a significant market opportunity."

Alta Devices mobile power technology converts light into electricity, extending the energy source of a system, and in many cases, completely cuts the traditional power cord.

The solution can be completely integrated into the final system, and is ideal for use in unmanned systems, consumer electronics, automotive, remote exploration, or anywhere size, weight, and mobility matter.

The firm has set the following records: single junction solar cell efficiency at 28.8 percent, dual junction solar cell efficiency at 30.8 percent, and single junction module efficiency at 24.1 percent. All records are under one sun and validated by NREL.



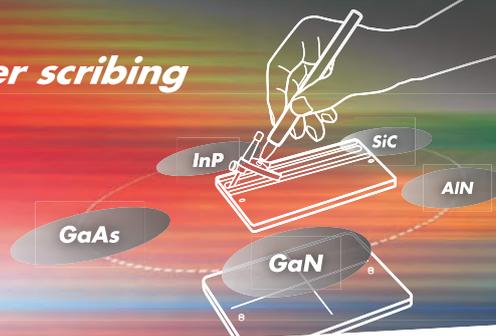
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# Scientists make progress toward quantum dot solar cell

THE RESEARCH PROGRAMME of Natcore Technology being conducted under a joint research agreement with Rice University has accomplished steps toward realization of a manufacturable quantum dot solar cell.

The work is being supervised by Andrew Barron, a Natcore co-founder.

Three key requirements must be met to make a quantum dot solar cell: create quantum dots of the proper size; create a uniform layer of those same quantum dots embedded in a thin film of silicon dioxide; and arrange the quantum dots such that the average inter-dot distance between any two of them is less than 10nm.

The scientists claim to have successfully met all three requirements. The researchers claim they have successfully embedded 20nm-diameter germanium quantum dots (Ge QDs) inside smooth, round shells of silica (silicon dioxide); dispersed the coated quantum dots on a surface with a simple spraying technique; and coated the layer with a film of silicon dioxide using Natcore's liquid phase deposition (LPD) process. The coated quantum dots are represented by the chemical symbol Ge@SiO<sub>2</sub>.

Scanning electron microscopes and transmission electron microscope analysis of the films, coupled with a measurement of the photocurrent generated when the film was exposed to a light source, showed that very nearly 70% of the Ge@SiO<sub>2</sub> quantum dots were within the 10nm maximum separation between nearest neighbours that is needed for high efficiency device operation. The resulting samples were one square centimetre in size.

With an applied voltage across the film thickness and illuminated by a laboratory white light operating at approximately one sun intensity, the film produced a current of over 6 milliamps.

The 6ma current represents a threefold increase over the first attempts to make a QD layer device, as reported by Natcore in an earlier news release.

"We've been working towards this for a long time," says Dennis Flood, Natcore's co-founder and Chief Technology Officer. "It paves the way to a tandem solar cell using quantum dot material. We're preparing a provisional patent application."

Chuck Provini, Natcore's president and CEO, says, "This is a remarkable improvement in photo-generated current in the silica film. Barron's group has done an excellent job moving this from scientific research through proof of concept.

Now the researchers at our Rochester R&D Center will focus on developing a working prototype.

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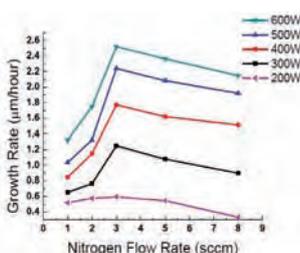
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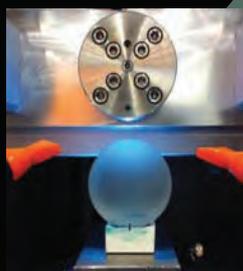
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# Saelig samples Plessey LEDs

SAELIG is now distributing samples of Plessey Semiconductors' GaN-on-Silicon MAGIC PLW111010 PLCC-2 SMT white light LEDs. These LEDs are claimed to be the first commercially available solid state illuminators manufactured on 6-inch GaN-on-Silicon substrates.

Magic PLW111010 Standard LEDs With production yields of greater than 95 percent and fast processing times, a significant cost advantage can be offered

over sapphire and SiC-based LED solutions for a wide range of industry-standard solid-state illumination and indicator applications.

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The 2000-piece reels of LEDs are binned for a single intensity and colour to provide close uniformity in manufacturing assembly lines. The LED's forward voltage drop is 3.8V at a maximum current of 25mA.

Using standard semiconductor manufacturing processing provides significant cost advantages over conventional, more expensive LEDs of similar quality which are based on sapphire or SiC technology.

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## III-V module hits 35.9 % efficiency

AMONIX has manufactured a III-V based solar module which achieved a national renewable energy laboratory (NREL) efficiency rating of 35.9 Percent under recently adopted CPV IEC test conditions of 1000 W/m<sup>2</sup> and 25°C cell temperature.

Amonix says the result is the highest ever independently rated module efficiency for any pv technology and is the first time NREL quantified the rating for a concentrator module with the cells at 25°C instead of at operating temperature.

Amonix worked with NREL to help mature this measurement process. Amonix 's last solar module set a efficiency of 34.9 percent at CSOC (concentrator standard operating conditions) in April, 2013. the firm claims this was the first to break 33 percent CSOC module efficiency in may 2012. "this 35.9 percent IEC CSTC module efficiency is a direct comparison to PV module efficiencies, which are often reported at IEC standard test conditions," says Vahan Garboushian, Amonix founder and CTO.

## Cree introduces \$99 LED street light

CREE is claiming that its recently launched XSPR LED Residential Street Light delivers better lighting while consuming over 65 percent less energy at an initial cost as low as \$99 for common applications.

The new Cree XSPR street light is said to be the ideal replacement for municipalities and cities using outdated high-pressure sodium fixtures up to 100 watts and can deliver payback in less than one year.

“With the low initial price of the XSPR street light and the dramatic energy savings, wholesale replacement of existing street lights becomes a simple choice,” said Al Ruud, Cree vice-chairman, lighting. “Utilities and city managers can now improve the lighting in their neighbourhoods, save energy and see payback in less than a year. Why

would anyone choose otherwise?”

Cree state that the 25-watt and 42-watt XSPR street light is designed to replace up to 100-watt high-pressure sodium street lights, reducing energy consumption while improving lighting performance. Cree’s NanoOptic Precision Delivery Grid™ optic technology achieves better optical control than traditional street lighting fixtures and efficiently delivers white uniform light for safer-feeling communities.

In addition to a low initial cost and significant energy savings, the XSPR street light is backed by Cree’s 10-year warranty.

“Street lighting is our city’s largest single energy-related cost, and the XSPR street light appears to dramatically change the economics of LED relative to traditional



lighting technologies,” said Dan Howe, assistant city manager, City of Raleigh, N.C. “This breakthrough technology can change the total cost of ownership equation, encouraging municipalities to transition sooner to LED with less risk, and redirect resources to other important community needs.”

## Korea deploys Infinera InP PICs for multi-terabit communication

INFINERA has announced that Dacom Crossing, a Korean provider of international IP communications, has deployed the Infinera DTN-X packet optical networking platform.

The platform will deliver a fully integrated network connecting Seoul, the terrestrial backhaul network and the EAC Korea landing station. The Infinera Intelligent Transport Network, featuring the DTN-X, enables Dacom Crossing to offer 10, 40 and 100 Gigabit Ethernet (GbE) services in addition to existing International Private Lease Circuit services up to 10 Gigabit per second (Gb/s).

The Infinera Intelligent Transport Network sDacom Crossing to use time as a weapon to increase revenues with highly reliable, differentiated services while reducing operating costs through scale, multi-layer convergence and automation. With Infinera Instant Bandwidth, Dacom Crossing further benefits from the rapid deployment of bandwidth in 100 Gb/s increments on demand. “The DTN-X allows us to scale our network as needed based on customer demand, while providing unprecedented speed and reliability,” says JH Kim, Dacom



Crossing CEO. “Coupled with the Instant Bandwidth feature, which allows us to deploy increments of 100G services, Infinera’s solutions enable differentiation by shortening provisioning times, accelerating service delivery, and reducing time to revenue.”

Dacom Crossing provides wholesale services to Tier One carriers, ISP’s and content providers, and is the first Korean network operator to deploy Infinera’s solutions. Dacom Crossing is deploying an Intelligent Transport Network enabled

by the industry’s only commercially available 500 Gb/s coherent super-channel transmission. The Infinera DTN-X is designed to scale without compromise to provide for future upgrades to terabit super-channels and Terabit Ethernet.

“Dacom Crossing is now providing South Korea with its first Intelligent Transport Network, featuring the industry’s only solution designed with photonic integrated circuits,” says Andrew Bond-Webster, vice president APAC Sales for Infinera. “Our solution’s ability to quickly and reliably provide network services on demand, with the ability to scale in the most efficient manner, really stood out against our competitors.”

The Infinera DTN-X is designed to scale without compromise to enable future upgrades to terabit super-channels and Terabit Ethernet. The DTN-X converges five Terabits of non-blocking OTN switching into the same platform, resulting in more efficient network utilization when compared to conventional WDM architectures. Intelligent software combined with this converged platform automates manual operation.

# GaN-on-silicon LEDs are catching incumbents

ENGINEERS at Samsung and Osram claim that LEDs grown on silicon can deliver a performance that is very close to that of today's emitters. Blue-emitting LEDs grown on silicon are now delivering efficiencies that are almost equal to that of the incumbent devices, which are formed on sapphire. "The performance gap is receding fast, and is less than 10 percent," claimed Youngjo Tak from Samsung Advanced Institute of Technology, Korea, in a talk to delegates at the International Conference on Nitride Semiconductors (ICNS) in Washington.

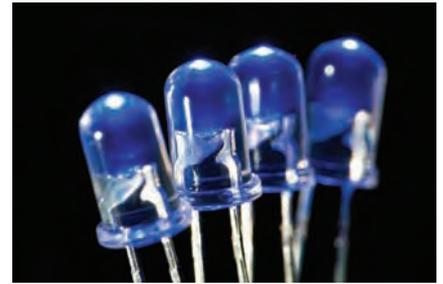
A similar view was offered by Martin Albrecht from the Leibniz Institute for Crystal Growth, who has been working with engineers at Osram Opto Semiconductors and the MPIE, Germany: "GaN-on-silicon LEDs have comparable efficiency to GaN-on-sapphire." Speaking in a session devoted to GaN-on-silicon LEDs on Monday 26 August, Tak refused to disclose the results of Samsung's best devices, which are grown on 200 mm silicon. But he did reveal that the performance of these LEDs is much higher than that of the devices announced at the 2011 ICNS meeting. Back then, Samsung's researchers extracted 580 mW from a 1 mm by 1 mm LED grown on 4-inch silicon and driven at 350 mA under a forward voltage of 3.2 V.

Albrecht was more forthcoming, providing details of performance of this team's latest LEDs. They requires just 2.91 V to operate at 350 mA, and when combined with phosphor technology produce 104 lm/W of warm-white light with a colour-rendering index of 83. The efficacy increase over last year's devices is mainly due to a 6 percent fall in output voltage, which has stemmed from improvements to the epitaxial layers and the quality of the quantum wells. GaN-on-silicon LEDs are attracting tremendous attention within the compound semiconductor industry, due to their promise to slash the cost of solid-state lighting.

"To replace the fluorescent lamp, we must reduce the cost [of LEDs] more and more," proclaimed Tak, who argued there are two ways to do this: trim manufacturing costs or improve

performance, such as by increasing efficiency. Substrates have a big role to play in both approaches. Tak said that although the cost-per-lumen for LEDs grown on sapphire is falling, it will plateau in 2015, and alternative platforms are needed to make light-emitting chips more affordable. Switching from 4-inch or 6-inch sapphire to 200 mm silicon can cut costs by 31 percent and 48 percent, respectively. That's partly because the sapphire substrates are not that cheap – according to Tak, it's typically \$500 for 6-inch sapphire and \$1500 for an 8-inch version – and also because LEDs grown on silicon can be processed in depreciated silicon fabs.

Tak dismissed the use of GaN substrates for cutting LED costs. Although Soraa has shown that a native substrate can yield very efficient LEDs operating at incredibly high current densities, so far fewer chips are needed to generate an equivalent power output; Tak argued that the cost of the GaN platform is too expensive. It has fallen over the last few years, but it is still around \$1300 for a 2-inch substrate. Growing an LED on silicon is not easy, because there are



lattice and thermal mismatches between the substrate and epitaxial layers that can cause the wafer to bow, or even crack. It is also not possible to grow GaN directly onto silicon, due to meltback, so AlN must be deposited first.

By controlling the shape of the wafer with an AlGaN-based buffer structure, Samsung's engineers can realise a bow of less than 30 microns. They have found that in order to realise a very low bow, it is critical to start with a silicon substrate with a low degree of warp. The thicknesses of Samsung's latest LED epistuctures are about 5 microns, compared with 8 microns for the previous generation of devices. "They have a similar processing time to sapphire," said Tak. With a growth time now comparable to that for the incumbents, a performing that is just a fraction behind them, and lower manufacturing costs, GaN-on-silicon LEDs look to have a bright future.

## Aixtron wins another order from HG Genuine

CHINESE COMPANY Wuhan Huagong Genuine Optics Tech Co., Ltd (HG Genuine) has ordered an Aixtron 6 x 2-inch Close Coupled Showerhead (CCS) epitaxial deposition system. The reactor will be used to manufacture light emitting and detection devices on InP substrates. HG Genuine's Chief Scientist, Zhaozhong Wang, says, "This repeat-order reflects our complete satisfaction with the performance of Aixtron's technology. Our existing system has demonstrated versatility, ease of operation and reproducibility. With the new system we will be able to carry out our planned expansion of capacity and to develop high quality epitaxy products. I am looking forward to another smooth ramp-up as well as the excellent service, installation and operation we have come to expect from Aixtron's service team."

HG Genuine is one of the manufacturers in China possessing complete mass production lines for epitaxy, chip fabrication, devices, optical modules and subsystems. The product range covers semiconductor laser and detector chips, active devices and transceivers, which are widely applied in digital communication, analogue communication and optical sensors.

Aixtron's CCS 6 x 2-inch system is designed for research and production. Processes developed using the CCS systems can be easily scaled up for deployment on the larger mass-production CRIUS platforms. The three-zone heater of the CCS is claimed to provide the best temperature uniformity standards.

# First Solar sells CdTe Canadian power plants

FIRST SOLAR has sold a collection of solar projects in Ontario, Canada to an investment partnership led by GE unit GE Energy Financial Services. The terms of the transaction were not disclosed. The 20MWAC Walpole Solar Power Plant is one of three solar projects in Ontario, Canada acquired by partners GE Energy Financial Services and Alterra Power Corporation from First Solar, Inc. Electricity from the 50MWAC collection of projects will be sold to Ontario Power Authority under its Renewable Energy Standard Offer Program (RESOP) with 20-year power purchase agreements.

It is the first project transaction between First Solar and GE since their solar technology and commercial partnership was announced on August 6th. The ABW Partnership, originally announced in 2011, consists of majority owner GE Energy Financial Services and Alterra Power Corporation, which made an equity contribution and will serve as the projects' managing partner.

The ABW Partnership raised debt for the acquisition, with The Manufacturers Life Insurance company serving as agent and lead arranger. The debt syndicate consists of The Great-West Life Assurance Company, Sun Life Assurance Company of Canada and Caisse de dépôt et placement du Québec. First Solar has completed construction of the power plants Amherstburg (10MWAC), Belmont (20MWAC) and Walpole (20MWAC).

The firm has also commissioned and energised them so they are providing power to the grid. First Solar will provide operations and maintenance services under long-term contracts. Output of the power plants will be sold to Ontario Power Authority under its Renewable Energy Standard Offer Program (RESOP), with 20-year power purchase agreements. "First Solar is proud to contribute to Ontario's renewable energy objectives," said Tim Rebhorn, First Solar's Senior Vice President of Business Development - Americas. "In addition to providing clean electricity, the projects have provided meaningful employment and local economic benefits, as well as contribute to the safe and efficient operation of the local utility system."

GE Energy Financial Services said the Ontario projects contribute to its cumulative one gigawatt, \$1.5-billion solar investment portfolio, comprising 50 installations, including several with First Solar in North America and Australia.



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# Eastern promise?

As the concentrated photovoltaic industry looks east for market success, silicon-based businesses with more established supply chains could have a head-start, reports Compound Semiconductor.

WITH THE CONCENTRATED photovoltaic industry acclimating to the US and European economic slowdown, surviving businesses are now looking elsewhere for more action. Still reeling from plummeting standard photovoltaic panel prices, and to date, poor bankability, key players have had to sit back and re-assess where best to focus efforts.

Speaking at a recent PV Insider webinar to debate the next steps for the CPV

industry – for both III-V and silicon cell manufacturers – Amonix chief technology officer and founder, Vahan Garboushian, and Solaria senior director of product management, Mike Mehawich, were both looking east.

“The Middle East and North Africa present a lot of market for CPV but CPV can also offer a lot employment locally and indigenously,” says Garboushian. “If you look at our [III-V] technology, only the cell cannot be made in the Middle

East but everything else can be made indigenously.”

Indeed, as the CTO highlights, this region is desperately trying to replace some oil consumption with photovoltaics. “Saudi Arabia will soon be consuming all the oil it produces leaving nothing to export. CPV can take care of these problems and bring local employment,” he adds.

Mehawich agrees that regions with high direct solar irradiation, including

Amonix is taking its CPV technology to MENA regions  
[credit: NREL]



MENA, offer new opportunities to CPV manufacturers, but highlights how Solaria is also looking to China. According to Mehawich, the manufacturer of silicon-based modules has poured vast resources into developing reliable tracking systems and having recently established operations in China, hopes to meet this nation's rising demand for large-scale solar projects.

As he adds: "Our technology is designed to be compatible with existing single-

A lot of people in the financial world jumped into the market early to make CPV systems and make money, but this was premature. The industry has seen a lot of consolidation. A year on, Amonix is back with a revamped cheaper module but Garboushian believes his industry's biggest challenge is to lower costs further. Cell efficiency is a major factor to driving costs down... and we expect module efficiency to be at 38 percent by 2015, which will reduce system cost drastically

axis trackers in the market and we have also built our own. For us it's about building this tracker market. We still find that certain emerging markets need education on the benefits of tracking... but in countries like China, we're seeing opportunities developing."

### Looking back

The shift in focus from West to East follows many industry ups and downs. In 2012, just as Amonix ended manufacturing in Nevada and ABB pulled the plug on Greenvolt's funding, SolFocus was gearing up to provide thousands of systems to a 450 MW project in Baja, California and Soitec and Schneider Electric were installing pilot projects in Morocco.

As Garboushian puts it: "A lot of people in the financial world jumped into the market early to make CPV systems and make money, but this was premature. The industry has seen a lot of consolidation."

A year on, Amonix is back with a revamped cheaper module but Garboushian believes his industry's biggest challenge is to lower costs further. "Cell efficiency is a major factor to driving costs down... and we expect module efficiency to be at 38 percent by 2015, which will reduce system cost drastically," he says.

But still the industry need more. As he highlights: "Cost reduction remains a major issue. We now need consolidation of technologies so spot buyers have

access to an orderly and low cost supply chain and we need large-scale manufacturing."

Garboushian believes its time for 'big balance' companies to step into the industry to develop the supply chain and drive manufacturing forward. "We need to get these long-term strategic companies involved rather than having venture capitalists that want to turn this around in a year or two," he adds. "Amonix has reduced the cost of its new product by 50 percent and is now looking to manufacture it on a very large scale."

Mehawich agrees with Garboushian, saying: "It's all about finding a way to achieve the scale to compete with massive incumbents in the industry."

But the silicon-based CPV manufacturer may have a head-start on manufacturability. As Mehawich points out, from word go, Solaria has focused on fitting into the existing supply chain of the silicon PV industry.

"We wanted to go with the flow rather than build a supply chain from scratch," he says. "So for everything from the back sheet to junction box and cells, we've been trying to insert the technology into the supply chain... to achieve scale."

And as Mehawich highlights, the company has already partnered with industry players that have 'critical mass in the industry'. "We can get there from a cost standpoint, and so we're much more competitive," he says.

# The rise and rise of Infinera

Infinera is storming long-haul fibre optic markets with its InP-based platform.

IN 2005, Infinera lit up the long-haul fibre optic telecoms market with the release of a wavelength division multiplexing platform, the DTN.

Based on the company's in-house InP photonics integrated circuits (PICs), the platform catapulted the then start-up to number one in the 10G North American market. Eight years later, history has repeated itself.

Watching demand for bandwidth rise at exponential rates, Infinera has spent the intervening years honing its DTN-X platform for 100G networks while competitors built 40G platforms before moving onto 100G. The platform was delivered in 2012, and today the company has seized around 35 percent of 100G market.

As Geoff Bennett, Director of Solutions and Technology at Infinera, puts it: "We've moved straight into the number one position in the 100G market. Eighteen months ago Ciena had 95 percent market share here and now they have less than 10 percent." And with analysts across the board forecasting continued strong growth for 100G – Infonetics predicts coherent 100G shipments to double this year, and then again in 2014 – the future looks bright for Infinera. Carriers, from New Zealand-based FX Networks to PacNet, Hong Kong, are snapping up the company's 100G platform to build

networks delivering 10, 20 and 100 Gigabit Ethernet services. And Infinera's finances reflect this.

"Our [North American] competitors, Ciena, Alcatel and Nokia Siemens Networks, are massively encumbered by debt," says Bennett. "We have something like \$300 million in the bank, we are a gnats whisker away from making money in the last quarter, and expect to move into profitability later this year. We're certainly optimistic about the rest of the year."

So what is Infinera doing that the rest of the pack isn't? Bennett firstly attributes the company's rising revenue to its sales of DTN-X. The platform features 500 Gb/s PICs, which integrate more than 600 optical functions onto a pair of chips, and built-in optical transport network (OTN) switching.

"Our product does not address the 100G marketplace with 100G transponders, as everyone else does. We are the only company shipping 500G super-channel line cards. And we are the only company that includes full non-blocking OTN [optical transport

network] switching in every node," he says.

Indeed, competitors are currently delivering 100G line cards and while OTN switching – crucial to eliminating stranded capacity and optimising network routing

Right: After years of heavy investment, Infinera's InP chip development is paying off



– was once considered niche, service providers now see the technology as a must-have for scaling future networks.

Clearly Infinera's dogged development twinned with industry insight – bypassing 40G and building OTN switching into architectures – has spawned sales, but Bennett also attributes success to the company's unique structure.

"We are the only long-haul systems vendor that builds its own chips. We design and fabricate our InP PICs, we have our own fab in Sunnyvale and we integrate these PICs into our own system products," he says. "We do not sell these chips to anyone and we have



Making waves: Telecoms providers across the world are turning to Infinera's latest platform, based on InP-based PICs, to take communications further

complete control of our supply chain. We don't have to pay any margin to a components company; we are completely vertically integrated."

Bennett will not be drawn on where in the supply chain his company's profitably lies; InP PICs are notoriously difficult and costly to fabricate while systems integration is relatively straightforward. But as he highlights: "Infinera took a huge risk in developing its own InP technology. That risk was venture capital funded and couldn't have been funded in any other way... so it's now good to see that risk being awarded by unprecedented market acceptance."

"We were shipping for just one quarter and we jumped from zero [market-share] to market leader; that's just astonishing," he adds.

Critically, the company's high risk InP technology is holding the cheaper, China-based competition – namely Huawei and ZTE – at bay, for now. Huawei is busy deploying its 100G WDM system across China, but Infinera still claims most 100G market share.

"Infinera is number one, Huawei is number two.

ZTE and Huawei are winning market-share by undercutting the competition... so when we encounter our Chinese competitors we've got to work really hard to differentiate our product," explains Bennett.

"We can do this with our 500G super cards and OTN switching but I fear for our western competitors," he adds. "They are basically shipping the same stuff as Huawei and ZTE and that's why they are not able to make money."



Geoff Bennett, Director Solutions & Technology, believes vertical integration is key to Infinera's success

# Sapphire substrates to lead future LED markets

Come 2020, US analyst business, Lux Research, predicts sapphire-based LEDs will still dominate a multi-billion dollar LED lighting industry. Compound Semiconductor finds out why.

LED LIGHTING is forecast to become a \$80 billion industry by the end of the decade, with manufacturers of LEDs based on sapphire, silicon and silicon carbide substrates jostling for market space. Today, the vast majority of devices are deposited on sapphire wafers, but could this change?

Both Plessey Semiconductors and Toshiba-Bridgelux recently unveiled GaN-on-silicon LEDs and have promised mass production before the end of this year while Cree is relentless in its delivery of GaN-on-SiC devices. But despite the progress, Lux Research analyst, Pallavi Madakasira, is certain GaN-on-sapphire LEDs will remain the industry's leading lights.

In her recent report, *Dimming the Hype: GaN-on-silicon Fails to Outshine Sapphire by 2020*, she predicts GaN-on-sapphire will remain the entrenched incumbent come the end of the decade. Meanwhile, the leading emerging technology, GaN-on-silicon, will snare only 10 percent market share while GaN-on-SiC will grow to 18 percent of the market. This, she believes, is down to cost and performance.

"GaN-on-silicon developers tout very loudly that fully

depreciated [CMOS] equipment can be used to make GaN-on-silicon [devices]," she says. "But can we really expect an organisation that has invested billions of dollars in its GaN-on-sapphire line for more than ten years to stop running that, and get into GaN-on-silicon [production]."

As she points out, industry players know how to make silicon substrates 'with their eyes closed', but depositing complex buffer layers onto silicon prior to GaN deposition, to overcome GaN and silicon lattice mismatches, adds time and cost to a manufacturing line.

"As much as these lines are full depreciated, they are still an additional investment for a company space- and time-wise," she says. "It's common knowledge that almost all the big businesses, such as Philips and Osram, have in-house programmes looking at GaN-on-silicon... but it's very unlikely you will see, say, Philips quit its GaN-on-sapphire programme and then move into GaN-on-silicon," she adds.

Madakasira also highlights that the performance of GaN-on-silicon LEDs has yet to be favourably demonstrated compared to alternative technologies. Her figures put the luminance efficacy of GaN-on-SiC LEDs at 200 lumens per

watt with GaN-on-sapphire devices coming in at between 150 to 180 lumens per watt. Meanwhile, at 80 to 90 lumens per watt, Madakasira asserts GaN-on-silicon LEDs are 'way behind'. "They have not yet achieved the luminous efficacy standards that GaN-on-sapphire devices had three years ago," she asserts. "So there might be a substrate cost benefit, but manufacturers will still need to grow complex buffer solutions and, even then, not achieve a performance that matches that of sapphire LEDs."

"And while early stage innovators [of GaN-on-silicon] LEDs argue they will be able to catch up, you have to remember they are catching up on a moving target. GaN-on-sapphire performances will keep improving and the costs are going to keep coming down," she adds.

Indeed, 6-inch silicon substrates may only cost \$25, but the 2-inch sapphire alternative is hardly expensive at between \$8 to \$10. And as Madakasira points out: "We now have so many Chinese players getting into the space and making LED dies. GaN-on-sapphire is something everyone is able to make."

So as sapphire-based LED manufacturers settle in for

a relatively secure future, where does this leave the manufacturers of GaN-on-SiC and, of course, GaN-on-silicon LEDs?

Cree, the dominant player in the GaN-on-SiC market is safe, reckons Madakasira. "This technology is very unlikely to lose out to silicon. Cree has successfully made the transition from 4-inch to 6-inch diameter wafers and is continually improving performance and bringing costs down," she says.

Meanwhile, the analyst believes it's time GaN-on-silicon developers started forging strategic partnerships with industry heavyweights. Azzurro recently announced its intention to licence out its GaN-on-silicon strain engineering intellectual property to LED manufacturers, while Bridgelux forged such a relationship with Toshiba some months ago now.

"Azzurro has made a smart move... and I think the way Bridgelux has formed its partnership is the way to go," she says. "For start-ups in this space, you need to have these critical, strategic partnerships or you really are going to go nowhere."

# Plessey thrusts LEDs into the market

As Plessey Semiconductors scales up commercial GaN-on-silicon LED production, where next for the UK technology pioneer?

IN APRIL THIS YEAR, UK-based semiconductor manufacturer, Plessey Semiconductors, sampled the industry's first commercially available GaN on 6-inch silicon LEDs amid claims of a massive capacity ramp.

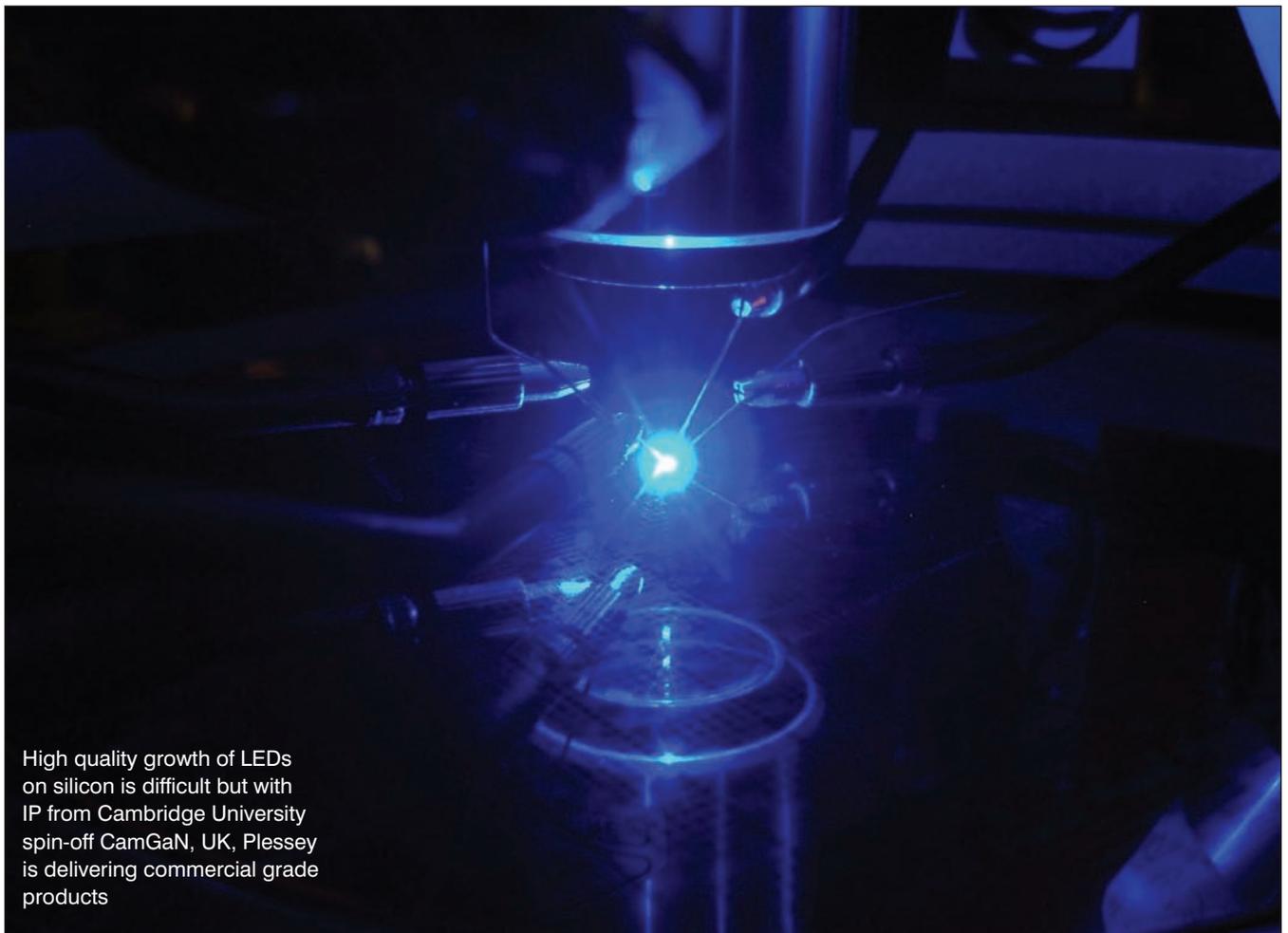
As promised, a raft of new, higher power LEDs has just been released and company executives have told *Compound Semiconductor* to expect much more. In the coming months, even higher power LEDs will be up for grabs, with the company then supplying its

GaN-on-silicon LEDs for incandescent replacement lamps next year. Come mid-2014, the company intends to move up the supply chain and, with an existing strategic partner, build lighting products, as well as LEDs. And by the end of that year, plans to install ten MOCVD reactors at the company's facility in Plymouth should be well underway. The intentions are ambitious; can Plessey really deliver?

"Releasing the entry level product generated a lot of interest in our LEDs particularly for backlighting and indicator

applications, and other custom LED designs," explains chief operating officer, Barry Dennington. "Customers have been interested in the GaN-on-silicon technology – it gives significant cost benefits – and that has opened up opportunities for us to quote new LEDs in the consumer space as well as signage."

"There are literally hundreds of different customer requests and market applications, it's a case of picking the right opportunity," he adds. Right now, the company is intent on demonstrating



High quality growth of LEDs on silicon is difficult but with IP from Cambridge University spin-off CamGaN, UK, Plessey is delivering commercial grade products

higher efficiency and higher power GaN on silicon LEDs. The initial, entry level LEDs delivered only a few lumens for low drive currents, targeting indicating applications. However, the latest 2 mm<sup>2</sup>, blue versions deliver 350 mW when driven at 420 mA – a leap from the entry level devices – and are making inroads to solid state lighting applications.

This move beyond what some have called the first ‘proof-of-concept’ devices, places the UK LED manufacturer ahead of the competition, for now.

Its main rival appears to be Toshiba, which is using technology developed by Bridgelux, and has just launched GaN-on-silicon LED with a flux up to 63 lumens.

Keith Strickland, chief technology officer at Plessey, is certain his company will have delivered a 70 to 80 lm/W device by the end of this year, and as Dennington says: “Next year we will also have an LED product capable of competing in the incandescent lamp replacement market, and with relatively few LEDs compared to what is on the market today.”

Indeed, as part of the European “Consumerizing Solid-State Lighting” programme, led by Philips, Plessey supplied the GaN on silicon LEDs that lit up the project’s \$9.95 lamp intended to replace the 60 W incandescent bulb.

“We’ve demonstrated our capability to do this through the CSSL European programme... and we are confident that if you look at the breakdown of the costs for these lamps, we will meet or beat cost targets by virtue of the GaN on silicon process and economies of scale from 6-inch manufacturing,” he adds.

Which brings Plessey to the next milestone on its roadmap; vertical

integration. Having provided the LEDs for tomorrow’s cheap incandescent replacement LED lamp, executives at Plessey believe vertical integration towards lighting would be pretty straightforward. As Dennington highlights, his researchers have mastered LEDs, a key part of the lamp, and the company already employs lighting as well as optical engineers.

“We think it’s a relatively easy step to move into producing lamps and we have at least four projects that could see Plessey producing lighting products in the second half of next year,” he says.

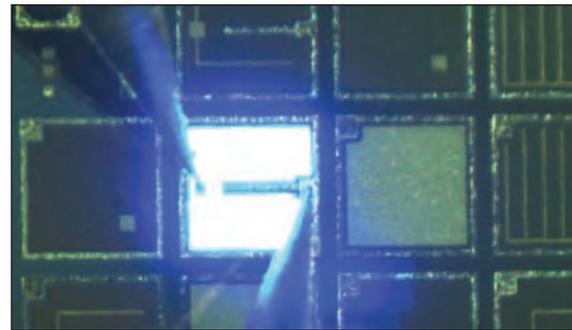
“This would give us an opportunity to be more vertically integrated in the market and offer a broader range of lighting solutions to customers, not just LED components.”

So as Plessey continues to drive LED performances forward – performances don’t yet match those of sapphire-based favourites – the appeal of GaN-on-silicon LEDs for the lights of tomorrow will only increase.

Relatively cheap, available silicon wafers twinned with fabrication on depreciated CMOS lines, makes manufacturing on large-size wafers more and more irresistible to manufacturers, and this is what the company is banking on.

The business is looking to increase its Plymouth-based fleet of MOCVD reactors from one to ten, but with each reactor costing some \$2.5 million, is this really viable?

Both Dennington and Strickland think so. As Strickland points out, the Plymouth facility has a lot of room for expansion and while this will require significant investment, the company plans to do just this.



Plessey’s LEDs are grown on 6-inch silicon wafers with an AlN nucleation layer and complex structure and layers of AlGaIn, GaN and SiN preventing wafer bowing and reducing dislocation density

“This expansion is driven by customer demand, so we have to be successful in getting our products from the roadmap to the market,” adds Dennington.

“But we have the right kinds of partners... and we are bringing in equipment to improve yields and throughputs so clearly the next step is to ramp up the number of reactors we have.”

And with each reactor capable of churning out 2 million, 1mm<sup>2</sup> die every week, the potential increase in output rates is breathtaking.

However, despite the rapid ramp in manufacturing, the company will be maintaining its chip production in the UK, and the UK alone.

“We have no plans right now to take the technology outside the UK,” concludes Dennington.

“It’s still a very disruptive breakthrough technology and our IP is very precious to us. We need to manage any outsourcing outside the UK very carefully; it could be considered with the right partner but we are very cautious right now.”

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# Replacing halogen lamps

Inferior light quality holds back the sales of most LED-based replacements for halogen lamps in casinos, hotels, high-end retailers and cruise ships. But that's not the case for Soraa's lighting products, which produce full-spectrum emission with a violet LED pumping red, green and blue phosphors. Richard Stevenson reports.

A FEW YEARS AGO, the lighting industry debated whether there would be a revolution in solid-state lighting. Now, however, it's not a question of it but when.

For chipmakers, this revolution can't come too soon. They are operating in a market suffering from over capacity, and shipments to light bulb makers offer the opportunity for higher margins and increased sales.

Many LED makers are now working hard to forge strong relationships with lamp makers, so that as sales of solid-state lamps surge, so do their own chip revenues. But this is not the only road to success, and a few other firms are taking a different path – one that allows them to take far greater control of their own destiny. Companies that fall into this category include Cree, which has diversified from being an LED manufacturer to a maker of replacements for 40 W and 60 W incandescents, and Soraa, a start-up based in Goleta, CA, that has developed a novel chip that features in its solid-state replacement for 50-75 W halogen lamps.

Soraa is by no means the only maker of an LED-based replacement for the halogen lamp. But its product has a far higher colour quality than that produced by many of its rivals – it has a colour-rendering index (CRI) of 95, compared to a typical value of 80 – and that should ensure success in this market.

"We see our customers as those that have refused to consider LEDs in the past," reveals Chief Operating Officer Douglas Devine. "They have refused to move away from the halogen, because saving a couple of bucks in the electricity bill isn't worth damaging the ambience of the customer-facing areas that they have spent so much time and effort on."

In May 2012, Soraa launched its full-colour MR16s that are winning deployment in businesses measuring revenue-per-square-foot, such as high-end retailers, casinos, cruise ships and hotels. "These are areas where they



The Soraa SNAP System combines a unique 10 degree lamp with an innovative array of interchangeable beam and colour-shifting accessories

employ lighting designers, who are more than sophisticated enough to appreciate the difference in the quality of light.”

To realise a full-colour spectrum, Soraa’s lamps pump red, blue and green phosphors with a violet-emitting chip. This is a markedly different approach from that used in most white-light sources, which employ a blue LED to excite a yellow phosphor, which is sometimes combined with a red variant.

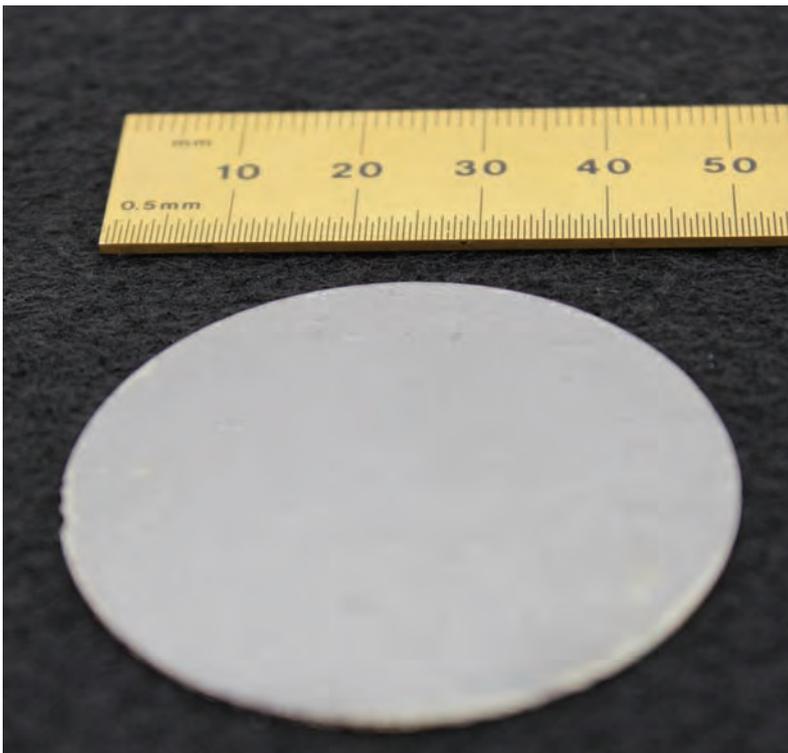
“When you excite with a blue LED, it is not possible with a phosphor to tune the light down to violet, so typical competitor products are missing the violet all together,” explains Devine. This omission makes a massive difference to the appearance of anything containing whiteners, which are excited by violet light.

Customers investing in Soraa’s MR16 lamps are rewarded by getting light quality of a halogen source, but at a 75 percent gain in efficiency – despite the 10 percent reduction in efficiency for pumping with a violet, rather than blue. The high efficiency of the Soraa lamp stems from a novel chip design with very high extraction efficiency.

### Triangular chips

Insights into the design of this LED are provided in an *Applied Physics Letters* paper, which details a triangular chip (note that the geometry reported in that journal does not represent a specific commercial device). The LEDs reported in that paper are grown by MOCVD on GaN substrates, and have a triangular shape to ensure in-plane light is extracted from the chip after one or two bounces within it.

50 mm diameter, free-standing SCoRA crystal



To optimise extraction, Soraa’s engineers model the proportion of light extracted from the LED at various chip heights. If it is just a few microns high, the device behaves like a thin-film chip with extraction resulting from just surface roughening. However, if the height of the chip increases to 50  $\mu\text{m}$  or more, extraction is appreciably higher, thanks to light exiting the device via its sidewalls.

Triangular-shaped LEDs made at Soraa, which have a roughened top surface and sides with lengths of about 380  $\mu\text{m}$ , produce a maximum external quantum efficiency of just over 73 percent. This high value is aided by the native substrate, which adds considerably to the device costs, but enables growth of an epistructure that is free from extended defects.

To prevent the LED costs within MR16s from becoming extortionate, devices are driven at incredibly high current densities, so very little chip real estate is required in each lamp. With a conventional LED – which is formed on sapphire, SiC or silicon – driving the device in this way leads to a significant reduction in efficiency, due to a controversial malady known as droop. This still affects Soraa’s LEDs, but the impact is far more modest, due to the combination of improved crystalline quality (due to native GaN substrate) and a light-generating active region that is far larger than a conventional device.

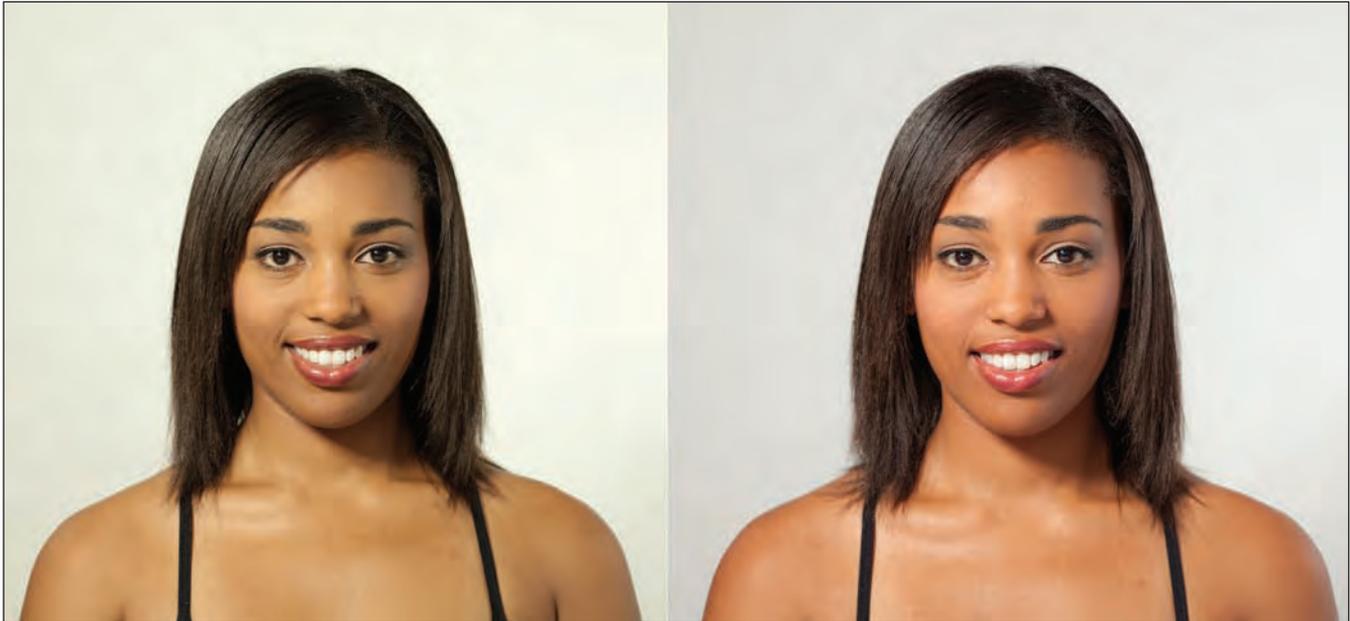
When the current is cranked up, the output produced by a single LED is sufficient for a halogen lamp (for the MR16 form factor, up to 75 W equivalence is achieved). Using a single source is beneficial, because it casts a single shadow. According to Soraa, rivals have multi-source lamps producing multiple shadows that fall far short of the 75 W equivalence mark.

This divergence from the norm, in terms of LED count, plus a difference in the operating temperature regime, mean that Soraa’s lamp was never going to be an off-the-shelf product. Instead, the lamp had to be designed specifically for a single GaN-on-GaN LED, making it better suited to a vertically integrated approach for the manufacture of MR16s.

But that is not to say every single manufacture steps takes place at Soraa. “We’re doing the design of the light chip and manufacturing the LED ourselves. Light chip manufacture and lamp [assembly] are done at sub-cons,” explains Devine. Sales of MR 16s then occur through web sites, and also via a network of distributors in Europe, Asia, Australia and New Zealand.

### Making substrates

To try to reduce the cost of these lamps, Soraa is developing a novel ammonothermal process to make its own substrates. “We have a team working on bulk GaN development, because



what we'd ideally like to buy is not available," admits Devine. "We've developed a type of reactor, called a SCoRA (scalable, compact, rapid ammonothermal), that is making very good progress."

The traditional ammonothermal method, which has been pioneered by Ammono of Warsaw, Poland, produces GaN of incredibly high quality, but growth rates can be as low as just a few microns per hour. In comparison, Soraa's approach is capable of growth at greater than 40  $\mu\text{m/hr}$ , and 10-30  $\mu\text{m/hr}$  in all directions.

One of the key features of the Soraa reactor is its internal heating. This circumvents the material property limitations of a conventional ammonothermal chamber. The Soraa reactor is also claimed to be cheaper and easier to scale than traditional autoclaves, which are fabricated from nickel-based superalloys. The capsule that contains the raw materials – seed crystals, a polycrystalline GaN nutrient, a mineraliser and ammonia – is surrounded by a heater, followed by a ceramic shell providing structural support and thermal isolation, and finally an externally-cooled outer shell providing mechanical confinement.

Thanks to low conductivity of the ceramic, the steel shell can remain below 200 °C at an operating temperature of 750 °C, allowing it to maintain high creep resistance.

GaN crystals grown in this reactor are transparent but yellow, due to residual impurities, and have a dislocation density below  $10^4 \text{ cm}^{-2}$ . These crystals have been sliced into wafers that have been used as the foundation for the growth of InGaN/GaN heterostructures. The intensity and full-width half maximum of the photoluminescence produced by this sample is virtually identical to that emitted

by an identical structure formed on HVPE-grown GaN. However, electroluminescence emitted by the former structure is complicated by a yellow luminescence emanating from the substrate.

Although engineers are now working to try and improve the transparency and luminescence properties of their boules, it will be several years before Soraa is making its own substrates for device manufacture. "We're not able to call the exact date," explains Devine. "It will depend on the application. The specifications for lasers are not as stringent as those for LEDs. We have a laser business, and we could begin to use our own substrates earlier in our laser manufacturing, than for LEDs."

Solid-state lighting, however, will continue to provide the majority of the company's revenue. During the next 12 months Soraa will ramp its production of the MR 16 lamp family, while moving into expanded flood lamp configurations.

"As you go into 2015 and 2016, the possibilities broaden," explains Devine. "For what the next area after the flood lamps will be, we need to do some more market research, as well as go through market acceptance of our flood lamp products."

One option for broadening the portfolio is to launch a replacement for the 60 W incandescent. This is not a trivial move, though, according to Devine, because it would mean a transition to a market where the price of light is more highly valued than its quality. "A market like that, which is a pure commodity, is a couple of years away from when it's going to be the right time for us to approach it."

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Skin tones under typical 80 CRI blue-based LED, left, compared to 95 CRI 95 R9 Soraa Vivid LED, right

#### Further reading

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Jpn. J. Appl. Phys.  
52 08JA01 (2013)

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Phys. Lett. 101  
223509 (2012)

WE'RE NOT ALWAYS HIGHLY productive at work. Instead, despite our best efforts, we fall short. We might blame a poor night's sleep, a lunch that was a little heavier than it should have been, or maybe, just maybe, a stuffy office that causes us to yawn and fail to maintain our concentration.

If the latter is to blame for sub-optimal productivity, help is on its way. In several countries, legislation is being introduced to set minimum standards for air quality at work, while in the UK, similar requirements will be set for schools.

In many workplaces, it is the operation of the heating, air-conditioning and ventilation system that determines air quality. To prevent fatigue-inducing carbon dioxide levels from getting too high, air is pulled in from outside to increase the proportion of oxygen within the building.

It is possible to always draw in enough air from outside to deliver sufficient air quality. But that's expensive: Air taken from outside often has to

be heated, so it is better for the amount of fresh air that is introduced to track the level of CO<sub>2</sub> in the building, which tallies with its occupancy. Do that and it is possible to trim the cost of air conditioning by up to 25 percent.

To realise these significant savings, a network of sensors have to be deployed to monitor carbon dioxide levels throughout the building. The expense associated with this is not only governed by the price of the sensors, but also their cost of installation. Traditionally, sensors have to be hard-wired to mains electricity, and if the layout of the building is altered – not an uncommon occurrence in offices – wiring must be stripped out before the sensors are repositioned and re-wired.

### Superior sensing

Fortunately, there is a more sensible way for monitoring the air quality. Recently, Scottish start-up Gas Sensing Solutions (GSS) launched the world's first CO<sub>2</sub> sensor that does not have to be hooked up to the mains, but can run off AA

# Simplifying air quality monitoring

Conventional sensors for assessing the air quality in buildings are wired into the mains, making them expensive to install and reposition. But portability and battery powering is possible with Gas Sensing Solutions' modules that feature mid-infrared LEDs and photodetectors.

Richard Stevenson reports.



batteries. Running off just one of them, this type of sensor, which incorporates an antimonide-based light emitter and photodetector, can take a reading every 2 minutes for 10 years thanks to its vastly superior efficiency over the incumbent technology.

The conventional sensors, which are under threat from those produced by GSS, typically combine a tungsten filament lamp for a light source with a pyroelectric or thermopile detector. The bulb, which consumes 100 mW or more, provides a broadband source that excites a CO<sub>2</sub> asymmetric stretching vibrational mode. By monitoring the amount of light absorbed by this mode that occurs at 4.26 μm, it is possible to determine the CO<sub>2</sub> level in the air.

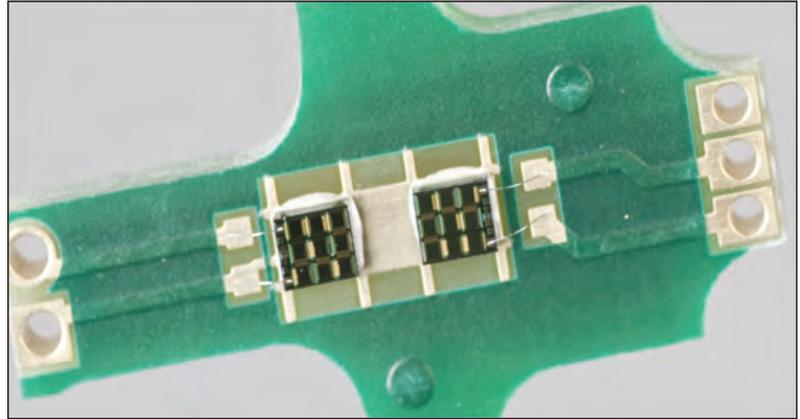
GSS' sensor works on the same operating principal. However, the LED is far more frugal than the bulb, drawing just 3.3 mW, and this solid-state source takes far less time to deliver a stable output.

"With a light bulb, you might have to wait a minute for it to stabilise, but with an LED it stabilises almost instantaneously," explains the CEO of GSS, Des Gibson. Slashing the stabilisation time holds the key to the vast improvement in the key figure of merit, the energy per measurement. "In our case, it's millijoules, whereas in a standard thermal source, it's hundreds-to-thousands of millijoules. So it's a radical improvement."

The tremendous energy saving is not the only area where the antimonide-based device outscores the incumbent. The established CO<sub>2</sub> sensor requires optical filtering, but thanks to the relatively narrow emission and detection profiles of the emitter and detector, the GSS design is filter-free. "This reduces cost, because these filters can be expensive," explains Gibson, who adds that they are also restrictive, requiring parallel light to work effectively. "We can use a neat, folded design that wouldn't necessarily be amenable to a filter-based approach."

### Multiple markets

In addition to the sensor market for monitoring air quality in buildings, which is valued at £100 million, GSS is targeting other markets. They include the automotive sector that could be worth even more. "Within cars, CO<sub>2</sub> monitoring is coming in as an anti-drowsiness system," says Gibson. "That's linked to the air-conditioning system: It will automatically control the in-cabin CO<sub>2</sub> level to a point where the driver isn't



going to fall asleep."

Opportunities also exist for CO<sub>2</sub> sensors in horticulture. It is possible to accelerate plant growth by up to 40 percent by optimising CO<sub>2</sub> concentration, humidity, temperature and light level. What's more, CO<sub>2</sub> sensors can help divers stay underwater for longer by switching to re-breathing systems. They were first used in the military by Special Forces, but are now being used for recreation. "You need to be able to monitor CO<sub>2</sub> very accurately, because it's a chemical scrubber system, so you need to make sure that you are removing the CO<sub>2</sub> as you recycle," explains Gibson, who reveals that GSS sells quite extensively into that market.

The core technology of GSS is the combination of mid-infrared LED and photodiode

Sensors for all these applications are assembled at the company's facilities in Cumbernauld, a few miles northeast of Glasgow. But production begins at GSS' facility at the West of Scotland Science Park, Glasgow, where III-V epiwafers are grown in a Veeco GEN 3 MBE reactor on 4-inch GaAs substrates, before they are dispatched to a local foundry, Compound Semiconductor Global, where they are processed to GSS specifications. Another subcontractor then dices these wafers, mounts LED and photodiode chips on bridgeboards and wire bonds them, before shipping these assemblies back to GSS. Here, all the components are brought together – including injection-molded plastic optics from China – and a portfolio of sensors are put together (see box, "The GSS range of sensors" for details of various products).

"Another piece of intellectual property is the calibration process," explains Gibson. "We calibrate the assembly for temperature and CO<sub>2</sub>. We 100 percent test and we download the calibration data into the firmware, so each sensor has its own unique calibration."

### Getting going

Following its founding in 2006 with funding from by Tweed Renaissance Investment Capital and The Scottish Co-Investment Fund, GSS worked with various partners to develop its product. The UK has a very strong track



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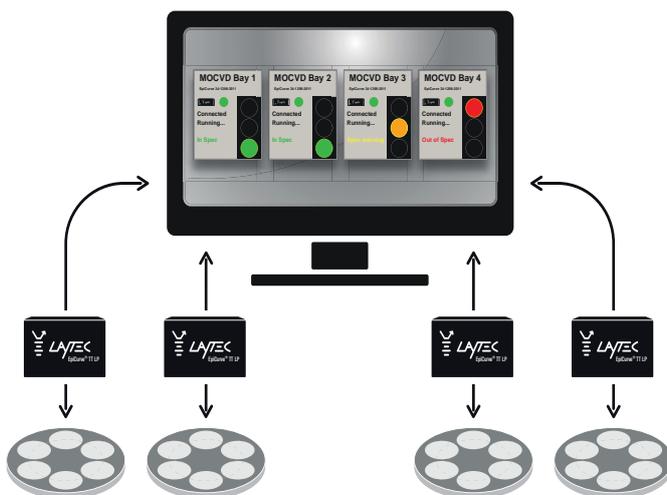
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record in III-V mid-infrared material research and development, and GSS tapped into this, quickly establishing ties with several universities. This includes a strong link with Glasgow University, which has supported efforts in device design and fabrication.

Initially, GSS outsourced the epitaxial process for making mid-infrared LEDs and photodiodes. However, the partner could not ramp up the supply of these wafers to a high enough level to cope with high-volume product manufacture, so the Scottish start-up went in search of an alternative supplier.

This failed. "If someone else had been producing mid-infrared LED-photodiodes, we would have happily brought them from them, but they weren't. So we were left in a position where we had to establish our own development and production capability," explains Gibson.

As well as having to find the funds to finance the introduction of high-volume production implementation, GSS had to bring in the epitaxial expertise to grow the epiwafers. They did this via a knowledge transfer partnership with Glasgow University, who provided an MBE grower. This know-how has now been transferred to GSS.

Moving to in-house epiwafer production appears to have been a good move for the company, because it can continue to develop its devices with fewer restrictions. Although there are no plans to replace the LED with a laser – it costs more to make and emits a far narrower bandwidth, so expensive hardware is needed to stabilise the cavities – the Scottish start-up is involved in a project funded by the UK's Technology Strategy Board (TSB) to investigate the potential of other routes to increased device efficiencies.

### Second string

The LEDs and photodiodes made at GSS have dimensions of 1.7 mm by 1.5 mm, and sensor shipments currently are at about 50,000 per year. This figure is well short of the capacity of the MBE tool, which is capable of producing 1.1 million LEDs and photodiodes per annum. So, to address this reactor redundancy, last November Gibson

and his co-workers set-up Quantum Device Solutions, which is a trading



The COZIR sensors produced by GSS are a low-power product. The 20 mm path length version can detect CO<sub>2</sub> levels of 0.2 percent to 100 percent, while the 70 mm version monitors CO<sub>2</sub> levels up to 1 percent

name within GSS.

"We have a unique capability in terms of mid-infrared III-V material combinations, and we are finding that there are lots of opportunities to sell on the worldwide market. It's almost now at a level where it pays for the running of the machine," explains Gibson.

The time that is available for fulfilling these external orders will steadily reduce as production of the portfolio of GSS sensors increases over the next few years. "We're now ramping into the hundreds of thousands per year, and ultimately this market will go into the low millions," explains Gibson.

One of the companies that GSS is shipping to is Schneider Electric Industries, the biggest operator in building control systems. The two firms have worked together to develop a specific sensor, which Schneider uses with its own electronics.

This additional revenue stream that results from shipping III-V devices, rather than sensing modules, looks set to grow. "We are seeing a lot of interest in people purely buying LED-photodiodes from us in extremely high volumes," says Gibson, who reveals that there are firms that are keen to use GSS chips in their own automotive air-conditioning systems. This approach could benefit both parties: The air-conditioning unit maker does not want to have to acquire the expertise in growing mid-infrared III-Vs, while GCS does

The Sprint IR is capable of 20 readings per second



A Veeco MBE reactor is used to produce photodiodes and sensors at GSS, and provide worldwide epiwafer services



not wish to take on the liability associated with a safety-critical sensor for anti-drowsiness. “Second-tier suppliers are well set-up to handle those liabilities,” claims Gibson.

GSS is also working to make the sensor technology less dependent on batteries, which can degrade with time. Alternative approaches include using a photovoltaic cell to charge a capacitor or a battery. En Ocean Alliance, a

Siemens spinout, is already marketing a GSS sensor powered with a silicon solar cell, and efforts are underway to provide power from other types of photovoltaic device.

“Silicon doesn’t work very well in diffuse lighting,” says Gibson. “Once you drop below 100 lux, it just stops working.” Dye-sensitized solar cells and organic photovoltaics don’t suffer from the same fate, and latter class of device is being developed for a GSS sensor in a TSB programme involving the London start-up Solar Press.

Yet another area of development being pursued by GSS is the development of sensors for other gases. The company’s mid-infrared LED and photodiode technology can make devices operating from 2.5  $\mu\text{m}$  to 6.0  $\mu\text{m}$ , a spectral range where many gases have absorption features. They include hydrocarbons, such as methane, an explosive gas that GSS is making a sensor for. Such a sensor can improve safety in the oil and gas industries and landfill sites, thanks to its very low operating voltage that prevents the generation of explosion-triggering sparks.

There are clearly many lucrative opportunities for GSS. So, if it can get the balance right between making sensors, supplying its chips to other sensor makers, and maintaining its epiwafer services business, it promises to be a big success story for Scotland.

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Right: Customers that want a low-cost product that can be wired into the mains can select the MISIR CO<sub>2</sub> sensor

## The GSS range of sensors

The portfolio of GSS sensors can be divided into three classes:

**COZIR**, the low-power product. This is available with a 20 mm and 70 mm path length. The former targets industrial safety and medical markets and measures CO<sub>2</sub> levels between 0.2 percent and 100 percent, while the version with the 70 mm path length is suitable for building control and horticultural markets, and monitors CO<sub>2</sub> concentrations up to 1 percent.

**Sprint IR**, which is capable of 20 readings per second and can measure CO<sub>2</sub> levels ranging from either: 0-5 percent, 0-20 percent, 0-60 percent or 0-100 percent.

**MISIR**, a lower-cost product with alternative optics. This sensor requires more power, and can be wired into the mains. Its benefit over the incumbent sensor technology is greater longevity, which stems from the use of III-V emitters and detectors.

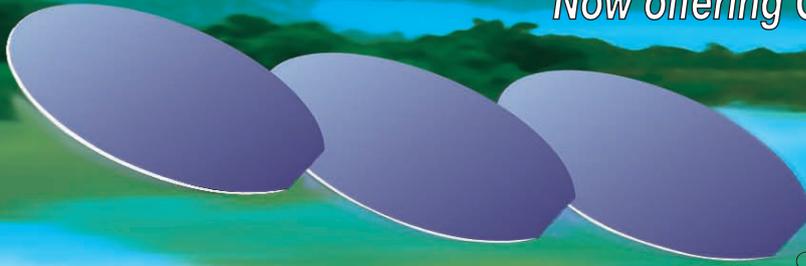


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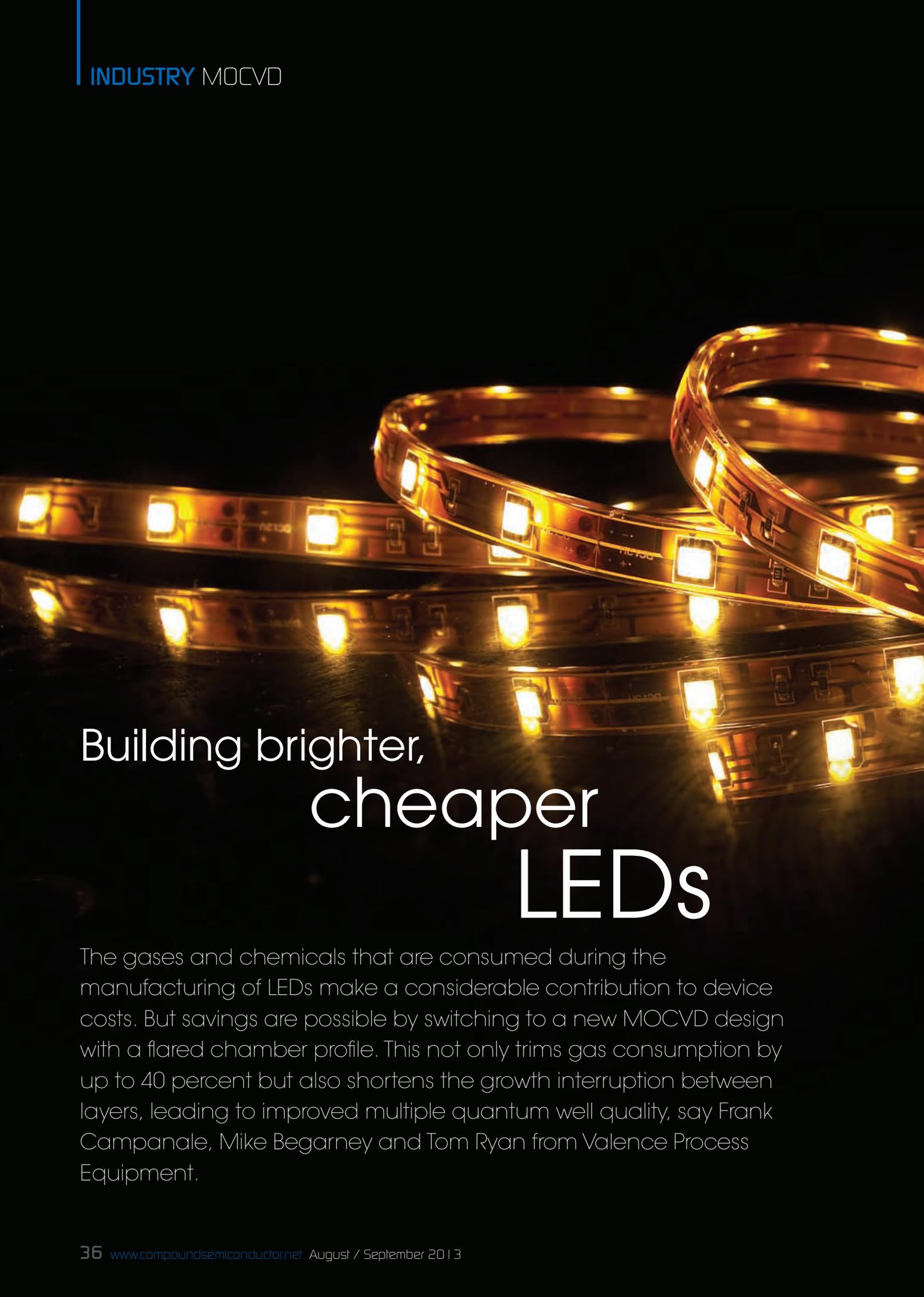
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# Building brighter, cheaper LEDs

The gases and chemicals that are consumed during the manufacturing of LEDs make a considerable contribution to device costs. But savings are possible by switching to a new MOCVD design with a flared chamber profile. This not only trims gas consumption by up to 40 percent but also shortens the growth interruption between layers, leading to improved multiple quantum well quality, say Frank Campanale, Mike Begarney and Tom Ryan from Valence Process Equipment.



AS THE PRICE OF THE LED light bulbs fall, sales are rising fast. But solid-state bulbs have still got a long way to go before they become the dominant lighting technology – this will require a substantial fall in the cost of the LED chips. One way to contribute to cost reduction is to make more efficient use of the gases and chemicals consumed in the making of an LED. That's been the goal of our team at Valence Process Equipment (VPE) of Branchburg, New Jersey.

During the last five years, we have been targeting the development of a reactor design with 50 percent higher gas efficiency than traditional MOCVDs that also reduces the need for cleaning and maintenance. We have made great progress, moving quickly from a small-scale, proof-of-concept prototype, to a number of custom systems, and finally on to the release of the first of a family of production-scale MOCVD reactors.

Although the initial focus of this work has been on gas efficiency, the novel reactor design has additional benefits. Its small chamber volume allows fast gas switching while its low thermal mass enables fast temperature ramping. In combination, these attributes lead to a very fast multi-quantum well (MQW) growth cycle time. This not only shortens the overall growth time, with the benefit of higher productivity, but also leads to QW structures with improved interface properties and higher internal quantum efficiencies. This means that LED manufacturers investing in our tool could see a reduction in overall manufacturing cost per device, as well as an increase in lumens-per-watt.

### Reactor design

Our reactor, which is capable of processing more than 50 2-inch wafers in a single run, is markedly different from the two 'widely available' designs on the market. These incumbents use either a

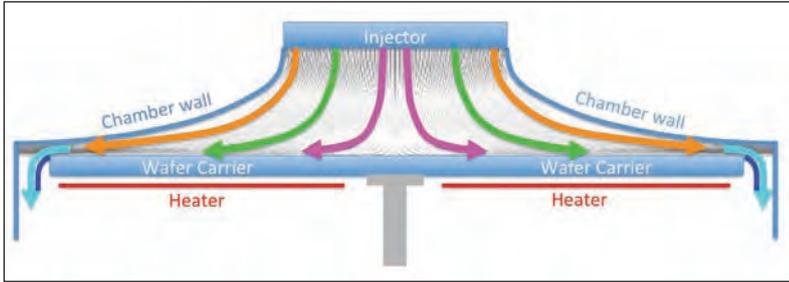


Figure 1. The chamber has flared profile, which alters the direction of gas flow

radial-horizontal or a vertical gas flow. If the former is employed, wafers are mounted on a rotating device to address the radial depletion of reactants. With the latter design, having an injector diameter the same as the wafer carrier, much of the gas is wasted as it flows over the fluid boundary layer above the wafer carrier and out of the exhaust.

In contrast, our design, US patent application 12/248,167, has a relatively small, multi-port injector mounted in a chamber with a curved top wall that flares out to the full diameter of the wafer carrier – more than 500 mm (see Figure 1). We adopted this design concept based on three observations. Our first of these was that many vertical-flow type reactors require high gas flows to suppress the rotation-induced recirculation zone that tends to form at the outer edge of a rapidly rotating wafer carrier. Much of this gas flows straight to the exhaust.

Our second observation was that gas arriving at the centre of the wafer carrier must migrate outward over the wafer carrier to reach the exhaust – because it can't flow through it! So substrates towards the edge of the wafer carrier are shielded by this gas from fresh gas delivered vertically downward from outer areas of the

The VPE GaN-500 that was released in summer 2013 can accommodate 52 2-inch wafers



injector. So there is a limited utility in delivering more reactant gases at the outer areas of a full-sized injector.

The third observation was that it is quite difficult to uniformly distribute gas flows from relatively small supply tubes through a very large diameter injector. But it is of extreme importance to achieve a flow front of highly-uniform velocity as the gases exit the injection surface. If there are velocity variations across the surface of the injector – as often occurs when flows from the tubes locally ‘punch-through’ areas of the injector – recirculation eddies form, compromising the laminar velocity profile of the reactor. This limits the ability to control the thickness uniformity over the wafer carrier, causes deposition of reaction by-products on the injection surface, and allows reaction by-products to incorporate into the growing layer.

We realized that these challenges could be addressed by using a small-diameter injector in combination with a curved reactor top-wall that eliminated the inefficient volume of a traditional cylindrical chamber. This design takes advantage of the natural tendency of the gas to expand as it flows down and outward over the wafer carrier. Our approach, then, was to develop a highly-symmetric, laminar reactor flow profile that allows reactants, injected through a smaller diameter injector, to reach the outer areas of the wafer carrier. The curved wall profile forces those gases into close proximity to the wafer carrier in order to squeeze out as much of the reactants as possible before they are ‘lost’ into the exhaust.

The result was a unique flared reactor design. Gas enters the chamber vertically, then, guided by the curved walls and rotating wafer carrier below it, becomes increasingly diverted in a more horizontal direction as it approaches the wafer carrier. As the gas progresses through the chamber, the curved top wall forces the gas closer to the wafer carrier. Fluid dynamics modelling results revealed that as the top, curved wall of the chamber approaches the horizontal surface of the wafer carrier, the convergence of the flow path-lines, combined with the increase of the tangential velocity of the wafer carrier with radius, produces differences in the radial and tangential velocity components of the gas when compared to a standard vertical reactor.

These differences indicate that a particular gas molecule will spend a greater amount of time in the reaction zone, allowing a higher proportion of material to be used for epitaxial growth. In addition, the profiled chamber dramatically reduces the proportion of gas flowing straight from the injector to the exhaust without interacting with the wafers.

A key decision for any designer of MOCVD tools is how to introduce the group III alkyl and group V hydride gas streams into the reactor. In our

system, these gas mixtures are kept separated until they enter the chamber through a multi-zone, multi-port injector array with a diameter considerably less than that of the wafer carrier. The gas streams enter separate chambers, and while confined there, are laterally diffused.

Gases then pass through an array of micro-tubes, where the temperature is stabilized, before entering the main volume of the reactor chamber. The multi-zone injection design allows the delivery of reactants to be adjusted proportionally to the surface area of the wafer carrier, offsetting the radial depletion that is characteristic of horizontal-flow reactors. This enables excellent uniformity, all the way to the outer edge of the wafer carrier.

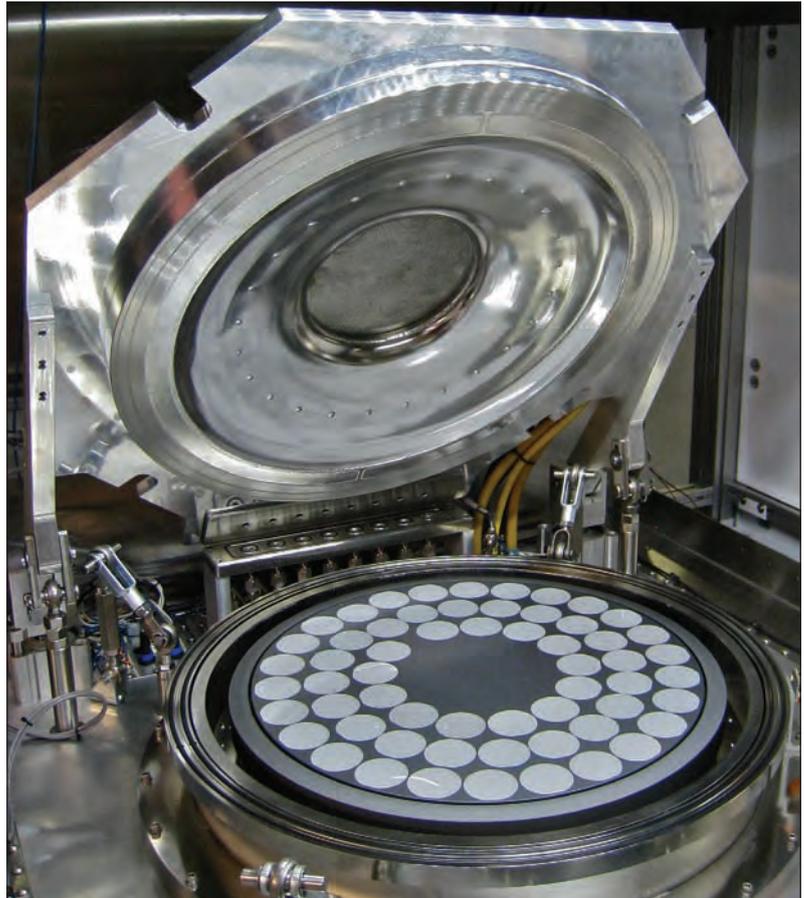
The carrier is heated with a three-zone, radiant heating system that achieves temperatures above 1200 °C. The walls of the chamber are lined with a thin exterior layer, with a fluid gap immediately behind. Through appropriate choice of heat transfer fluid, it is possible to control the temperature of the walls and injector over a wide range. One of the attractive features of our MOCVD reactor is that virtually no reaction products are deposited on the injector – so regularly scheduled cleaning is not needed. This is possible because the wafer carrier is located far enough away from the injector array to prevent the deposition of reaction products on the injector.

The chamber lid is a top-loading, clamshell design, allowing easy access for loading and unloading of the wafer carrier and routine maintenance. Perhaps more importantly, the top-loading design minimises the internal volume of the chamber and maintains the chamber symmetry. This attribute, which is not present in systems that use a gate valve for wafer carrier transfer, helps realise a fully-symmetric flow field and abrupt switching of gases between layers.

### Proven capability

Our current version, the GaN-500 MOCVD reactor, released in summer 2013, accommodates 52 2-inch wafers in three concentric rings, and is easily expanded to 59 wafers with no significant design changes. This tool's high degree of capability is revealed by photoluminescence mapping of a typical LED structure, which we have grown using a gas flow rate of around 120 standard litres per minute – some 40 percent lower than normal flow rates in 'widely available' MOCVD reactors of comparable capacity. The chosen structure comprises 4 µm of GaN, a 20-period strain-relieving superlattice and an eight-period multi-quantum well, capped by a standard p-type GaN layer.

This heterostructure, which was formed using a GaN growth rate of 5 µm/hr, has an average peak wavelength of 460 nm (see Figure 2). The full-platter standard deviation ( $1\sigma$ ) is less than 1.8



nm, and the difference between the maximum and minimum values of the average wavelength emitted by the wafers is less than 4 nm. Within wafer uniformity is also excellent: Standard deviations are less than 1 nm, with many wafers showing less than 0.5 nm (see for example, Figure 3, which shows a photoluminescence map of a representative middle-ring wafer with a uniformity, in terms of  $1\sigma$ , of 0.417 nm).

We attribute these excellent values of uniformity to: good macroscopic temperature and gas composition uniformity across the whole wafer carrier; excellent strain compensation at the multi-quantum well growth temperature, which ensures that the wafer lies in good thermal contact

The VPE GaN-500 features a novel injector/chamber assembly. One can see the profiled wall and the multi-port injector

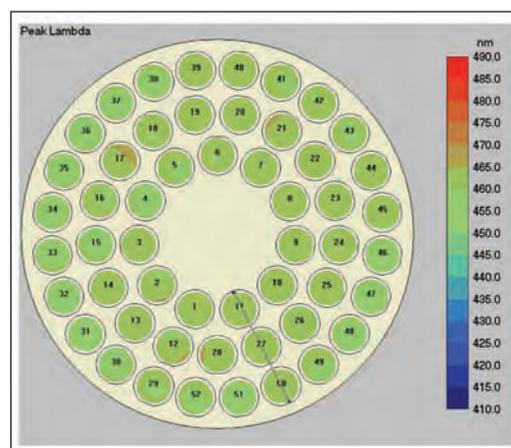
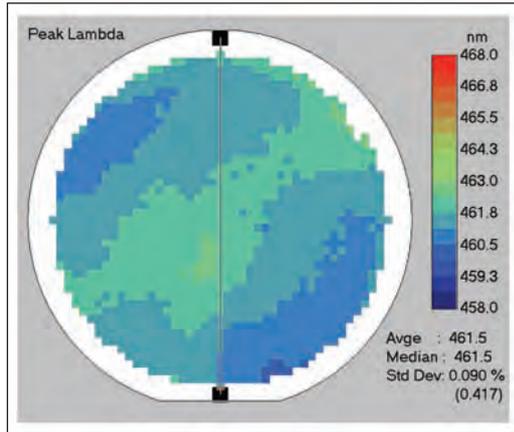


Figure 2. A high degree of wafer-to-wafer photoluminescence uniformity is possible with the VPE GaN-500

Figure 3. Uniformity across the wafer, evaluated in terms of the standard deviation, can be less than 0.5 nm. This wafer is numbered 14 in Figure 2

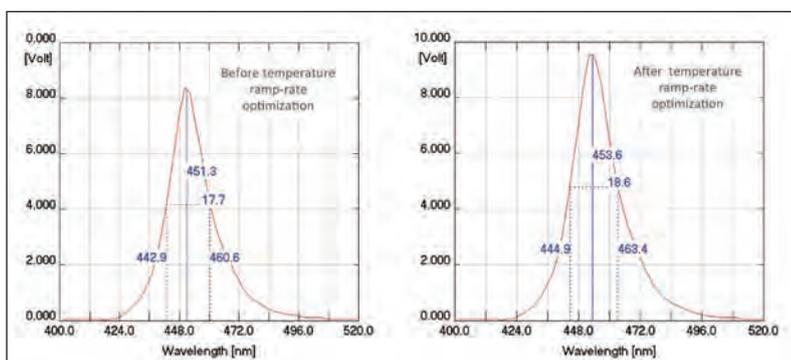


with the pocket; and good work practice to ensure particle free placement of the wafer in the pocket. Characterisation of LED epiwafers has not been limited to photoluminescence studies. We have also investigated the thickness uniformity, crystalline quality and electrical properties of other key layers, such as the *n*-type GaN, *p*-type AlGaIn and *p*-type GaN layers, wherein material quality is very high, validating the high level of capability associated with the reactor design.

### Influencing material quality with reactor design

Although excellent wavelength uniformity is an essential attribute of any production-worthy MOCVD reactor, the factors that contribute to good uniformity don't necessarily guarantee a brighter LED. There are many factors that influence the quantum efficiency of this device. Basic quality of the epitaxial material, dislocation density and background contamination levels are obvious examples. The quality of the MQW interfaces is also a major contributor. In a typical MQW LED the InGaIn active layers must be grown at a precise temperature while the GaN barrier layers are grown at a temperature that may be over 100 °C higher. To obtain atomically sharp interfaces with an absolute minimum of inter-diffusion or contamination between the layers demands gas switching that is rapid and abrupt; fast temperature ramping and stabilization and, when the growth temperature is reached, rock-solid stability. Our reactor, thanks to its novel design, excels in all these areas. The small injector in combination with the curved wall profile reduces

Figure 5. The left and right plots show photoluminescence intensity before and after improved temperature ramping and stability during quantum well growth. These improvements can lead to better interface quality



the volume of gas within the reaction chamber compared with a conventional, barrel-type chamber with a full-platter injector. Consequently, residual gas is swept out of the system very quickly.

The thermal response is also very rapid, thanks to an over-powered heater and a very light wafer carrier. Thermal reflectors, built into the flow guide surrounding the wafer carrier, maximise the efficiency of the heater while also shielding exhaust gases from being directly exposed to the heating elements. The end result is a system that is capable of very rapid gas switching, very rapid thermal ramping and very rapid temperature stabilisation – leading to sharp and clean interfaces and uniform indium concentration within the QWs. Both these effects can be observed in the detail of high-quality triple-axis X-ray diffraction data (see Figure 4). The intensity and widths of the higher-order satellite peaks are influenced by the 'sharpness' of the QW structure. Fast thermal cycling and stabilization also has a throughput benefit. For an eight-period MQW, total growth time can be reduced by as much as 40 minutes.

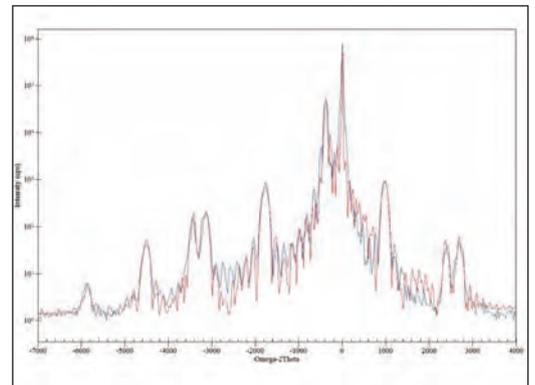


Figure 4. Triple axis X-ray diffraction data and simulation from an eight period MQW structure with 20-period strain-relieving superlattice. Note the narrow and symmetrically shaped superlattice peaks and how well they match the simulated data

But the biggest benefit is the effect on photoluminescence or electroluminescence intensity. After optimisation of the MQW growth temperature control and cycle time, we have seen up to 20 percent higher intensities from identical structures grown under otherwise identical conditions (see Figure 5).

This gain in emitted intensity, along with a faster growth time that contributes to a higher throughput and up to a 40 percent reduction in gas and alkyl consumption, demonstrates that our reactor may be ideal for LED manufacturing. In short, we believe that chipmakers armed with this tool can build LEDs cheaper and brighter.

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Handset front-ends are becoming more complex, due to an ever-increasing number of bands used for mobile communication. Will this trend play into the hands of GaAs chipmakers? Or is silicon CMOS technology going to grab market share?

**Keynote presentation: Jeremy Hendy**

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### 2. Wide Bandgap RF Devices

GaN and SiC have a great set of attributes that make them very promising materials for producing RF devices. But are they now fulfilling their potential and netting substantial sales?

**Keynote Presentation: Andrew Barnes**

Overview of GaN reliability improvement activities at the European Space Agency

esa



### 3. LEDs

LEDs are the dominant source for backlighting screens of all size. So, to penetrate new markets and grow revenues, can chipmakers now trim the cost-per-lumen of the LED or equip the device with additional features?

**Keynote Presentation: Young Soo Park**

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\* All speakers and presentations are subject to change.

## 4. Solar

Triple-junction solar cell efficiencies are increasing steadily. Will this help to spur rapid growth in the concentrating photovoltaic sector, or will it be more valued by those requiring a power source for satellites?

**Keynote Presentation: Vijit Sabnis**

Setting a new benchmark for space solar cell performance



## 5. Laser and PICs

Rocketing levels of internet traffic are putting greater and greater strain on optical networks and data centres. Can this be addressed by advancing the performance of conventional lasers, or does the market need to turn to greater use of PICs?

**Keynote Presentation: Michael Lebby**

OEICs for 100G and beyond datacentre opportunity using indium phosphide



## 6. Power Electronics

Silicon has dominated the power electronic market, wide bandgap semiconductors will soon replace this material. What's the primary role for SiC, and where will GaN feature?

**Keynote Presentation: Ming Su (Ford - Right)**

Can GaN or SiC make an impact in electric vehicles?

**Keynote Presentation: Mike Briere (International Rectifier - far right)**

Revolutionary performance and commercialization of GaN-on-Si based power devices



## 7. Integration of CMOS and III-Vs

Silicon is running out of steam, and the future is widely tipped to be high-mobility channels made from germanium and III-Vs. But how will these materials be introduced in the world's leading silicon foundries?

**Keynote Presentation: Dr Jean Fompeyrine**

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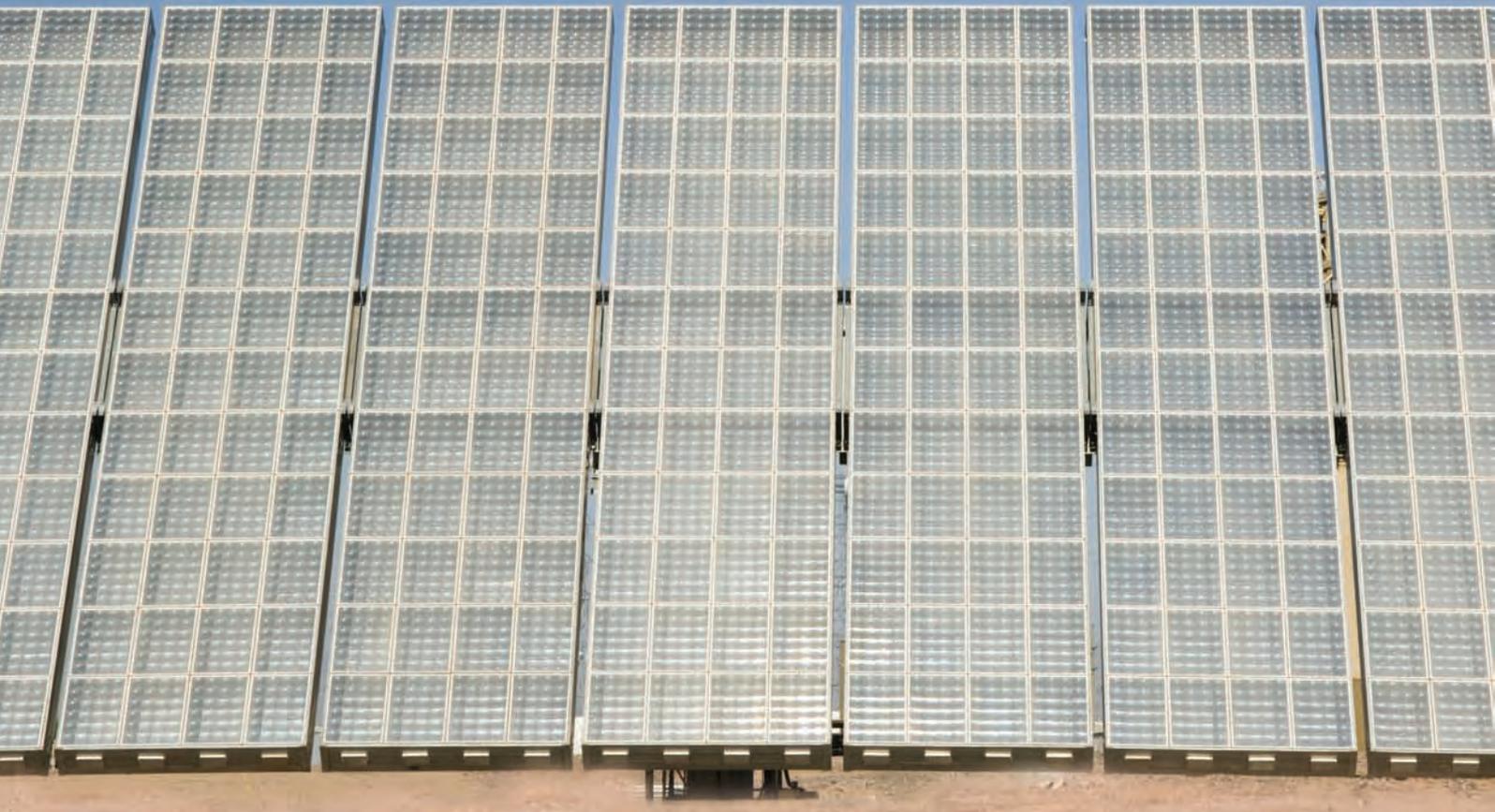
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# CS INTERNATIONAL CONFERENCE

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# Boosting triple-junction yield with *in-situ* monitoring

*In-situ* monitoring provides a great deal of valuable information for developers and producers of multi-junction solar cells. It can determine interface quality; the thickness, doping level and composition of every layer; and wafer bow, says Oliver Schulz from LayTec.



CHIPMAKERS STRIVE FOR PERFECTION, and that includes trying to produce in-spec devices from everywhere on every epiwafer. This equates to a 100 percent yield target across every wafer in every run, regardless of the material backbone of the product.

To succeed, all the layers within the device have to have a high degree of homogeneity in terms of layer thickness, ternary or quaternary composition, doping, and interface and surface morphology. In the last ten years, variations in these parameters have reduced significantly, thanks to widespread adoption of *in-situ* metrology – measurements of surface temperature, in particular have spurred epiwafer uniformity to a new level.

At LayTec of Berlin, Germany, we have been a major player in this revolution in *in-situ* monitoring through our sales of tools for aiding the growth of epiwafers. Many of these have been used to monitor the deposition of stacks of nitride films, which form the foundation for white and blue LEDs. Sales of these solid-state emitters are booming, leading many to overlook advances in the production of conventional III-V chips. Nevertheless, *in-situ* monitoring has achieved tremendous success in the production and development of such devices, including: InP- and GaAs-based RF electronics, such as HEMTs and HBTs; optoelectronic components, such as laser diodes, VCSELs, photo receivers, semiconductor optical amplifiers and modulators; and concentrating photovoltaic (CPV) cells.

**In the lab**

The latter class of chip is being grown at Ioffe Physical Technical Institute in St. Petersburg, Russia, using a reactor equipped with an EpiRAS TT system. This monitors the growth of these multi-junction heterostructures, which are based on III-Vs and germanium. At Ioffe, small chips are mounted into photovoltaic modules that focus the sunlight onto cells with Fresnel lenses.

One major challenge associated with the production of triple-junction cells is the deposition of a low-defect III-V heterostructure on a covalent, group IV germanium substrate. This goal is easier to fulfil using an EpiRAS TT: It helps to avoid the formation of anti-phase boundaries at the interface between the III-Vs and germanium; it can determine composition and growth rate via wide-range spectral reflection measurements; it can reveal doping levels, using reflectance anisotropy data; and it can offer an accurate measurement of wafer temperature, through emissivity-corrected pyrometry.

Researchers at Ioffe have used the reflectance transient at 2.1 eV for growth rate measurements during deposition of the triple-junction heterostructure (Figure 1a, red). It is possible to extract more information from this data, with

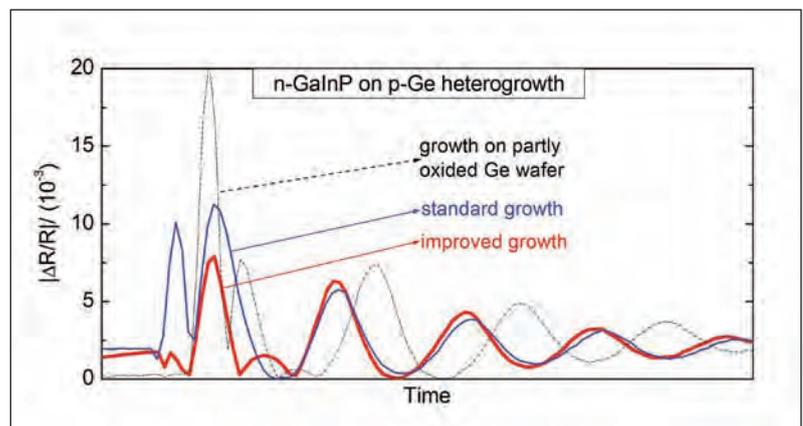
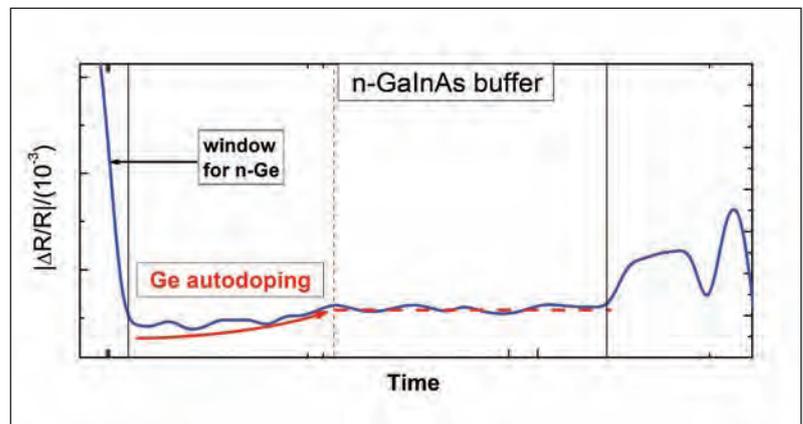
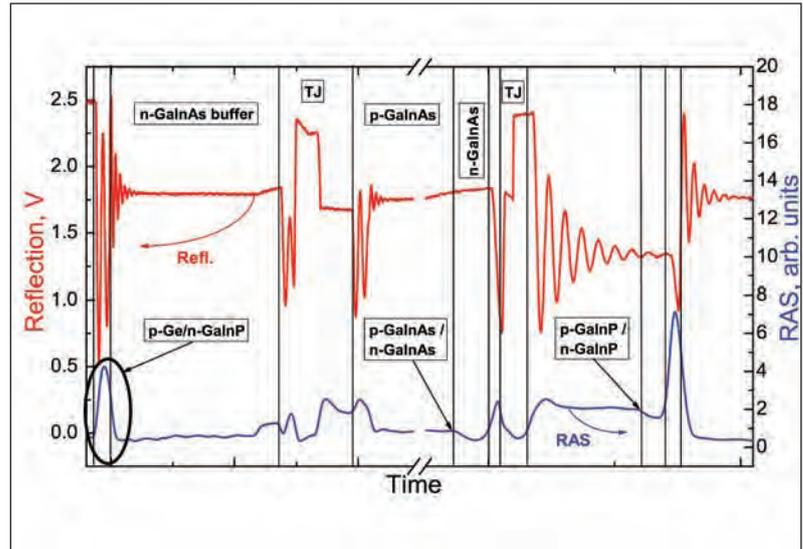
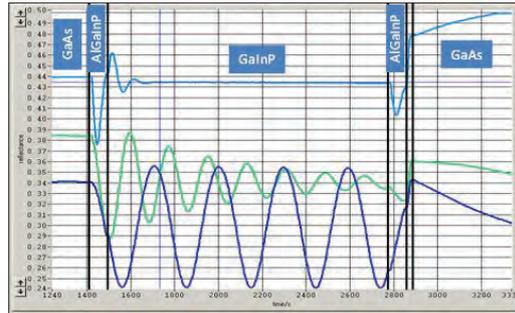


Figure 1. Complete growth of a triple-junction GaInP/GaInAs/germanium solar cell structure monitored by EpiRAS TT at Ioffe PTI. Figure 1a: red - reflectance transient at 2.1 eV, blue – reflectance anisotropy measurement at 3.8 eV. The reflectance signal is used for growth rate and ternary composition determination. Figure 1b: *n*-type GaInAs buffer growth: blue – reflectance anisotropy signal at 3.8 eV helps estimate the doping concentration during growth. Figure 1c: *n*-type GaInP on *p*-type germanium hetero-growth. Reflectance anisotropy signal at 3.8 eV: blue –standard growth, red – improved growth. The quality of the interface can be determined during growth.

Figure 2. Reflectance measurement of a multi-junction solar cell at three wavelengths: 950 nm, 633 nm and 450 nm (courtesy of Fraunhofer ISE Freiburg, Germany)



the amplitude of the Fabry-Pérot oscillations providing information on the refractive index, a material parameter that directly correlates to the composition of the ternary alloys. With the help of the EpiRAS software database and appropriate fitting algorithms, it is even possible to determine the composition of very thin layers – such as the tunnel junction – in real time.

Meanwhile, short-wavelength reflectance anisotropy can determine doping levels. At Ioffe, researchers correlated the reflectance anisotropy signal at 3.8 eV with doping measured *ex-situ*, to establish their own process control database (see Figure 1a, blue trace; and Figure 1b). Armed with this information, it is possible to estimate changes in doping at homo-interfaces during epiwafer growth.

Analysing the reflectance anisotropy signal during the growth of the first III-V monolayers on germanium provides a wonderful insight into the quality of this epilayer. If the reflectance anisotropy signal is high, this interface is rough and germanium auto-doping can arise (this occurs when dopant atoms evaporate from a germanium

substrate to the surface during high temperature treatments, and are then reintroduced into the epiwafer, causing undesired variations in dopant concentration at its surface). It is possible to avoid auto-doping by optimising the growth conditions, a step taken by the researchers at Ioffe. Thanks to insights offered by the reflectance anisotropy signal, this team quickly established a growth recipe for realising high-quality window layers and GaInP buffer layers on germanium substrates (see Figure 1c – red).

**In the fab**

In-depth analysis of *in-situ* data is a major aid to a research and development project, but in a high volume fab there is not the time to do this (it also requires expertise that takes time for the operator to acquire). In that environment, what is needed is a more robust analysis of the growth, combined with real-time statistical process control.

Our EpiTT and EpiCurveTT product families, working in unison with the EpiGuard software package, meet this need. These *in-situ* systems offer a comprehensive, robust monitoring of growth parameters. Measuring the wafer's temperature with emissivity corrected pyrometry is incredibly insightful, because it is this temperature that governs crystalline quality, composition and doping level. This temperature can be determined on various substrates, including those made from III-Vs, silicon and germanium. For the growth of high-quality epiwafers for efficient triple-junction cells, it is critical to deposit the optimal thickness for every layer. Multi-wavelength reflectance measurements can help (see Figure 2, which shows a screenshot of simultaneous reflectance

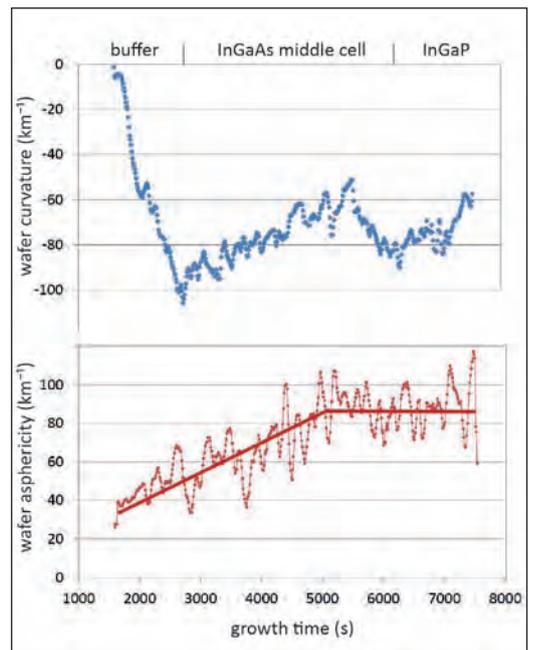
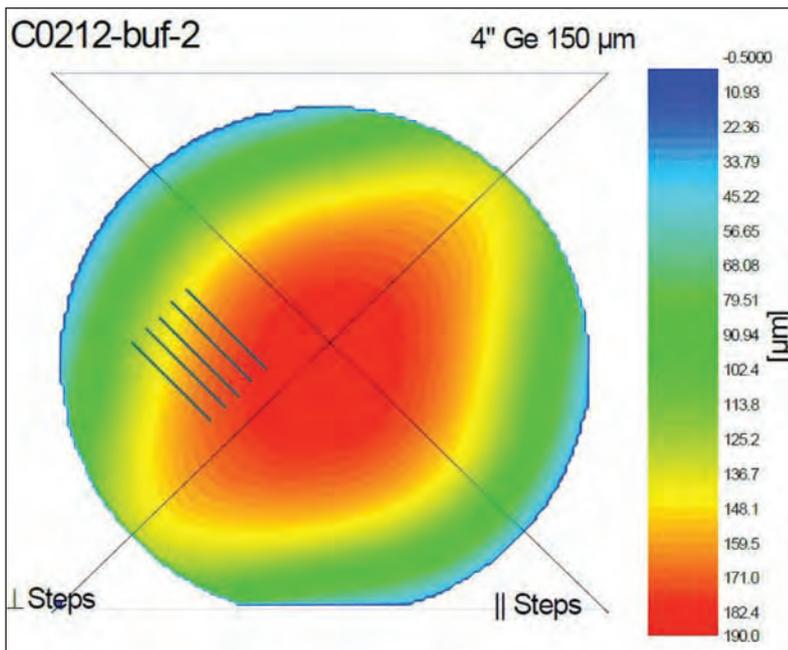


Figure 3 (a, left) Bow profile (*ex-situ*): aspherical bow perpendicular to the step edges of the off-cut germanium substrate. (b, top right) *in-situ* wafer curvature measurements: strained InGaAs middle cell compensates for metamorphic buffer bow. (c, bottom right) wafer asphericity measurements by advanced resolution *in-situ* curvature measurements: asphericity starts with first pseudomorphic buffer relaxation

measurement at 405 nm, 633 nm and 950 nm). Since the frequency of the Fabry-Pérot oscillations decreases with increasing wavelength, the 950 nm measurement is most appropriate for thick layers deposited with a high growth rate. Meanwhile, the signal generated by reflectance from the 633 nm source is more suitable for scrutinising thinner layers. 405 nm emission is absorbed in III-V materials, making this reflectance measurement highly surface sensitive. It offers insights into surface morphology and interface quality, and can determine tunnel junction thickness.

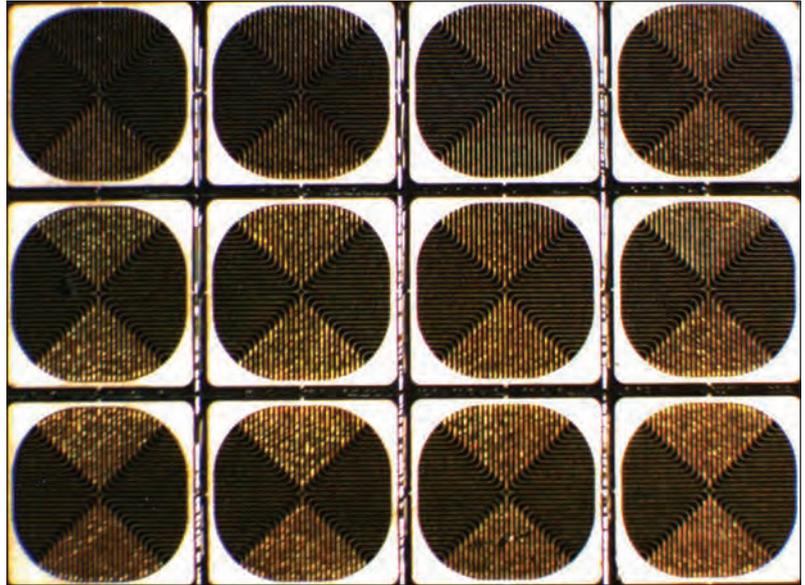
### Keeping it flat

If a fab is to have a high yield, it must produce wafers with minimal bow, both during and after growth. Historically, curvature measurements have focused on nitride films grown on foreign substrates, due to the high degree of strain in these materials – meanwhile, measurements on lattice-matched III-Vs have been neglected. But even with the latter material system, wafer bow and warp can occur during cooling, due to differences in the thermal mismatch of the substrate and the deposited layers. And when it comes to triple-junction structures, strain engineering becomes essential, due to the growth of pseudomorphic and metamorphic structures.

At Fraunhofer Institute for Solar Energy Systems, scientists employ the EpiCurve TT in the production of multi-junction solar cells, where it is used for managing the strain and optimising the process. The wafer bows significantly when intentionally lattice-mismatched III-V layers are deposited on germanium, and its curvature is strongly aspheric after intentional buffer relaxation for metamorphic growth (see Figure 3 a). With LayTec's advanced resolution curvature technology, it is possible to distinguish between spherical curvature and asphericity (Figures 3b and 3c). The resulting signal helps a process engineer to optimise the growth of the buffer and its relaxation at early, decisive stages of the epitaxial process.

Researchers are striving to increase the efficiency of multi-junction cells, because this should make CPV technology more competitive. New designs are being pursued, which are often more complex than their predecessors, due to the addition of a fourth junction or the use of an inverted architecture. We can help these ambitious efforts – we can provide the tools for *in-situ* monitoring, and thanks to our close collaboration with leading researchers in academia, we can offer advice to industry customers from our resulting extensive know-how in analysing and understanding *in-situ* data associated with epitaxial processes. Our hope is that we will play a key role in driving up the yield and quality of multi-junction solar cells, and ultimately the rapid growth of this industry.

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At Ioffe Physical Technical Institute, researchers produce multi-junction solar cells using an Aixtron MOCVD tool equipped with a LayTec's EpiRAS TT system. These cells have been deployed in a concentrating photovoltaic system

#### Further reading

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# Water-based strippers tread lightly on the environment

A novel, water-based stripper offers a fast, environmentally friendly approach to high quality removal of photoresist and the carrying out of metal lift-off, claims Dirk Schumann from Bubbles & Beyond.

ALTHOUGH LASERS, LEDs and transistors are significantly different species, their manufacture involves many similar processing steps. This includes the coating of surfaces with photoresists, which can be subsequently stripped or used as the foundation for a metal lift-off process.

One metric for judging how good these resists are is the ease with which they can be removed after certain processing steps. Why is that important? Because the resist can change during subsequent processing – for example, thermally activated cross-linking may take place, making the subsequent stripping step more complex.

Another factor that can complicate resist removal is metal layer deposition. Subsequent processing must not damage this layer, ruling out the use of materials with aggressive stripping chemistry. And complicating matters further, microelectronic structures are getting increasingly complex: Their fabrication demands the use of fluids that remove resists out of grooves or bridge patterns that cannot be directly accessed from the top of the structure.

On top of this list of device-related concerns, engineers must take into account the impact of the stripper on the environment, and whether it complies with an increasingly strict set of regulations. Most state-of-the-art resist removals use solvents, such as N-methyl-2-pyrrolidone (NMP), D-methyl sulfoxide (DMSO) and acetone; or even more aggressive mixtures based on ammonium hydroxide/hydrogen peroxide (SC1) or the harmful Piranha Clean. Plasma ash processes are also widely used in industry, and involve etching with gases.

## Going green

At Bubbles and Beyond, a start-up from Leipzig, Germany, we are addressing the need for environmentally friendly, effective stripping chemicals with our development of novel, water-based stripping fluids, which we refer to as phase fluids. They work in a neutral pH range, are biodegradable, do not contain aggressive ingredients, have a high water share and are free from N-Methyl-2-pyrrolidone (NMP), which is a reproductive toxicant.



Working in partnership with the Fraunhofer Center Nanoelectronic Technologies in Dresden, Germany, we have benchmarked the performance of our phase fluids – that have the commercial name lisoPUR – against a conventional photoresist alkaline stripping agent. These tests, involving the removal of photoresists from silicon or glass substrates, reveal that our phase fluid has a high degree of cleaning efficiency and does not cause significant contamination. Thanks to these strengths, our novel fluid is suitable for use in the compound semiconductor industry.

Our strippers are liquid-liquid-based complex fluids, which form dynamic structures and are an enhanced micro emulsion. They differ from classical emulsions, which feature dispersed spherical oil or water droplets, and are built up from dynamic and flexible plasmicells – these are globular shapes of fluid, shown in Figure 1.

These plasmicells interact with each other, often changing their forms within milliseconds. This leads to the creation of a highly dynamic,

molecular super-structure with a fractal dimension that alters shape between 1,000 and 8,000 times every second. Thanks to this behaviour, phase fluids exhibit a highly effective mode of action: They penetrate layers through the smallest openings to lift off material from the surface (see Figure 2). Initially, the fluids start to penetrate into the photoresist. Then, thanks to low surface tension, they start to creep the varnish and fragment the resists, before lifting off these fragments. It is then possible to remove all residues from the surface with a water rinse.

### Addressing contamination concerns

With any new form of stripping chemistry, there are concerns over contamination. To alleviate these fears we have carried out investigations using Fourier transform infrared spectroscopy. In addition, we have developed an adequate rinse and drying process after the phase fluid cleaning step. With this procedure, the resulting interface is suitable for subsequent standard cleaning sequences. Our rinse-off procedure also ensures a low addition of post-stripping defects.

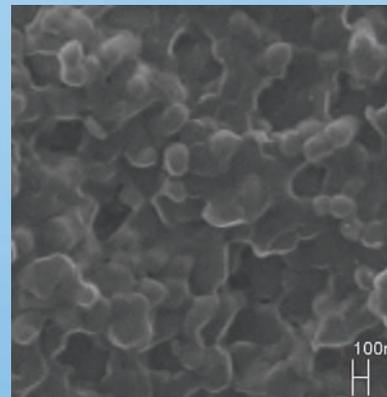


Figure 1: Freeze fracture of a phase fluid makes it easy to identify the globular plasmicells

Figure 2: The working principle of the Bubbles & Beyond phase fluid lisoPUR. The layer (orange) is penetrated, fragmented and finally lifted off from the substrate (red)

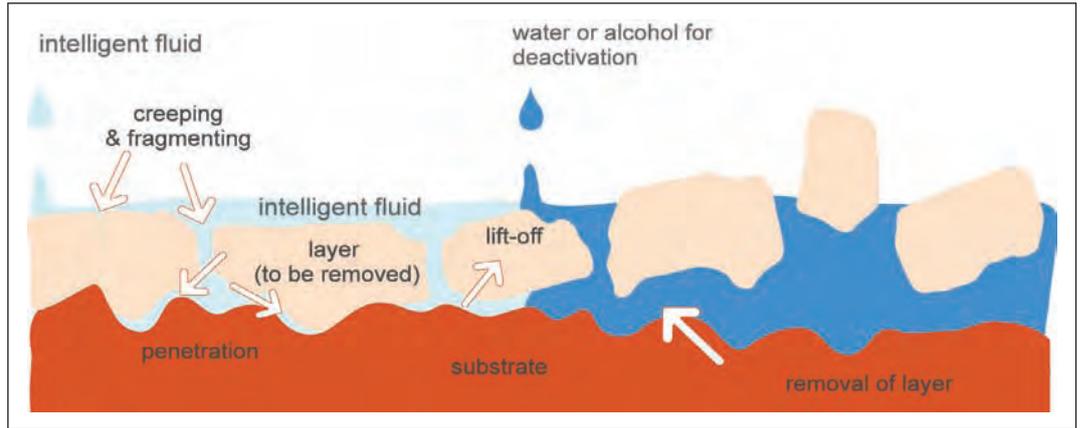
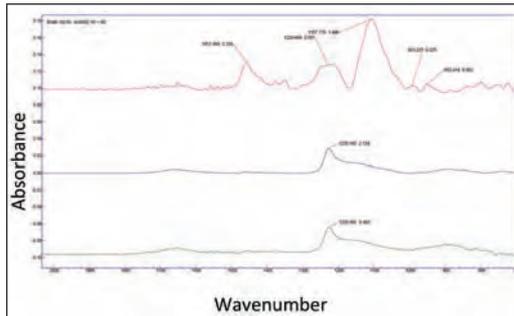


Figure 3: Spectra reveal surface recovery after processing. The upper trace shows the silicon sample prepared with a phase fluid (without rinse), while the middle and lower plots reveal surface recovery after rinse off with deionised water and the spectra for the bare silicon reference, respectively



Scrutinising surfaces with Fourier transform infrared spectroscopy provides evidence of full surface recovery after the application of a phase fluid (see Figure 3). It is clear from these spectra that the fluid leaves no residues after a rinse off with water. Regular cleaning rinses, such as IPA, can also be used. Another characteristic of the phase fluids is revealed by these results: Adding water (or alcohol) to the phase fluid immediately stops its activity.

In addition to this study of molecular surface recovery, we have undertaken a 'high scale' assessment of remaining residues, searching for particles with a KLA-Tencor SP2 tool. This effort commenced by applying a fluid, via a single spin process, to a 300 mm silicon wafer.

Post-cleaning followed, using deionised water, followed by a shorter step with diluted, cold SC1 – a mixture of ammonium hydroxide and hydrogen peroxide. The KLA-Tencor tool, set to detect particles with sizes from 0.12  $\mu\text{m}$  to 1  $\mu\text{m}$ ,

determined that just 38 more defects were found after processing (see Figure 4).

Although these first results are only on the laboratory scale, they are very encouraging, showcasing the promise that phase fluids have throughout the entire semiconductor industry.

By selecting the optimum conditions – such as the right temperature, ultrasonic treatment and drying procedure – it is possible to realise fast stripping of various photoresists, including positive and negative varnishes. For example, these harmless process fluids can remove a photoresist greater than 10  $\mu\text{m}$ -thick in less than 5 minutes to leave a pristine surface.

We can alter the formulation of our phase fluids so that they can be tailored to a particular task. Through our work with the Fraunhofer Center Nanoelectronic Technologies, we have found that cleaning efficiency increases by heating the fluid, and also using steps such as agitation and ultrasonic treatments.

The opportunity to work with a water-based formulation, rather than harmful fluids, has caused quite a stir within the market. Trials have revealed that if our phase fluid is heated to 80°C, metal lift off takes just 10 minutes. To realise full compatibility with a semiconductor environment, the approach involves a deionised rinse process, followed by SC1 cleaning when necessary. Note that phase fluids can be used in either bath or single-wafer processing.

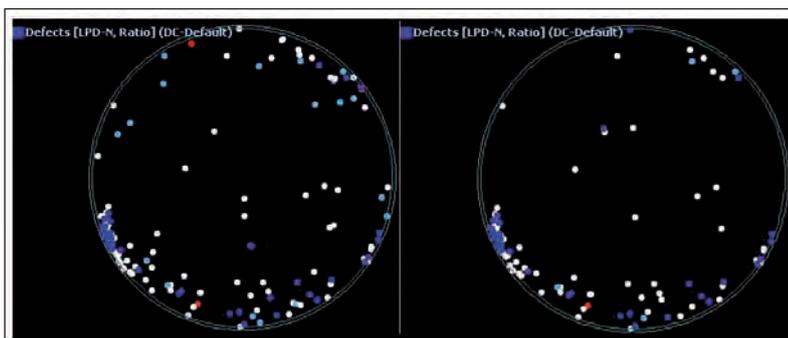
These results highlight the very optimistic outlook for phase fluids. Initially they'll be used for photoresist removal and metal lift-off, but as time goes by, they will start to also make an impact in the cleaning of various pieces of equipment, such as catch cups and photomasks.

## Further reading

[www.intelligent-fluids.de](http://www.intelligent-fluids.de)

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Figure 4: A KLA Tencor tool enables particle measurement on a 300 mm silicon wafer subjected to a single spin process. The scans compare before and after phase fluid application (removal is followed by a deionised water rinse and SC1 short cleaning)





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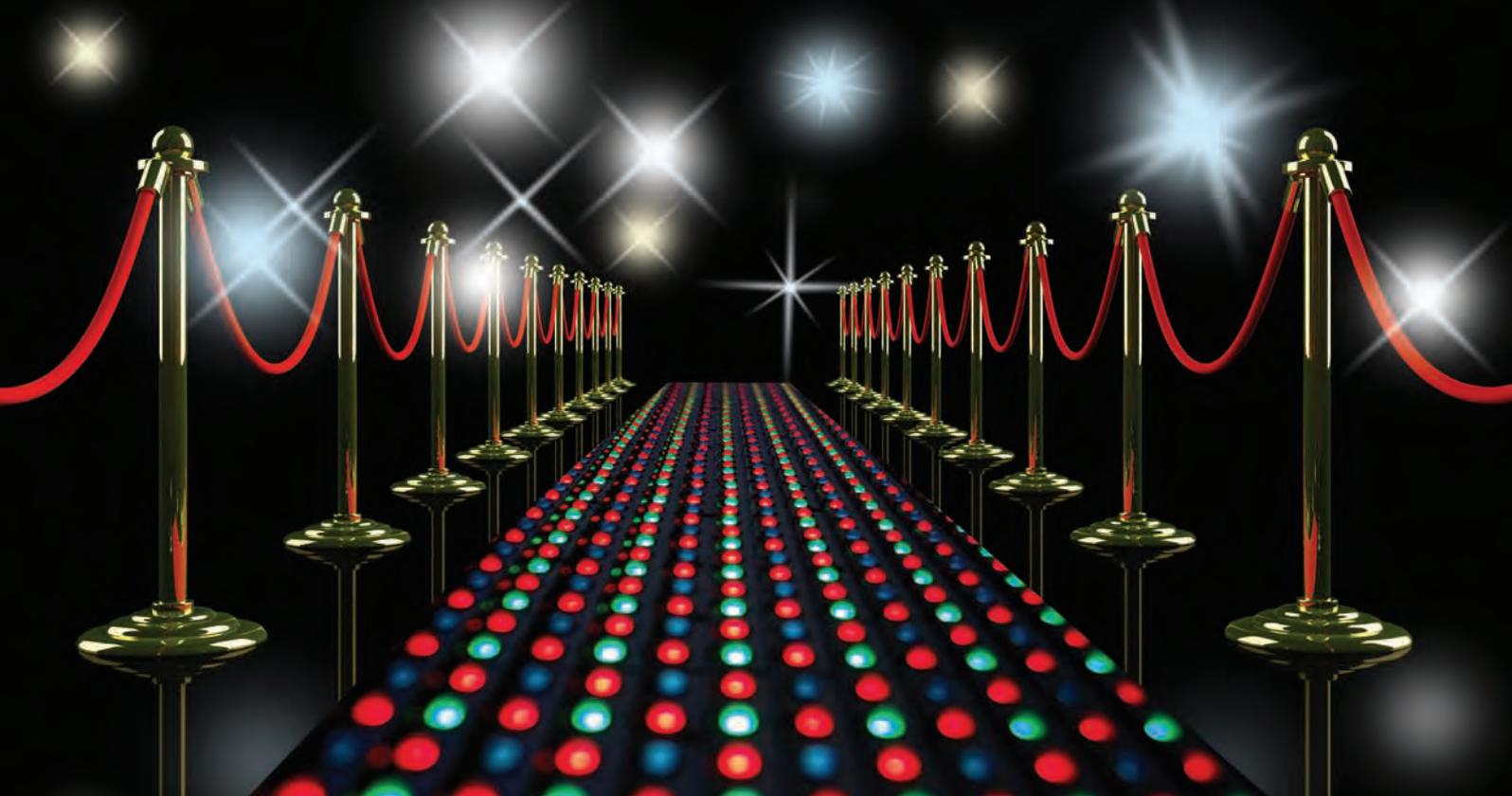
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## An elemental change to laser design

Today's telecom lasers are plagued with Auger-related losses, which drive down efficiency and make device cooling mandatory. The solution: Switch to an active region with alloys featuring a bismuth content of more than 10 percent, claim members of the European team BIANCHO.

THE DAYS WHEN WE COULD only access the internet with a PC are long gone: Most of us now spend more time browsing the web than making a call on our mobile; and if we don't like what's on television, many of us will surf through listings on internet TV.

These activities are placing increasing strain on optical networks and data centres, which have to handle a 60 percent rise in traffic every year. This is good news for telecom component makers, because it creates a market for the sale of lasers operating at higher data rates. But it is not good news for the environment, because it drives up the energy consumption associated with the internet. In Europe, telecommunication and data networks already account for as much as 3 percent of the continent's electricity, and this figure is only going to go up over the next few years.

To try and prevent electrical consumption in these networks from reaching an exorbitant level, our

team is pursuing the development of far more efficient telecom components through a four-year research and development initiative called BIANCHO - Blsmide And Nitride Components for High temperature Operation. This effort, which is supported by the European Union Framework 7 programme and backed by over €2 million of funding, involves five leading European research groups from industry and academia. Our groups have complementary expertise in: epitaxy; fabrication; device physics and modelling; characterization of materials and devices; and commercialisation of semiconductor technologies.

The primary goal of our project is very simple – to provide a substantial improvement in the efficiency of semiconductor lasers and semiconductor optical amplifiers that are deployed in telecommunication and data networks. To achieve this, we are developing a new class of bismuth alloys for use in optoelectronic device. This novel semiconductor suppresses non-radiative Auger

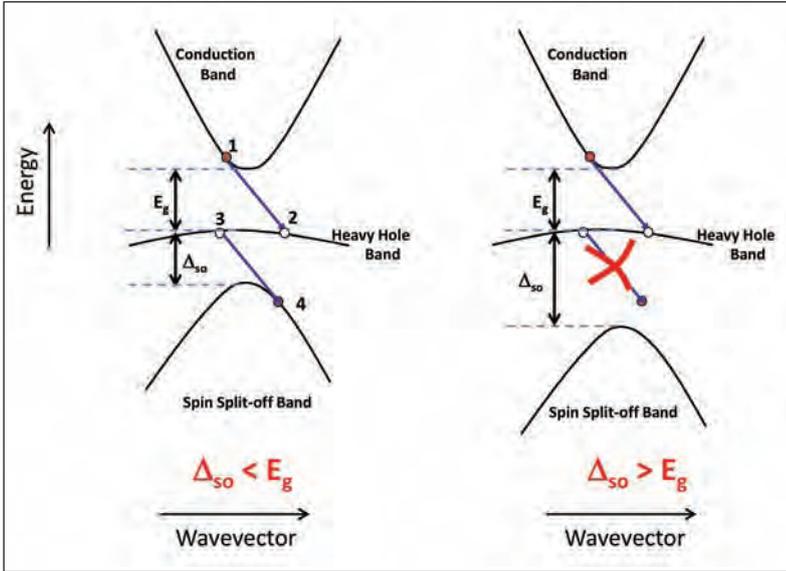


Figure 1: (Left) Auger recombination is the dominant loss mechanism in conventional InP-based lasers. Here a conduction electron (1) recombines with a valence hole (2), with the released energy exciting a valence hole (3) to the spin-split-off band (4) instead of creating a photon. (Right) This Auger loss mechanism can be suppressed when the spin-orbit-splitting energy exceeds the band gap. When this occurs, the Auger recombination process is forbidden, due to conservation of energy, because the energy required to excite a hole to the spin-split-off band exceeds the energy produced by electron-hole recombination

recombination, which dominates conventional telecom lasers and SOAs, wasting about 80 percent of the input electrical power. Thanks to this energy saving, our devices will generate far less heat, and will not require power-hungry thermoelectric coolers for temperature control.

**Addressing Auger**

The energy sapping, Auger loss mechanism that severely degrades the efficiency in today’s InP-based devices stems from the recombination of an electron in the conduction band and a heavy-hole in the valence band (see Figure 1). Instead of interacting to emit a photon, this pair of oppositely charged carriers excites a hole from near the valence band maximum into the spin-split-off band. The hole then relaxes, releasing energy in the form of heat.

Over the years, incremental approaches have been pursued to reduce these Auger-related inefficiencies, but they have failed to address its fundamental cause: It originates from the electronic band structure associated with the constituent materials in the device’s active region. Manipulating the band structure is the only way to tackle this issue head-on – and that is what we are doing by turning to the unique properties of bismuth-containing alloys, which enable the design of Auger-free lasers.

One attractive attribute of bismide alloys is the behaviour of their energy gap: It decreases very rapidly with bismuth composition, allowing growth of telecom lasers on a GaAs substrate. But even more important than that – and the key idea behind the suppression of the dominant Auger loss process – is that GaBi, in contrast to conventional III-V materials emitting in the near-infrared, is predicted to have a very large spin-orbit-splitting energy (see Figures 2 and 3). Its value, which is the difference between the valence band maximum and the lower lying spin-split-off valence band, is of the order of 2.2 eV – large and controllable



Kerstin Volz (left) and Peter Ludewig (right) standing next to the MOCVD tool at Philipps University Marburg, Germany.

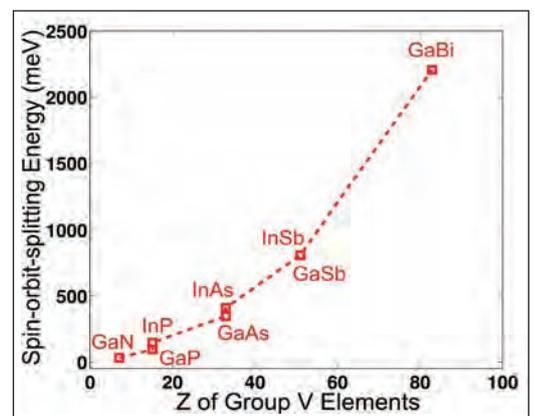


Figure 2: Spin-orbit splitting energy for various III-V materials. The very large value for the spin-orbit-splitting energy  $\Delta_{so}$  for GaBi holds the key to suppressing Auger-related losses in GaBiAs/GaAs-based lasers

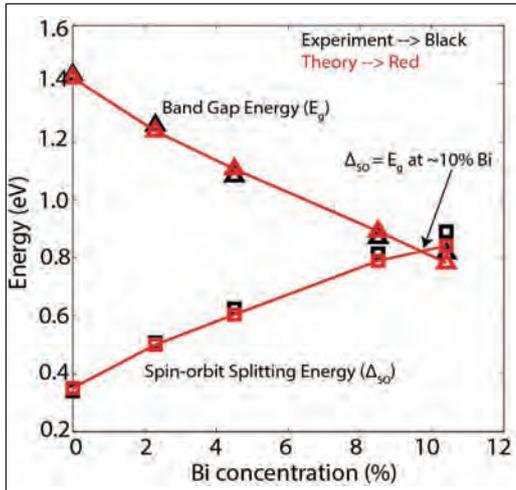


Figure 3: Comparison of the experimental and theoretical values of the energy gap ( $E_g$ ) and spin-orbit-splitting energy ( $\Delta_{SO}$ ) for epitaxially grown  $\text{GaBi}_x\text{As}_{1-x}$  samples on GaAs substrates. Auger losses are suppressed when the bismuth composition is greater than about 10 percent, because at concentrations at this level and higher,  $\Delta_{SO}$  exceeds  $E_g$ .

spin-orbit-splitting energies are also possible with bismide alloys, such as  $\text{GaBiAs}$ ,  $\text{InGaBiAs}$  and  $\text{GaBiInAs}$ . If this spin-orbit-splitting energy exceeds the bandgap energy of the telecom laser, which is typically below 1 eV, the law of conservation of energy dictates that there will be a significant reduction in Auger recombination in this device.

We are aiming to design and fabricate a device that behaves just like this. Our efforts kick-started with a study of the bandstructure of epitaxially grown  $\text{GaBi}_x\text{As}_{1-x}$  samples on a GaAs substrate. Photo-modulated reflectance spectroscopy and atomistic theoretical calculations undertaken by us have revealed that the introduction of bismuth into GaAs has the desired effect on the band structure.

This combined theoretical and experimental effort by our team has garnered three key insights: the band gap energy of the alloy  $\text{GaBi}_x\text{As}_{1-x}$  decreases dramatically with bismuth composition, thereby offering a possibility to achieve 1550 nm emission on a GaAs substrate; spin-orbit-splitting energy increases rapidly with bismuth richness and exceeds the bandgap energy at a content of 9-10 percent; and  $\text{GaBi}_x\text{As}_{1-x}$  has a type-I band offset relative to the GaAs substrate, a condition favourable for realising large optical gain and ultimately an efficient laser.

### Building bismide lasers

Our next step has been to form bismide quantum wells with high optical quality on a GaAs substrate. We have adopted a two-pronged approach, using both MOCVD and MBE to try and obtain high-quality heterostructures. Producing these structures is challenging because the epitaxial growth of metastable  $\text{GaBiAs}$  requires very low

growth temperatures compared with conventional III-Vs. What's more, the photoluminescence signal is always very sensitive to the bismuth content and the growth conditions.

Both growth technologies have produced some noteworthy success. MBE is, to date, capable of alloys with higher bismuth content, while MOCVD has produced epilayers that have been processed to yield the world's first electrically pumped, dilute-bismide laser.

Using MBE, we have grown ternaries with a bismuth content greater than 10 percent. Higher values are possible – Tom Tiedje's group from University of Victoria, Canada, have recently reported values in excess of 20 percent.

Meanwhile, with MOCVD, we have grown a laser structure in a commercially available AIX 200-GFR reactor system, using palladium-purified hydrogen as the carrier gas at a reduced reactor pressure of 50 mbar. For the quantum well growth, triethyl gallium is used as a group III precursor, while tertiarybutyl arsine and trimethyl bismuth are used as the group V precursors, since low growth temperatures (around 400 °C) are required. By

## Efficient terahertz generation using dilute bismide alloys



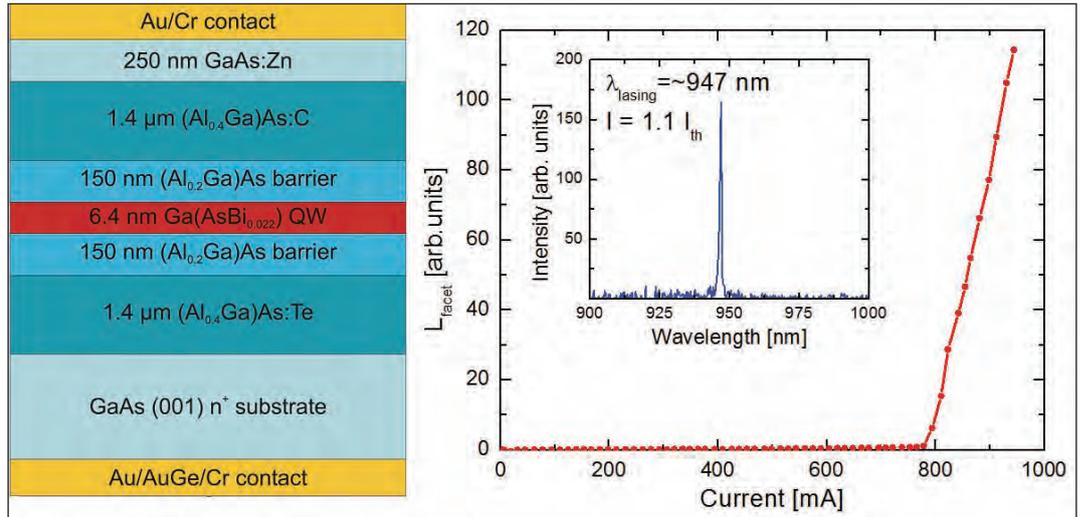
Fibre-coupled photoconductive terahertz detector featuring a  $\text{GaBiAs}$  layer

Dilute bismide layers are not just promising for the fabrication of telecom lasers and modulators – they also offer significant opportunities for the development of low-cost, efficient terahertz technologies. At the Center for Physical Sciences and Technology (FTMC) in Vilnius, Lithuania, Arunas Krotkus' group are exploiting very short photoexcited electron trapping times, which were typical in the first  $\text{GaBiAs}$  epitaxial layers grown with large bismuth content.

The sub-picosecond trapping times in  $\text{GaBiAs}$ , together with the narrow bandgap and relatively high electron mobility, make this material very attractive for manufacturing photoconductive antennas for terahertz emission and detection. Such devices are in demand for spectroscopic, imaging, and security applications. Until recently, terahertz emitters and detectors were mainly manufactured from epitaxial layers of GaAs grown by MBE at low substrate temperatures.

This approach is not ideal, because GaAs is transparent to wavelengths beyond 850 nm, so bulky and expensive femtosecond Ti:sapphire lasers are required for carrier excitation in this class of optoelectronic terahertz radiation system. In contrast, compact fibre or diode lasers emitting in the 1.0-1.5  $\mu\text{m}$  range can activate optoelectronic terahertz emitters and detectors developed at Vilnius. Bismide-based systems have already been commercialized. They are available from TERAVIL, a spin-off company of the FTMC.

Figure 4: (Left) The BIANCHO team have fabricated the world's first electrically pumped bismuth containing laser – an GaBi<sub>0.022</sub>As/AlGaAs single quantum well laser diode. (Right) Light-current relationship for a 50 μm x 1000 μm GaBiAs/AlGaAs single quantum well laser at room temperature. The lasing spectrum is shown in the inset



carefully designing these growth conditions, we have been able to form high-quality GaBiAs single-quantum-well lasers with a bismuth incorporation of 2.2 percent. These devices, measured in 'as-cleaved' form under pulsed operation to minimize heating effects, produce 950 nm emission at room temperature and have a threshold current density of 1560 A cm<sup>-2</sup> (see Figure 4). Our next goal is to systematically increase the bismuth composition in the active region of these lasers, with the aim of achieving 1550 nm lasing while the spin-orbit splitting energy exceeds the bandgap.

Commercialisation of our technology is being driven by CIP Technologies of Martlesham Heath, UK. This company, which is now a part of Huawei, has been developing designs and fabrication processes for making lasers and modulators with these new materials.

**Future targets**

Funding for our project continues to July 2014, and over the coming months we will spend our time focusing on increasing the bismuth content in single- and multi-quantum-well GaBi<sub>x</sub>As<sub>1-x</sub> lasers, until the spin-orbit splitting energy in these devices exceeds the bandgap energy. This should unlock the door to an Auger-free 1550 nm laser. This is our highest priority, because it will enable devices with greatly reduced cooling (and hence energy) requirements and consequently a simpler circuit design. Our epitaxy experts are trying to grow heterostructures by MOCVD and MBE that feature bismide-based wells with a bismuth content in excess of 10 percent, and our team is also pursuing the practical realization of temperature-insensitive, electro-absorption modulators based on the quaternary alloy GaBi<sub>x</sub>N<sub>y</sub>As<sub>1-x-y</sub> and grown on a GaAs substrate.

In addition, we are investigating the growth and characteristics of other bismides. This includes the alloy GaBiNAs, which offers significant scope for tailoring the optical and electronic properties of new devices. Nitrogen and bismuth have opposite effects on material strain, making it possible to grow lattice-matched GaBiNAs layers that combine narrow band gaps with almost independently controllable band offsets and an enhanced spin-orbit splitting. In other words, GaBiNAs has the potential to produce high-efficiency, mid-infrared emitters on GaAs substrates.

One class of device that falls into this category is the mid-infrared VCSEL. This could combine reflective mirrors built from GaAs and AlGaAs, a pair of materials with a significant difference in refractive indices, with an efficient mid-infrared

**The BIANCHO team**

The BIANCHO team, led by Tyndall, is pursuing suppression of Auger recombination with the alloy GaBiAs. This approach was originally presented and patented in 2010 by academic Stephen Sweeney from the University of Surrey. Five institutions are involved in BIANCHO:

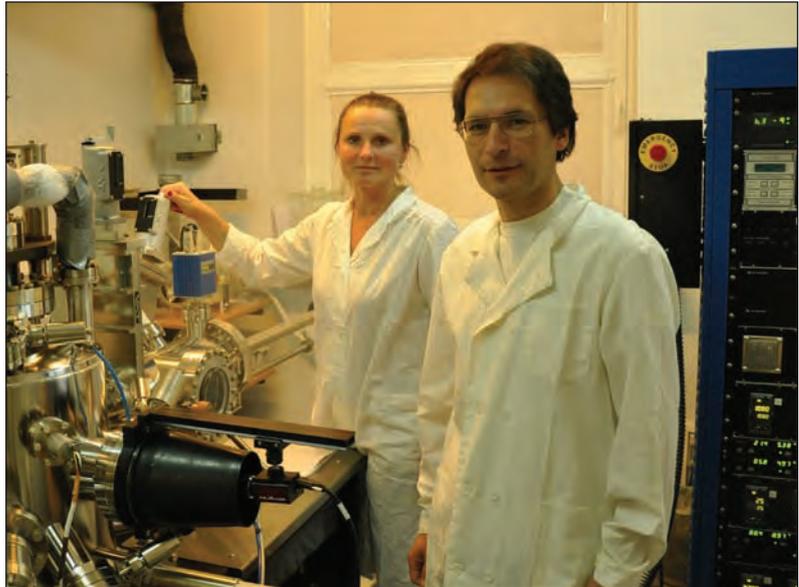
- Researchers at Philipps University Marburg, Germany, (Kerstin Volz, Peter Ludewig and Nikolai Knaub) are performing MOCVD growth and structural characterisation of bismuth-based alloys.
- Scientists at FTMC Lithuania, (Arunas Krotkus, Renata Butkute, and Vaidas Pacebutas), are pursuing MBE growth and characterization of bismide epitaxial layers.
- Researchers at the University of Surrey (Stephen Sweeney, Igor Marko, Shirong Jin, Konstanze Hild and Zahida Batool) have pioneered the concept of bismuth-based alloys for device applications, and combined device modeling with state-of-the-art experimental techniques to determine electronic and optical properties of semiconductor materials and devices.
- Theorists at Tyndall National Institute, Ireland, (Eoin O'Reilly, Muhammad Usman (who led the preparation of this article) and Christopher Broderick) are developing theoretical models to simulate and predict the optoelectronic properties of dilute bismide alloys and devices.
- Engineers at CIP Technologies UK are leading the fabrication work, developing processes for this new material class.

Right: Renata Butkute and Vaidas Pakebutas from the Center for Physical Sciences and Technology (FTMC) in Vilnius, Lithuania, near their MBE reactor

active region. Such a device could be used for low-cost sensors for environmental monitoring and portable medical diagnostic equipment. Other types of device could also benefit from the introduction of alloys containing nitrogen and bismuth. Lattice-matched GaBiNAs layers have the potential to form the 1 eV (and other) junctions for multi-junction solar cells, while lattice-matched GaBiAs/GaNAs superlattices could find application in mid-infrared detectors.

There is also the opportunity for InP substrates to provide the foundation for bismuth-based materials, such as GaBiNAs. With this particular quaternary, a bismuth content of just over 4 percent is required to realise an optimised band structure and allow the construction of high-efficiency lasers beyond 2  $\mu\text{m}$ . Using this material system provides an opportunity for InP foundries to diversify into mid-infrared devices with little or no change in infrastructure, whilst opening up new markets in sensing and defence. The potential for bismuth-containing alloys is enormous, and today we are just skimming the surface.

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# Better electron blocking boosts UV efficiency

Electron-blocking layers formed from AlN and  $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$  improve efficiency by almost an order of magnitude.

A TEAM OF SCIENTISTS from Germany have improved ultraviolet LED efficiency by introducing superior electron-blocking structures into the devices. By replacing the conventional  $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$  electron-blocking layer with the pairing of an AlN layer with a thickness greater than 3 nm and an  $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$  layer, the team has increased the efficiency of its 290 nm LEDs by a factor in excess of eight.

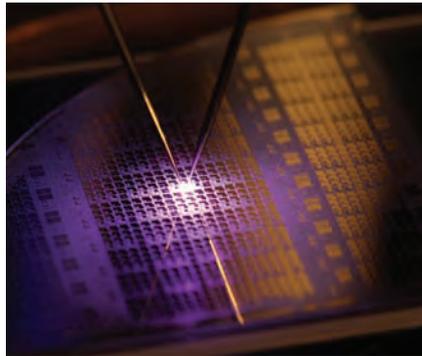
This hike in efficiency will aid the development of brighter ultraviolet LEDs, which are promising sources for water purification, curing and phototherapy. Today, these ultraviolet emitters have an external quantum efficiency of typically just a few percent, due to: poor carrier confinement, which can be addressed with a superior electron-blocking structure; a high defect density; and unsatisfactory carrier injection.

Efforts by the German team – a partnership between researchers at the Technical University of Berlin and the Leibniz Institute for High Frequency Technology – kicked-off with a series of simulations of different LED structures. Their calculations employed a one-dimensional drift-diffusion model.

Team member Micheal Kneissl, who has positions at both universities, admits that it is hard to know how accurate the model is. That's because its accuracy depends on the values that are used for material characteristics, such as effective mass, carrier mobility, band offset and magnesium acceptor ionisation energy.

"In the end, the simulations provide us with guidance for the optimisation of the heterostructure design, which has to be confirmed by experiment." Hindsight, however, shows a strong correlation between the experimental results and the simulations, which offered a great insight in how to improve ultraviolet LED performance.

Experimental work involved the fabrication of two series of structures:



On-wafer measurements reveal that by optimising the electron-blocking layer, ultraviolet LED's external quantum efficiency can hit 0.4 percent, roughly double that of the best devices reported by other groups

The first featured an electron-blocking heterostructure that combined a 4 nm-thick layer of  $\text{Al}_x\text{Ga}_{1-x}\text{N}$  (with values for  $x$  of 0.8, 0.9 and 1.0) and a 25 nm-thick  $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$  layer; and the second featured an AlN/ $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$  electron-blocking heterostructure with AlN layers 0 nm to 8 nm thick.

These electron-blocking regions had a strong influence on the performance of LEDs, which were grown by MOCVD on AlN/sapphire templates, and contained: a short-period superlattice based on the pairing of 130 layers of 0.8 nm-thick AlN and 0.8 nm-thick GaN; a 600 nm-thick  $\text{Al}_{0.5}\text{Ga}_{0.5}\text{N}$  layer; a silicon-doped, 4.1  $\mu\text{m}$ -thick contact layer; an active region with three  $\text{Al}_{0.35}\text{Ga}_{0.65}\text{N}$  wells surrounded by  $\text{Al}_{0.46}\text{Ga}_{0.54}\text{N}$  barriers with identical thickness; an electron-blocking region; a short-period superlattice based on the pairing of 30 layers of magnesium-doped  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{N}$  and  $\text{Al}_{0.35}\text{Ga}_{0.65}\text{N}$ , both 2.5 nm-thick; and a 20 nm-thick magnesium-doped GaN cap.

To activate the magnesium, epiwafers were annealed in nitrogen gas. Devices were then formed that featured 150  $\mu\text{m}$  by 150  $\mu\text{m}$  palladium-based  $p$ -contacts, which had an indium  $n$ -contact deposited on the cleaved edge of the wafer. Output

power nearly tripled when aluminium content in the 4 nm-thick AlGa<sub>x</sub>N layer in the first series of samples increased from 80 percent to 100 percent. Meanwhile, the second experiment showed that if the AlN layer was at least 3 nm-thick, output power was 8.5 times higher than if it were not there at all.

The optimum 290 nm LED, which had an electron-blocking heterostructure comprising 3 nm-thick AlN and 25 nm-thick  $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$ , had a maximum output of 1.1 mW and a peak external quantum efficiency of 0.4 percent. The latter figure is roughly twice that of the best value for other LEDs emitting at the same wavelength.

"We should note that a number of other research groups have reported even higher external quantum efficiencies for LEDs working in the adjacent UV-A or UV-C spectral ranges," points out Kneissl. According to him, to assess the performance of all these LEDs, it is essential to consider whether the measurements are on-wafer, or the chips have been packaged.

"External quantum efficiency results that we have reported are for on-wafer measurements," says Kneissl. "The extraction efficiency is quite low – just 6 to 9 percent of the total ultraviolet light generated within the LED is coupled out." However, this extraction efficiency could hit 50 percent with an optimal chip and package design.

The team's new electron-blocking structure should benefit shorter wavelength LEDs even more. "This is the focus of our current work, where we aim at LEDs with a wavelength below 265 nm," says Kneissl. "We already have very encouraging results from our first series of experiments in this spectral region."

T. Kolbe *et. al.*  
Appl. Phys. Lett. **103** 031109 (2013)

# Heavily doped silicon enables chemical lift off

Etching a sacrificial GaN layer with oxalic acid boosts LED light extraction

REMOVING THE SAPPHIRE substrate from a GaN LED is a tried-and-tested route to increasing light extraction efficiency. This process normally involves a laser lift-off step to separate the substrate from the epilayer, but this can damage the material, so several research groups are now pursuing chemical lift-off techniques. These are being refined, and are now in their simplest form yet, thanks to the recent work of researchers in China.

This team of scientists from National Chung Hsing University and Feng Chia University has pioneered a chemical lift-off technique involving etching a thin, heavily silicon-doped layer of GaN in oxalic acid solution. Other groups, in comparison, have used more radical sacrificial layers made from the likes of CrN, ZnO and AlN.

Team member Chia-Feng Lin from Feng Chia University says that the undoped-GaN-on-sapphire templates liberated by the etching process can be used to regrow the InGaN LED and silicon-doped GaN structures in an MOCVD system, reducing the time and cost for depositing a full LED structure.

To separate the LED from the substrate, the researchers begin by growing a fairly

conventional device on top of a heavily doped, 0.1  $\mu\text{m}$ -thick sacrificial GaN layer. Specifically, the MOCVD growth that is carried out on 2-inch sapphire to produce the epiwafer involves the deposition of: a 30 nm-thick buffer; a 1.4  $\mu\text{m}$ -thick, unintentionally doped GaN layer; a 0.1  $\mu\text{m}$ -thick GaN layer with a silicon doping level of  $2 \times 10^{19} \text{ cm}^{-3}$ ; a 1.0  $\mu\text{m}$ -thick undoped GaN layer; a 3  $\mu\text{m}$ -thick n-doped GaN layer; a multiple quantum well region with nine  $\text{In}_{0.2}\text{Ga}_{0.8}\text{N}$  quantum wells; and a 30 nm-thick p-GaN cap.

Dry etching with a plasma to a depth of 2.2  $\mu\text{m}$  defines the mesa regions, before a 250 nm film of indium tin oxide is deposited, to provide a transparent conductive layer. A pairing of chromium and gold provides the metallic contacts for the LEDs, which are isolated from one another – but still attached to the substrate – using a laser-scribing process.

To remove the sacrificial layer, the samples are immersed in 0.5 M oxalic acid solution for 40 minutes while they illuminated by a 400 W mercury lamp and subjected to a 15 V DC bias.

“The oxalic acid attacks the silicon-doped GaN layer to form a nanoporous

structure,” says Lin. According to him, the higher the silicon-doping concentration, the faster the GaN etching.

Lateral etching in the sacrificial layer takes place at a rate of 315  $\mu\text{m/hr}$  to yield 240  $\mu\text{m}$  by 180  $\mu\text{m}$  chips featuring a 30  $\mu\text{m}$ -wide nanoporous structure in the thicker n-type silicon layer, which has a lower doping level than the sacrificial layer.

This nanoporous, n-type silicon layer is not an impediment to high performance, however. “By forming nanoporous GaN close to the mesa region, high light scattering occurs in the InGaN LED, leading to high light extraction efficiency in the normal direction of the LED chips,” says Lin.

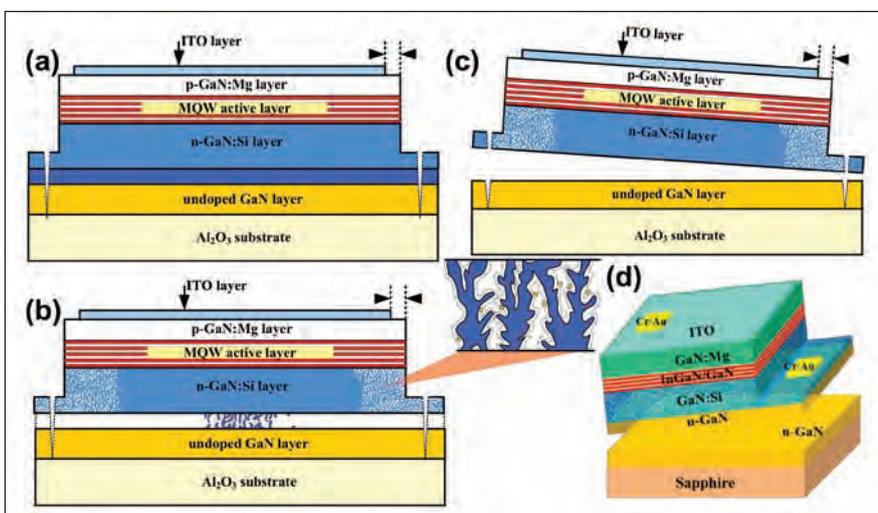
The team have compared the performance of their LED to a control sample that had not been subjected to a chemical lift-off process. Electroluminescence spectra for both samples featured Fabry-Pérot interference fringes, indicating that etching had not had a major impact of the flatness of the bottom surface of the LED.

Driven at 20 mA, the sapphire-free LED produced an output power 2.1 times higher than that of the control.

The team attribute the superior brightness to an increase in the light scattering process at the bottom lift-off GaN surface and the GaN nanoporous structure around the LED chip.

Lin believes that the team’s process is compatible with high-volume manufacturing. He argues that the modification to the epitaxial structure is minimal, and points out that it is compatible with a vertical LED process, because a patterned metal structure can be electroplated onto the chip.

The researchers are planning to fabricate this type of device, and also increase the lateral wet etching rate by increasing the silicon doping concentration. The latter will impact the crystalline quality of the LED structure above, but this can be addressed by turning to an alternative heterostructure, according to Lin.



Fabrication of the LED involves: laser scribing; lateral wet etching, which leads to the formation of nanoporous GaN; and self-separation to yield chips

K.-C. Wu *et al.* *App. Phys. Express* 6 086501 (2013)

# Exposing anti-phase profiles in GaP-on-silicon

Scrutinising samples with several microscopes reveals the presence of anti-phase boundaries in GaP that jump from one atomic plane to another.

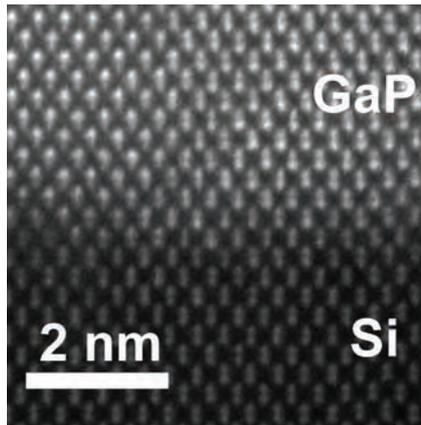
FOR MANY YEARS, engineers have dreamed of the possibilities that would result from monolithic integration of III-V transistors and lasers on large, low-cost silicon substrates. And GaP has been marked out as a compound with a big role to play, thanks to its very favourable lattice constant – but little is known about the boundaries between device-degrading anti-phase domains that can form in this binary when it is deposited on silicon.

To address this shortcoming, researchers from the Philipps University Marburg and Jülich Research Centre have carried out a theoretical and experimental study into the nature of the anti-phase boundaries found in GaN grown on silicon. This team was surprised with what they found: “Theory predicted something different from what was experimentally observed,” explains team member Kerstin Volz from Philipps University Marburg. The anti-phase boundaries were not atomically abrupt, as expected, but have a finite thickness, due to random jumps between atomic planes.

One key finding by the team is that the jumping between planes can lead to a charge distribution that is macroscopically neutral along some planes, but leads to local charging along others.

“If there are free charges, even if macroscopically neutral, these charges can still have an impact on the functionality of devices that rely on charged carrier transport,” explains Volz. “Knowing the structure of these defects and correlating the structure to the growth conditions will allow us to control the charge distribution in these layers.”

Samples for the team’s study were formed by using MOCVD to deposit a GaP layer on a silicon (100) substrate with an intentional miscut of  $0.1^\circ$  in the [110] direction.



High angular dark-field imaging on GaP grown on silicon reveals the nature of anti-phase domains, which can lead to device-degrading free charges

“Growth conditions are chosen in a way that no twins or stacking faults occur, and only a minimum of anti-phase domains remain,” reveals Volz. To realise this, the deposition process includes a pulsed nucleation step at  $450^\circ\text{C}$  and continuous overgrowth at  $675^\circ\text{C}$ .

High-angle, angular dark-field (HAADF) images of the electron-transparent samples that were prepared from the epiwafers were obtained with three different scanning tunnelling electron microscopes: a JOEL ARM 200F, a JEOL 2200 FS, and an FEI Titan 80-300. Spherical aberrations of specific lenses were corrected to realise the high level of resolution.

To complement these measurements, the team calculated HAADF-intensities using commercial software.

According to Volz, it is essential to carry out these simulations: “The often-used assumption that the HAADF intensity is proportional to the square of the atomic number is just a rough approximation. In reality, the contrast is more complex, and depends on imaging conditions, as well as sample properties, such as strain.”

One example of this is that despite having a lower mean atomic number than GaAs, GaNAs produces a higher intensity.

Viewing along the [110] direction, Volz and his co-workers acquired images showing an anti-phase boundary with a thickness of one atomic layer in the GaP film. They explained this by arguing that the anti-phase boundary is not fixed on a {110}-plane, but jumps from one {110}-plane in the viewing direction to another.

To confirm the presence of these jumps, the team looked at cross-section samples in a  $\langle 110 \rangle$  projection. This revealed that the anti-phase boundary does not run straight along a charge-neutral [110]-plane, but is faceted on higher indexed planes.

Volz believes that these jumps may be driven by temperature, so they could be suppressed by lowering the deposition temperature. “However, a certain temperature is needed for decomposition of the precursors, which makes the jumps unavoidable.”

The jumps are not necessarily bad news, because they can provide a mechanism for self-annihilation of the anti-phase domains. The German team have done this, producing a GaP-on-silicon (001) template that is free from anti-phase domains after 50 nm of deposition of the binary compound.

Goals for the team are to now perform calculations to estimate the energy of the jumps, and to carry out additional HAADF measurements to determine the three-dimensional nature of the anti-phase domains.

A. Beyer *et al.*  
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# LEDs

## Everlight extends JU series of COB LEDs

The firm's expanding portfolio of single light sources for directional lighting applications offer a cost/performance ratio of over 400lm/\$

Everlight has expanded its JU series of chip-on-board (COB) LEDs to include 7, 10 and 15 W types in addition to the existing 4W version.

COB LEDs are especially suited for directional applications that require a powerful single light source for effective illumination such as GU, MR and PAR retrofits, downlights and candelabras.

The JU series now consists of four JU1215 (15 x 12 x 1.6mm) and one JU2024 (20 x 24 x 1.6mm) type/s with powers ranging from 4 watts to 15 watts.



JU 1215 LEDs



JU 2024 LED

All types provide an efficacy of 110lm/W or more at 3000K

CCT, a CRI of over 80Ra and 25°C substrate temperature, and are available in versions ranging from ANSI bin 2,700 K to 6,500 K. The JU series also offers 3 step (McAdam) options for advanced utilisation.

JU COB LEDs are multi-chip solutions that are directly applied to the board without housing, for efficient thermal dissipation. Their ceramic substrate base allows for thermal resistances of below 2°C/W, with the largest wattage COB measuring around 0.8°C/W. Low thermal resistance and good heat dissipation ensure high reliability and increase the LEDs' service life.

Each COB has its unique features with carefully calculated chip configurations for optimal lumens per dollar of over 400lm/\$ and optically compact light emission surfaces (LES) for effective pairing with secondary optics.

Additional JU COB options such as "Color Choice", high voltages from 45 to 250V for different regions and applications, and high CRI (>90Ra) are available to meet customers' specific needs. All JU COBs have completed LM80 lumen maintenance testing and are offered with a complete line of accessories such as standardized holders, appropriate reflectors and more.

The future product roadmap of the JU family provides for additional higher power members as 25W / 35W / 50W for track light, down light or low bay applications by Q4/2013. Meanwhile, 4W / 8W / 13W / 17W / 26W MCPCB 120lm/W COB are coming out for wider options.

Samples are available upon request and mass production has already started.

## Air Water to develop GaN-on-SiC-on-silicon with Aixtron reactor

The company is building on large diameter SiC on silicon technology for LEDs and power devices

Air Water of Azumino in Japan has reported the successful installation of a fully automated Aixtron AIX G5 HT planetary reactor in an 8 x 6 inch configuration for the growth of GaN epitaxial layers.



Aixtron AIX G5 HT planetary reactor

Aixtron says Air Water selected this MOCVD system to deliver superior material uniformity, a key factor in demonstrating the advantage of Air Water substrates for GaN epitaxy.

Following the installation, the company has announced the release of GaN-on-SiC on silicon substrates for this year.

In order to address future market demand, Air Water is also considering upgrading the system to an Aixtron AIX G5+, which can handle up to 5 x 200 mm (8 inch) silicon substrates.

As compared to traditional silicon substrates, the additional SiC layer displays the advantage of protecting the silicon substrate in the initial GaN nucleation process. Due to its crystal structure SiC is considered as an ideal template for the GaN growth.

So, the SiC-on-silicon substrate is enabling the growth of superior crystal quality GaN layers onto large areas. This characteristic brings efficiency and cost savings to a wide range of high-power and LED applications.

Air Water is a Japanese industrial gas manufacturer and has developed SiC growth on silicon for both power device and LED applications as part of the semiconductor gas business.

The company has already succeeded in the production of high quality 3C-SiC (111) on up to 8 inch silicon substrates and has also announced the release of these products for GaN epitaxial growth required to manufacture electronic devices for LED and power electronic applications.

## Power Integrations & Cree launch reference design for LED spotlight

The DER-350 is claimed to achieve excellent dimming performance for all TRIAC dimmer types

Power Integrations has announced a reference design for a dimmable PAR38 spotlight, developed in collaboration with LED lighting company Cree.

The new reference design, described in DER-350, uses Power Integrations' new LYT4317E, a member of the company's LYTSwitchTM-4 family of single-stage drivers, along with Cree's MT-G2 EasyWhite® LEDs.

DER-350 includes an isolated, high-power-factor, TRIAC-dimmable LED driver optimized to deliver an LED current of 550 mA at 36 V (nominal) from an input voltage range of 90 VAC to 132 VAC. The combined PFC and CC single-stage, isolated topology of the LYTSwitchTM-4 IC delivers excellent efficiency, power factor of 0.98, and low component count. Over-voltage, overcurrent and over-temperature protection features are built-in.

DER-350 also showcases the LYTSwitch-4 IC's excellent TRIAC dimming with very fast sub-200 ms start-up, reduced pop-on and no dead-travel, easily satisfying NEMA dimming curve requirements, for both leading-edge and trailing-edge

dimmers.

Co Andrew Smith, product marketing manager at Power Integrations comments, "The combination of the high lumen output, excellent optical control and color consistency of Cree's MT-G2 EasyWhite LEDs makes it ideal for directional luminaires such as the PAR38 replacement lamp."

Adds David Cox, Cree's director of alliance development, "Power Integrations' low-cost, high-efficiency drivers complement our LEDs and facilitate designs that are compact, require little heatsinking and provide excellent dimmability. The result is LED-lighting solutions that are being readily accepted by customers."

## Azzurro's GaN-on-Si LED wafer achieves 1 nm standard deviation

The firm's subsidiary announced the news during a talk at ICNS yesterday



While showing production values of less than 3 nm wavelength uniformity, Azzurro's 1.0 nm result came straight from development.

This latest result demonstrates the capability to achieve 1 nm (or 1 bin) GaN-on-silicon LED uniformity.

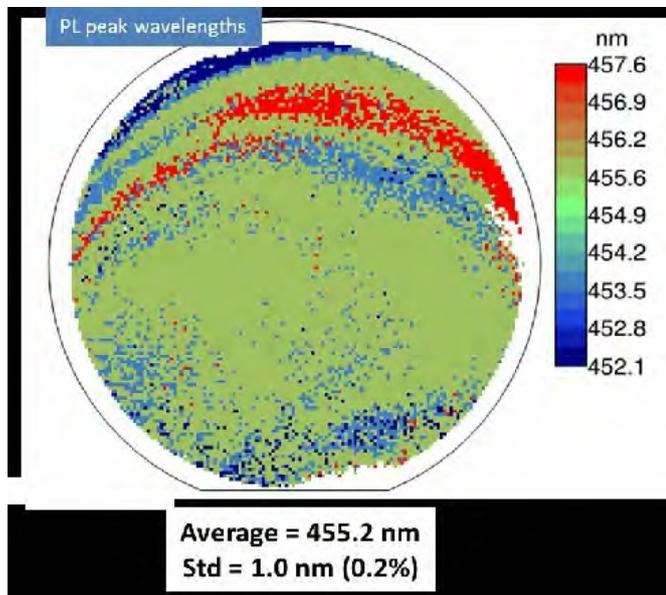
GaN-on-silicon contenders have always found that the yield question has remained open. The large mismatch of crystal lattice structure and thermal expansion coefficient cause highly bowed LED wafers after and during growth.

This in turn has a very big negative impact on uniformity levels for wavelength, forward voltage and output power. Azzurro uses its proprietary and patented strain-engineering and growth technologies to overcome these obstacles.

Breakthrough uniformity from production for wavelength (less than 3 nm or 0.6 percent), forward voltage (1.3 percent) and output power (3.9 percent) for highly reduced binning were presented at the ICNS-10 in Washington D.C., USA together with excellent crystal quality values for 150 mm blue emission GaN-on-silicon LED wafers (all values are standard deviation).

At the same time equally impressive values for 200 mm LED wafers show Azzurro's technological scalability. Manufacturability parameters like low bow (less than 20  $\mu$ m) and thickness uniformities (1.7 percent) are not compromised on.

Based on these achievements the technical team continues to push for the ultimate “1 bin” wafer aim and demonstrated the benchmark result for wavelength with only 1.0 nm uniformity and a min/max value of 5 nm (one wavelength bin). This is illustrated in the map below.



Azzurro's latest results from production and development indicate that in addition to the cost advantages from lower cost substrates and by using standard silicon fabs for LED chip processing GaN-on-silicon LED wafers with the right strain-engineering technology can also help reduce binning dramatically.

Azzurro's co-founder and CMO, Alexander Loesing, who is also heading its LED Technologies business unit, comments on the results, "We are very proud of our team's record 1.0 nm achievement. With these results we show that our GaN-on-Si technology can bring the LED industry closer to the aim of making "1 bin" LED wafers."

Azzurro specialises in the growth of GaN on silicon substrates. The company manufactures epitaxial wafers for LED and power semiconductor applications.

## Major LED manufacturer finds ALSI's dicing system cutting edge

The tool will be used in the manufacture of GaN and GaP LEDs

Advanced Laser Separation International (ALSI) N.V. introduced its new laser dicing system, the ICA 1204 for GaN and GaP devices, at one of the world's largest major LED manufacturers with great success.



ICA 1204 laser dicing system

The ICA1204 system is equipped with a specific UV laser and ALSI's unique multi-beam laser splitting technology.

The overall process is based on a high speed full cut laser dicing process for wafers in the range of 150-200µm thick. Due to the specific nature of the applied coating, additional special coating process units were integrated into the system.

As a result, this new system outperformed ALSI's previous models and a competitors system with significant results. The total cycle time including the specific coating process, multi-beam dicing and wafer cleaning, which are completely integrated in the system, was reduced by almost a factor two.

Since all the process steps are integrated inside the system, the operator cost and handling cost are reduced as well. ALSI says this combination of faster cycle time, reduced handling time, and fast dicing process, also reduced the overall cost per wafer by a factor 2.

The multi-beam process is based on 10-14 beams which achieves a very high dicing speed and a fast process time, while creating an extremely narrow kerf giving superior dicing quality.

This new process and system has been tested by customers resulting in firm orders and is used in full production.

## Opto Diodes' AlGaAs 850nm LED boosts optical output

A new gallium aluminium arsenide night vision device may improve illumination tasks

Suited for night vision illumination tasks, Opto Diodes', OD-669-850 infrared LED illuminator produces uniform optical beam and has optical output from 800 to 1,250 mW (typ) and a peak emission wavelength of 850nm.

Spectral bandwidth at 50 percent is typically 40nm, and half-intensity beam angle is 120°. All surfaces on standard

2-lead, TO-66 electrically-isolated packages are gold plate. Operating and storage ranges are - 40 to +100°C.

Opto Diode, a division of ITW, and a member of the ITW Photonics Group, has launched the OD-669-850 high-power AlGaAs infrared IRLED illuminator.

Ideal for night vision illumination tasks, the infrared illuminator features ultra-high optical output, from 800 (minimum) to 1250 mW (typical) and a peak emission wavelength of 850nm.

Opto Diode's new device provides a uniform optical beam. The spectral bandwidth at 50 percent is typically 40 nm, and the half-intensity beam angle is 120 degrees. All surfaces on the standard 2-lead, TO-66 electrically-isolated package are gold plate.

The OD-669-850 IRLED illuminator's operating and storage temperatures range from - 40 degrees C to +100 degrees C with a maximum junction temperature of 100 degrees C.

Power dissipation (under absolute maximum ratings at 25 degrees C) is 6 W, with a continuous forward current of 370 mA, a peak forward current of 1A and reverse voltage at 5 V. The lead soldering temperature (at 1/16 in. from case for 10 seconds) is 260°C.

Opto Diode Corporation, is a member of the ITW Photonics Group and delivers standard and custom photodetectors, and reliable, high quality, standard and custom infrared and visible LEDs.

The company, with the recent acquisition of International Radiation Detectors, also designs and manufactures semiconductor radiation devices that detect photons in the UV range, X-rays, and other high energy particles. The domestic U. S. manufacturing plant includes a wafer fab and ensures delivery of volume quantities at competitive prices with short lead times.

Opto Diodes works in a variety of industries, including test & measurement, biotechnology, medical, entertainment, military and defence, industrial, aerospace, automotive and R&D sectors.

The ITW Photonics Group was created to bring together and build on the technical expertise of three individual companies that specialise in photonics technology and span a spectrum of wavelengths.

## LED light bulbs could be a shock hazard

Consumers have been advised to stop using Philips' Endura and Ambient LED dimmable light bulbs unless otherwise instructed

Although no injuries have been reported, the U.S. Consumer Product Safety Commission is recalling Philips' Endura and Ambient LED dimmable light bulbs.

The main issue is that a lead wire in the bulb's housing can have an improper fitting, which can electrify the entire lamp and pose a shock hazard.

Consumers have been recommended to immediately stop using the recalled LED bulbs, unplug the fixture, remove the bulb and contact Philips for free replacement bulbs.

Philips Lighting can be contacted on (800) 295-5147 between 9am and 5pm ET from Monday to Friday and can also be reached online at [www.recall.philips.com](http://www.recall.philips.com).

So far the units related to is about 99,000.

This recall involves Endura 12-watt and Ambient 12.5-watt LED dimmable light bulbs. The bulbs are orange in colour and have "MADE IN CHINA," "Fabrique en Chine" followed by a slanted "S," and the model number 9290001829 printed on the grey plastic band on the neck of the bulbs.



Image depicting EnduraLED and Ambient LED dimmable light bulbs

The date codes, 2L for the Endura bulbs and 2K or 2L for the Ambient bulbs, are printed on the metal screw base. The bulbs give off a white light and are used indoors to replace incandescent bulbs. The following chart outlines the recall details:

Product Name	Model Number	Ordering Code	UPC	Date Code
EnduraLED 12W A19 2700K Dimmable 120V	9290001829	12A19/END/2700-000 DIM	46677 40994	2L
AmbientLED 12.5W A19 2700K Dimmable 120V	9290001829	BC-12.5A19/AMB /2700-000 DIM	46677 42215	2K and 2L

The bulbs have been sold at Home Depot, grocery and home centre stores nationwide, online retailers, including Amazon.com and through electrical distributors between October 2012

and May 2013 for between \$15 and \$30.

The U.S. CPSC works to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters and household chemicals.

### Sharp and Osram to take LEDs and lasers to the next level

A patent agreement between the two firms is expected to boost R&D in these markets and others

Sharp and Osram have entered into a patent cross-licensing agreement covering LEDs and laser diodes.

This cross-licensing agreement grants each party the right to use inventions related to LED and laser diodes covered by the patents owned by the respective companies around the world.

Both companies expect that this will spur their R&D and contribute to further advances in LEDs, laser diodes, and related industries.

Sharp began mass-production of LEDs in 1970 and the world's first production of infrared laser diodes for CDs in 1982.

With these LED and laser diode technologies built up over the years, the company has recently come out with numerous unique devices, including a high-efficiency, high-brightness 100 W-class LED for lighting, and a red laser diode that can be used as a light source for displays.

Under this agreement, the companies' mutual licensing of patents will allow each party to complement its respective technologies. Sharp and Osram believe this will accelerate development of high-performance LEDs and laser diodes and have a positive effect on the creation of devices that match the needs of worldwide markets.

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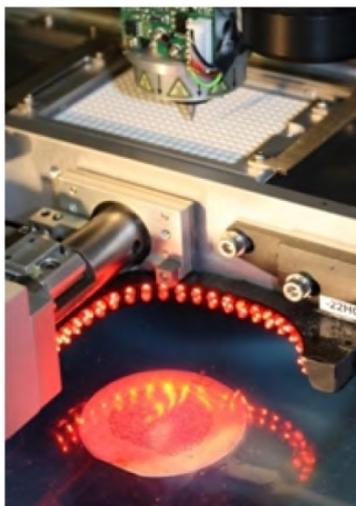
## SETi cuts pricing on its AlGaIn LEDs

The company says new high volume pricing make its aluminium gallium nitride UVTOP LEDs commercially viable in consumer type applications

Sensor Electronic Technology, Inc. has completed product qualification and shipped the first SMD packaged UVTOP devices from its new high volume manufacturing line.

This is the result of the first phase of growth of Sensor Electronic Technology, Inc. (SETi) that began in October 2011 with a \$20 million investment into a new dedicated volume production facility and an expansion of its Advanced Technology Centre.

These first LEDs delivered from the new line were UVC LEDs operating at 275nm for disinfection applications and give customers access to germicidal UVC LEDs intended for consumer markets.



UVTOP LED

Mainstream disinfection markets are very cost sensitive, but SETi has set a new pricing structure for standard SMD UV LEDs manufactured through the new line to compete with traditional light sources.

"The new volume production facility has allowed SETi to focus a part of its business solely on manufacturing, which has reduced costs through operational methods and yield improvements" says Remis Gaska, President and CEO of SETi.

He adds, "We are passing these savings directly to the customer to enable new market opportunities."

SETi also says that UVC LEDs are now available as standard SMD products at prices similar to conventional white LEDs, enabling new product opportunities to take advantage of UV LEDs and enter new consumer markets.

"This marks an important milestone for SETi and for deep UV LEDs" comments Gaska. "We have been working with manufacturers of consumer products for the past few years and soon we will see UV LEDs in our homes disinfecting water, air and surfaces and keeping our food fresher for longer."

Additional wavelengths are being qualified through SETi's high volume manufacturing line and 310nm LEDs are expected to be available by Q4 2013.

SETi has ISO9001 and AS9100 certified design and manufacturing and produces LED chips ranging from 240nm to 360nm.

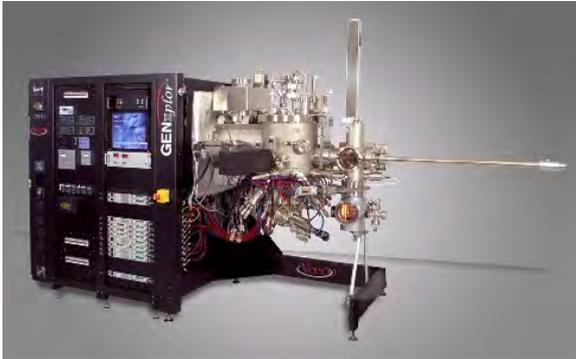
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## Veeco to reveal compact MBE tool

The company says its latest molecular beam epitaxy reactor is the industry's first integrated MBE System for the compound semiconductor R&D market

Veeco Instruments has introduced the GENxplor Molecular Beam Epitaxy (MBE) deposition system.

The GENxplor can create high quality epitaxial layers on substrates up to 3" in diameter and is ideal for cutting edge research on a wide variety of materials including GaAs, nitrides, and oxides.



Latest GENxplor R&D MBE System

"The compound semiconductor R&D community asked for a more affordable, flexible, and easy-to-use MBE system and Veeco has delivered with the GENxplor," says Jim Northup, Veeco's Vice President and General Manager. "We have repackaged Veeco's industry-leading MBE technology into a novel 'all-in-one' design that combines the reactor and electronics on a single frame. It will change the way researchers use MBE."

The GENxplor uses Veeco's GEN10 growth chamber design and features process flexibility, ideal for materials research on emerging technologies such as UV LEDs, high-efficiency solar cells, and high-temperature superconductors.

Its efficient single frame design combines all vacuum hardware with on-board electronics to make it up to 40 percent smaller than other MBE systems, saving valuable lab space. And as the manual system is integrated on a single frame, installation time is reduced.

Veeco says the open architecture design of the GENxplor also improves ease-of-use and provides convenient access to effusion cells. And it also allows easier serviceability when compared to other MBE systems. When coupled with Veeco's recently introduced retractable sources, the system is ideally suited to oxide materials research.

## LED Engin's 365nm emitter breaks barriers

The firm's III-nitride based UV LED Gen 2 emitters are claimed to deliver class-leading irradiance in demanding curing applications

LED Engin has launched a 365nm UV LED Gen 2 emitter that delivers up to 1000mW flux output at 2.8W power - claimed to be the highest radiant flux available in the market from a single die package.

The 365nm Gen 2 LZ1-00UV00 emitter produces its irradiance

from a compact 4.4mm x 4.4mm footprint, one of the industry's smallest high power UV LED packages. It has a narrow beam angle of 70° that results in more flux in the beam and maximum power density (W/cm<sup>2</sup>) on target, at least four times higher than its closest competitor.



LZ1-00UV00 LED

Due to its small size and high irradiance, the robust emitter offers unparalleled flux density for system developers of fast curing inks, adhesives and coatings. What's more, medical, sterilisation, currency verification, forensic and contamination inspection applications benefit from system efficiencies and cost savings driven by smaller emitters and optics.

The Gen 2 emitter, based on LED Engin's proprietary LuxiGen platform, delivers a combination of low thermal resistance (4.2°C/W) and an improved thermal derating, producing 80 percent relative flux at 100°C case temperature. This enables it to be driven at high drive currents (nominal 700mA) and high junction temperatures (maximum 130°C). The result is sustained maximum flux performance for high temperature applications that allows system designers to employ a smaller heat sink with passive cooling.

President and CEO of LED Engin, David Tahmassebi, comments, "We are proud to have made such a pioneering breakthrough in UV LED technology. Our latest high flux density emitter will deliver new capabilities to UV curing applications, particularly in areas where it is vital to produce and maintain maximum levels of performance. Those customers that have been waiting for dramatic progress in flux density will be very pleased with what LED Engin can offer."

The 365nm UV LED Gen 2 emitter (Part number: LZ1-00UV00) is available now from LED Engin and its distributors.

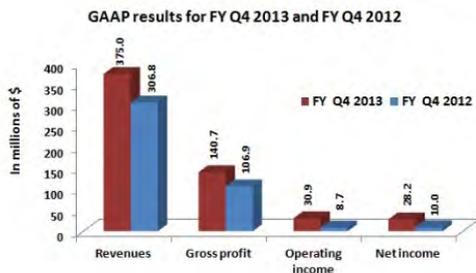
## Cree not a casualty in financial crisis

The LED and SiC power device chip manufacturer has shown robust growth over the last fiscal year

Cree announced revenue of \$375.0 million for its fourth quarter of fiscal 2013, ended June 30th, 2013.

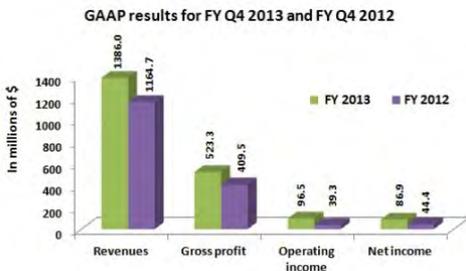
This represents a 22 percent increase compared to revenue of \$306.8 million reported for the fourth quarter of fiscal 2012, and a 7 percent increase compared to the third quarter of fiscal 2013.

Net income for the fourth quarter was \$28.2 million, or \$0.23 per diluted share, an increase of 182 percent year-over-year compared to net income of \$10.0 million, or \$0.09 per diluted share, for the fourth quarter of fiscal 2012.



For fiscal year 2013, Cree reported revenue of \$1.39 billion, which represents a 19 percent increase compared to revenue of \$1.16 billion for fiscal 2012. GAAP net income was \$86.9 million, or \$0.74 per diluted share, an increase of 96 percent compared to \$44.4 million, or \$0.39 per diluted share, for fiscal 2012.

The company generated \$285.2 million of operating cash flow and \$186.9 million of free cash flow (cash flow from operations less capital expenditures) during fiscal 2013.



“Our fiscal fourth quarter was a strong finish to a great year, with record revenue and good earnings growth in line with our targets,” stated Chuck Swoboda, Cree Chairman and CEO.

“Total company backlog is ahead of this point last quarter and we are targeting solid growth in LED lighting in Q1. Our new products have opened new applications, improved payback, and fuelled growth in LED lighting. We remain focused on driving mass adoption and our goal of 100 percent upgrade to LED lighting,” adds Swoboda.

Gross margin decreased 60 basis points from Q3 of fiscal 2013 to 37.5 percent. Cash and investments increased by \$86.9 million from Q3 of fiscal 2013 to \$1.0 billion. Accounts receivable, net increased by \$10.6 million from Q3 of fiscal 2013 to \$192.5 million, with days sales outstanding of 46. Inventory increased by \$1.3 million from Q3 of fiscal 2013 to \$197.0 million and represents 76 days of inventory.

Business Outlook:

For its first quarter of fiscal 2014 ending September 29th, 2013,

Cree targets revenue in a range of \$380 million to \$400 million, with gross margin targeted to be 38.5 percent. The firm’s gross margin targets include stock-based compensation expense of approximately \$2.2 million. Operating expenses are targeted to increase by approximately \$3 million sequentially.

The tax rate is targeted at 23.0 percent for the first quarter of fiscal 2014. Net income is targeted at \$28 million to \$34 million, or \$0.23 to \$0.28 per diluted share and is based on an estimated 122.4 million diluted weighted average shares.

All data quoted in this article is GAAP based.

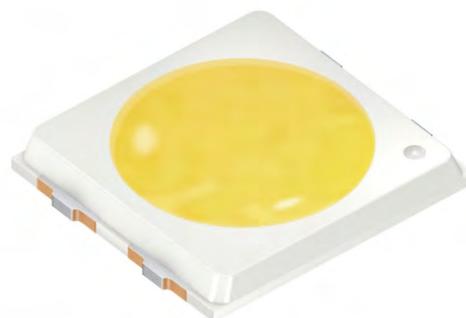
## Osram unveils compact multi-chip LED for interior lighting

The Duris S 8 InGaN (indium gallium nitride) based LED offers lots of light from a small surface, particularly for use in directional retrofits

Osram Opto Semiconductors is launching the Duris S 8, a new, multi-chip, high-power member of the Duris “S” LED series.

The close grouping of the LED permits very good colour consistency in combination with a high luminous flux.

The new Duris S is primarily used in directional and omnidirectional retrofits, as well as in LED spots in indoor lighting. It is particularly suitable for directional lighting in office and business premises, as well as in the home.



Duris S 8 LED

The very good colour consistency (colour binning) in the directional retrofits is achieved through the close grouping of the LEDs, which corresponds to the coverage of a 5-step MacAdam ellipse. 3-step MacAdam grouping is additionally available for applications requiring very good colour homogeneity.

The Duris S 8 is grouped by colour coordinates at the junction temperature of 100 °C instead of at room temperature, as is customary. “In terms of colour rendering, the Duris S 8 has a CRI of more than 80. An even higher CRI will be the next step,” says Janick Ihringer, the responsible Product Manager SSL at Osram Opto Semiconductors.



*The Duris S 8 features a high colour consistency for directional retrofits, downlights and spots as shown above*

The new Duris S also emits a great deal of light from a small surface, permitting efficient optical solutions. It measures just 5.8 x 5.2 mm and is available in two versions - with six or eight chips.

Thanks to the luminous flux of 500 lm at 200 mA, a directional retrofit is possible even with the 8-chip version.

“Compact, low-cost driver modules are available on the market for the forward voltage between 20 and 30 V. Moreover, their technical characteristics, such as a longer service life of 25,000 hours or operating temperatures of 110 °C, are perfectly tailored to the target applications,” continues Ihringer.

Osram says its Duris S 8 can also reduce the system costs of lighting systems: The Duris S package consists of an innovative plastic housing material that is not only particularly resistant to ageing at high temperatures and in short-wave light, but also costs less than the ceramic housings frequently used.

Technical data describing the Duris S 8:

Types	Version 1 (6 chips) (GW P9LMS1.EM)	Version 2 (8 chips) (GW P9LRS1.EM)
Housing size	5.8 mm x 5.2 mm	5.8 mm x 5.2 mm
Grouping current	200 mA	200 mA
Forward voltage	18.6 – 22.2 V	24.8 – 29.6 V
Luminous flux (typical at 25 °C, 3,000 K)	390 lm	500 lm
Colour temperature	2,700 K, 3,000 K and 4,000 K	2,700 K, 3,000 K and 4,000 K
Colour Rendering Index (CRI)	> 80	> 80

## LED device for capturing your signature in lights

A new sensor incorporating GaN (gallium nitride) could provide an artificial sense of touch and be used in biological imaging and MEMS systems

Researchers at the Georgia Institute of Technology have developed a sensor that converts mechanical pressure - from a signature or a fingerprint - directly into light signals that can

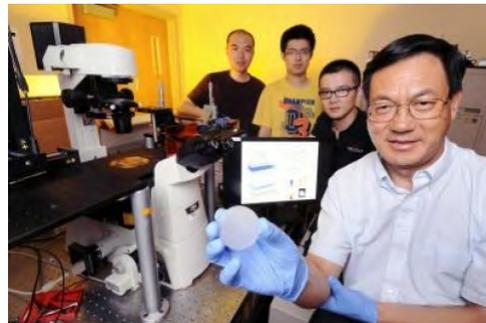
be captured and processed optically.

The scientists used thousands of zinc oxide (ZnO) nanometre-scale wires to accomplish this,

The sensor device could provide an artificial sense of touch, offering sensitivity comparable to that of the human skin. Beyond collecting signatures and fingerprints, the technique could also be used in biological imaging and micro-electromechanical (MEMS) systems.

And ultimately, it could provide a new approach for human-machine interfaces.

“You can write with your pen and the sensor will optically detect what you write at high resolution and with a very fast response rate,” says Zhong Lin Wang, Regents’ professor and Hightower Chair in the School of Materials Science and Engineering at Georgia Tech. “This is a new principle for imaging force that uses parallel detection and avoids many of the complications of existing pressure sensors.”



*Zhong Lin Wang holding the sensor device along with his research team in the background*

Individual ZnO nanowires that are part of the device operate as tiny LEDs when placed under strain from the mechanical pressure. They allow the device to provide detailed information about the amount of pressure being applied.

Known as piezo-phototronics, the technology - described by Wang in 2009 - provides a new way to capture information about pressure applied at very high resolution: up to 6,300 dots per inch.

Piezoelectric materials generate a charge polarisation when they are placed under strain. The piezo-phototronic devices rely on that physical principle to tune and control the charge transport and recombination by the polarisation charges present at the ends of individual nanowires.

Grown on top of a GaN film, the nanowires create pixelled light emitters whose output varies with the pressure, creating an electroluminescent signal that can be integrated with on-chip photonics for data transmission, processing and recording.

“When you have a zinc oxide nanowire under strain, you create a piezoelectric charge at both ends which forms a piezoelectric potential,” Wang explains. “The presence of the potential distorts the band structure in the wire, causing electrons to remain in the *p-n* junction longer and enhancing the efficiency of the LED.”

The efficiency increase in the LED is proportional to the strain created.

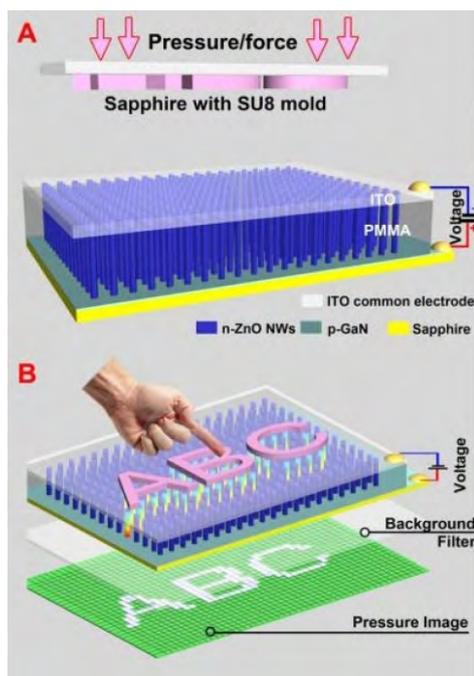
Differences in the amount of strain applied translate to differences in light emitted from the root where the nanowires contact the GaN film.

To fabricate the devices, a low-temperature chemical growth technique is used to create a patterned array of ZnO nanowires on a GaN thin film substrate with the *c*-axis pointing upward.

The interfaces between the nanowires and the GaN film form the bottom surfaces of the nanowires. After infiltrating the space between nanowires with a PMMA thermoplastic, oxygen plasma is used to etch away the PMMA enough to expose the tops of the zinc oxide nanowires.

A nickel-gold electrode is then used to form ohmic contact with the bottom gallium-nitride film, and a transparent indium-tin oxide (ITO) film is deposited on the top of the array to serve as a common electrode.

When pressure is applied to the device through handwriting, nanowires are compressed along their axial directions, creating a negative piezo-potential, while uncompressed nanowires have no potential.



Schematic showing a device for imaging pressure distribution by the piezo-phototronic effect. The illustration shows a nanowire-LED based pressure sensor array before (a) and after (b) applying a compressive strain. A convex character pattern, such as “ABC,” molded on a sapphire substrate, is used to apply the pressure pattern on the top of the indium-tin oxide (ITO) electrode.

The researchers have pressed letters into the top of the device, which produces a corresponding light output from the bottom of the device. This output - which can all be read at the same time - can be processed and transmitted.

The ability to see all of the emitters simultaneously allows the device to provide a quick response. “The response time is fast, and you can read a million pixels in a microsecond,” says Wang. “When the light emission is created, it can be detected immediately with the optical fibre.”

The nanowires stop emitting light when the pressure is relieved. Switching from one mode to the other takes 90 milliseconds or less, Wang says.

The researchers studied the stability and reproducibility of the sensor array by examining the light emitting intensity of the individual pixels under strain for 25 repetitive on-off cycles. They found that the output fluctuation was approximately 5 percent, much smaller than the overall level of the signal. The robustness of more than 20,000 pixels was studied.

A spatial resolution of 2.7  $\mu\text{m}$  was recorded from the device samples tested so far. Wang believes the resolution could be improved by reducing the diameter of the nanowires - allowing more nanowires to be grown - and by using a high-temperature fabrication process.

The researchers’ study is described in detail in the paper, “High-resolution electroluminescent imaging of pressure distribution using a piezoelectric nanowire LED array,” by Caofeng Pan *et al* in *Nature Photonics* (2013), published online on 11th August 2013. [DOI:10.1038/nphoton.2013.191](https://doi.org/10.1038/nphoton.2013.191)

This research was sponsored by the U.S. Department of Energy’s Office of Basic Energy Sciences, the National Science Foundation, and the Knowledge Innovation Program of the Chinese Academy of Sciences.

## PhotonStar reshuffles board

The III-nitride LED manufacturer has appointed a senior executive who worked at GE Lighting

PhotonStar LED Group plc, a British designer and manufacturer of smart LED lighting solutions, has appointed Philip Marshall as a non-executive director with immediate effect.



Philip Marshall

Marshall most recently served as the President and Chief Executive Officer at GE Lighting EMEA, the \$600 million turnover division of General Electric specialising in lighting

solutions.

In this role, he led the infrastructure development across the entire region for GE's Lighting business, which included transitioning the business to an energy solutions provider, encompassing LED technologies.

Prior to this, he served as the President and Chief Executive Officer at GE Industrial (low voltage) Systems & Consumer Products EMEA, a division of GE integrating the GE Industrial Systems and GE Appliances & GE Lighting ("Consumer Products") groups in Europe, Middle East and Africa.

Philip Marshall holds a Bachelor of Arts Degree from Thames Valley University, and is a qualified Chartered Management Accountant

Also, PhotonStar's Chief Financial Officer, Russell Banks, who joined the Group in April 2013, has been appointed to the board with immediate effect.

James McKenzie, Group Chief Executive, says, "We are very pleased to welcome Philip to the Board. He has a strong industry background and brings valuable experience in technology commercialisation and strategy at an exciting time for our business."

PhotonStar comprises two divisions. The first is LED Lighting Fixtures which works with lighting designers, architects, house builders, facilities management companies and sustainability consultants to provide intelligent, high-end LED lighting solutions for the commercial and architectural market. The second is LED Light Engines which provides LED lighting solutions for specialist applications such as film & television production lighting, UV curing and medical applications.

## How many people do you need to change a light bulb?

None - it's an LED bulb



Gallium nitride-on-silicon is a hot topic for LEDs and power devices.

But LEDs could be the game changer - in the immediate future at least - as LED bulbs can last a lifetime. With new government regulations to make our world more environmentally friendly, and the demise of incandescent bulbs, LEDs are on the rise.

It was in the late 1800s when Thomas Edison invented the first commercially practical incandescent light that some of us are still using.

But it's time for us to move on.

In the last ten years, there have been a cluster of companies targeting the massive lighting market. The question is who will be the quickest to come up with the goods? We want the brightest, eco-friendliest most versatile LED bulb at the lowest cost which is also easy on the eye.

It's a tall order.

Most white to blue semiconductor LEDs incorporate the wide bandgap compound semiconductor gallium nitride (GaN). And you may be spoilt for choice with the different substrates that can be used in making the device - these include sapphire, SiC, silicon and GaN itself.

Many of these substrates are costly though. The exception is silicon, which comes in large substrate sizes such as 6" and 8".

So what are the challenges of growing GaN on silicon?

Firstly the difference in lattice parameter between the most prevalent silicon (111) and GaN is large (around 17 percent). One of the key aspects to counter this is growing a layer (often AlN) - this layer prevents chemical reactions between gallium and silicon and makes the wafer behave like a substrate having lattice parameters closer to that of GaN. Then the buffer layer (mainly AlGaIn) is grown to further reduce the mismatch.

There is also a 52 percent thermal mismatch between GaN and silicon. This means that once the wafer is cooled down after growth, the GaN will contract at a different rate to the silicon substrate.

Having said that, the plus side would work two-fold. Silicon substrates are cheap and also, growing on silicon would enable fabs to use their existing tools without having to invest in costly alternative equipment.

Current players in the GaN-on-Si market include Toshiba and Plessey. Both companies have recently launched LEDs for the lighting market. But efficiencies are still relatively low.

Using technology initiated by Colin Humphreys' group at Cambridge, Plessey and Aixtron are working together to optimise a process using a close coupled showerhead (CCS) reactor capable of growing 6 inch GaN-on-Si.

Apart from Toshiba, competitors include Lattice Power, Transphorm, Azzurro, Infineon, Philips Lumileds, Samsung and imec (and partners). Soitec, Azzurro, Kyma, Translucent and EpiGaN provide GaN-on-Si templates.

So only time and investment will tell who comes out on top.

## Pomerantz Law files class action against SemiLEDs

One of the complaints alleges the company was experiencing known, but undisclosed, pricing pressures for its products which could result adversely on SemiLEDs' future revenues and operating income

Pomerantz Grossman Hufford Dahlstrom & Gross LLP has filed a class action lawsuit against SemiLEDs Corporation and some of its officers.

The class action, filed in United States District Court, Southern District of New York, on behalf of a class consisting of all persons or entities who purchased or otherwise acquired securities of SemiLEDs between December 9th, 2010 and July 12th, 2011 both dates inclusive (the 'Class Period').

This class action seeks to recover damages against SemiLEDs and certain of its officers and directors as a result of alleged violations of the federal securities laws pursuant to Sections 10(b) and 20(a) of the Securities Exchange Act of 1934 and Rule 10b-5 promulgated there under.

Shareholders who purchased SemiLEDs securities during the Class Period have until September 9th, 2013 to ask the court to appoint them as Lead Plaintiff for the class.

SemiLEDs Corporation develops, manufactures, and sells LED chips and components. The firm's products are used primarily for general lighting applications, including street lights and commercial, industrial, and residential lighting, as well as specialty industrial applications, such as ultraviolet (UV) applications, curing of polymers, LED light therapy in medical/cosmetic applications, counterfeit detection, and LED lighting for horticulture applications.

The complaint alleges that throughout the Class Period, Defendants made materially false and misleading statements regarding the Company's business prospects, and operations. Specifically, the complaint alleges, among other things, that SemiLED misrepresented and failed to adequately disclose:

(a) that the company was experiencing known, but undisclosed, pricing pressures for its products which were reasonably likely to result in a material adverse effect on SemiLEDs' future revenues and operating income;

(b) that SemiLED failed to disclose known events or uncertainties, including the reduction in demand for its products, the loss of a large customer, and the decline in the value of its inventory that had or were reasonably likely to cause SemiLEDs' financial information not to be indicative of future operating results; and (c) that the Company had filed a false and misleading Registration Statement and Forms 10-Q with the SEC.

On July 10th, 2011, SemiLEDs issued a press release announcing its financial results for its 2011 third quarter ended May 31st, 2011. For the quarter, the company reported revenue of \$5.6 million, down 43% from the previous year's third quarter, and a net loss of \$5.1 million, or \$0.19 per diluted common share.

SemiLEDs' results for the quarter were adversely impacted by a \$1.1 million inventory charge during the quarter, an amount equal to more than 7 percent of the value of the Company's total inventory at February 28, 2011. On this new announcement, SemiLEDs' stock price fell nearly 11%, or \$0.71 per share, to close at \$5.87 per share on July 12th, 2011.

## Ultratech/Cambridge NanoTech branches out in Massachusetts

A new state-of-the-art facility will expand operations for next-generation ALD equipment development and enable leading-edge scientific research

Ultratech, a supplier of lithography, laser-processing and inspection systems used to manufacture semiconductor devices and high-brightness LEDs (HB-LEDs), has moved Ultratech/Cambridge NanoTech to Waltham, Massachusetts.

After acquiring the assets of Cambridge NanoTech last December, Ultratech invested in a new facility to enhance atomic layer deposition (ALD) development. With this new facility, Ultratech/Cambridge NanoTech has now greatly enhanced its capability to develop innovative process technology for ALD applications.



*Ultratech/Cambridge NanoTech cleanroom*

ALD is an enabling technology which provides coatings and material features with significant advantages compared to other existing techniques for depositing precise nanometre-thin films.

This technology is expected to be in high demand in volume manufacturing environments for integrated optics, micro-electro-mechanical systems (MEMs), implantable devices in the biomedical sector and batteries and fuel cells in the energy market.

Ultratech Chairman and Chief Executive Officer Arthur W. Zafiropoulos states, "By creating a new state-of-the-art facility and leveraging the valuable Cambridge NanoTech intellectual property, we have further enhanced our ability to advance the development of next-generation ALD solutions. In addition, we have retained the same team that Cambridge NanoTech customers have worked with in the past."

Zafiropoulo concludes, "The completion of the new facility marks our successful integration of the Cambridge NanoTech assets into Ultratech's nanotechnology product group. By investing in the expansion of these operations, we expect to generate increased revenue in new and existing markets. Ultratech, and our ALD unit, Ultratech/Cambridge NanoTech, will continue to focus on technology solutions that support our global customers' advanced product and technology roadmaps."

## Cree LED lighting highlights Bashas' groceries

The renovated Arizona based supermarket can now showcase its merchandise with better light, improved efficiency and continued savings

Bashas', a family-owned and operated grocery retailer in the western United States, recently installed energy-efficient LED lighting from Cree to better illuminate its Tempe, Arizona location.

The newly renovated store features luminaires powered by Cree TrueWhite Technology, delivering superior light quality that helps make products more attractive to customers, while enjoying the benefits of a quick payback and an anticipated energy savings of 47 percent over the store's previous design.

"Shopping is a highly visual experience and it's critical to showcase products in their most appetising colours," notes Scott Murphy, construction manager for Bashas'. "When we decided to remodel the Tempe location, we initially chose fluorescent T8s and CFL downlights until we were introduced to Cree LED lighting. Cree luminaires not only deliver the best LED lighting in the industry but also provide significant energy and maintenance savings compared to outdated technologies. In the grocery store industry, it's all about margins and Cree helped add green to our bottom line."

Featuring a number of luminaires from Cree's extensive portfolio - Cree CS18 linear luminaires, CR24 troffers, and LR6 and LE6 downlights - the installation resulted in a one-for-one replacement against the original specification due to the upgrade in light quality as well as energy and maintenance savings.

What's more, the Cree CS18 luminaires deliver strong vertical light levels, illuminating all levels of the store's shelves using less power and providing significant energy savings.

"Businesses like Bashas' no longer have to choose between colour quality and savings," says Mike Bauer, vice president of lighting sales, Cree. "Cree luminaires provide a truly no-compromise alternative to fluorescent lighting with exceptional light quality, reduced energy and reduced maintenance costs - all working to increase the bottom line."

The installed Cree luminaires further help reduce energy consumption with their dimming capabilities. Supermarkets can see even greater energy savings with this technology, especially during hours with low shopper volume.

Bashas' expects the Cree system to pay for itself within two years. This is based on commercial usage of 18 hours per-day and the national average of \$0.11 per kWh electric costs, lighting-related HVAC impact and relamp maintenance reductions.

The Cree luminaires are backed by the firm's 10-year warranty, providing investment protection.

"Bashas' is so pleased with our decision to install Cree LED lights, it is now the standard for new and retrofit stores," Murphy continues. "Not only do they offer energy and maintenance savings, but they produce beautiful, long-lasting lighting that make the store's products pop."

## Seoul Semi's mid-power LEDs achieve 180 lm/W and halve costs

The company believes its latest III-nitride LEDs offer world class performance for solid state lighting

Seoul Semiconductor has launched two new mid-power packaged LED lighting products, the 5630C and the 3030. These packaged LEDs have been improved dramatically in terms of luminance efficacy (lm/w) and cost efficiency (lm/\$).



5630 packaged LED

The 5630 package offers 180 lm/W efficacy at 60mA in the 5000K CCT range. It is an extension of the mid-power LED lighting family that Seoul Semi released as one of the first ever mid-power LEDs for solid state lighting products.

When it was released, the performance of the 5630 LED was better than existing high-power packaged LEDs. In the past 2 years, it became the best selling item among Seoul's product portfolio. The new 5630C is targeting the high growth segment of LED lighting including bulbs, tubes and panel lights in the US, Japan, and Europe.



3030 packaged LED

The newly introduced 3030 LED extends the Seoul mid-power LED portfolio and offers up to the high-power one watt (1W) range. This performance was achieved by enhancing both the LED chip and package in terms of thermal resistance. Even though traditional 3030 packaged LEDs were mid-power, the new versions can be used in high power applications with the additional benefit of reducing costs by more than 50 percent over 1W high power LEDs.

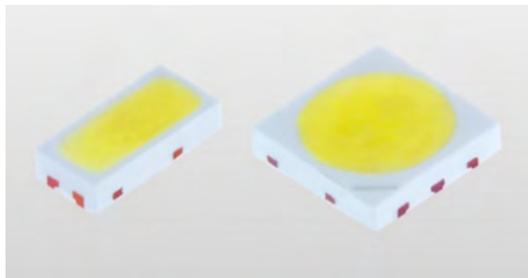
Marten Willemsen, Vice President of Marketing for Seoul Semiconductor, says, "The 3030 and 5630 packages are LED products which focus on both price competitiveness (lm/\$) and luminance efficiency (lm/W). We have already sold billions of pieces in China, USA, and Europe for various LED lighting products."

He adds, "If you use these two LEDs properly, you can chase two rabbits at the same time in terms of 'lm/W' and 'lm/\$' which most lighting designers consider the most important factors."

## Toshiba unleashes low power GaN-on-Si white LEDs

The two sets of gallium nitride-on-silicon LEDs are anticipated to commence mass production in August 2013

Toshiba Corporation has launched a series of white LEDs fabricated with a GaN-on-silicon (GaN-on-Si) process.



Toshiba's Sub-Watt Type White LEDs, TL2FK Series (left) and TL3GA Series (right)

The LEDs are low power sub-watt type, due to reduction of forward voltage (VF). Two package line-ups, the TL2FK series with 3.0 x 1.4mm package and the TL3GA series with 3.0 x 3.0mm package, will be made available. Mass production is scheduled to start from August, 2013.

The LEDs can be used in light sources for general lighting, including straight tube lights, light bulbs, base lights and ceiling lights.

Sub-watt type lineup

Part Number	Color temperature (K)	Package (mm)	Characteristics (Ta=25°C)					Conditions	
			Luminous flux $\phi_v$ (lm) Typ.	Typical chromaticity $C_x$	$C_y$	$R_a$ Min	$V_f$ (V) Typ.	$I_f$ (mA)	
TL2FK-DW1	6500	3.0×1.4×0.67 (t)	23.0	0.313	0.329	80	2.85	80	
TL2FK-NW0	5000		25.5	0.345	0.355	70	2.85	80	
TL2FK-NW1	5000		23.0	0.345	0.355	80	2.85	80	
TL2FK-WH1	4000		23.0	0.382	0.380	80	2.85	80	
TL2FK-LW1	3000		20.5	0.434	0.403	80	2.85	80	
TL2FK-LL1	2700		20.0	0.458	0.410	80	2.85	80	
TL3GA-DW1	6500	3.0×3.0×0.67 (t)	57.0	0.313	0.329	80	5.7	100	
TL3GA-NW0	5000		62.7	0.345	0.355	70	5.7	100	
TL3GA-NW1	5000		57.0	0.345	0.355	80	5.7	100	
TL3GA-WH1	4000		57.0	0.382	0.380	80	5.7	100	
TL3GA-LW1	3000		51.3	0.434	0.403	80	5.7	100	
TL3GA-LL1	2700		49.0	0.458	0.410	80	5.7	100	

## Veeco big in China with multiple MOCVD order from Sanan

The largest LED manufacturer in China will use the reactor to grow LEDs for applications including backlighting and general illumination

Sanan Optoelectronics placed a multi-tool order for Veeco's TurboDisc MaxBright M MOCVD systems in the third quarter of 2013.

The multi-reactor systems will be used to ramp production of LEDs in its Xiamen, China fab for applications including backlighting and general illumination.



Zhiqiang Lin, Chief Executive Officer of Sanan, says, "Veeco has been and remains our MOCVD supplier of choice. As we were selecting equipment for our new phase of expansion, it was evident that the MaxBright M would give us the best footprint efficiency to maximise space and productivity in our Xiamen fab. Veeco has been a great partner for us since as we have solidified our position as the top LED manufacturer in China and as we have increased our business outside of China as well."

William J. Miller, Veeco's Executive Vice President, comments, "We are pleased to continue our partnership with Sanan and look forward to supporting their expansion plans. According to IHS - IMS Research, a leading LED industry research firm, China remains the largest region in LED chip production with the most potential for adoption across all lighting applications. We believe Sanan is well positioned to capitalize on that growth."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System is one of the industry's highest footprint efficiency MOCVD systems designed to manufacture high quality, high brightness light emitting diodes. The MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers flexible layout configurations compared to the original MaxBright.

Sanan Optoelectronics is engaged in the design, development, manufacture and distribution of full colour ultra-high brightness LEDs, epitaxial wafers, photo-diode detectors and compound solar cells. The company is headquartered in Xiamen, PRC.

## KaiStar selects Veeco to support LED manufacturing ramp

The joint venture will use Veeco's MOCVD reactor to increase its indium gallium nitride (InGaN) LED production

KaiStar Lighting ordered multiple Veeco TurboDisc MaxBright M MOCVD Systems in the second quarter of 2013.



KaiStar, a joint venture between Epistar Corporation and Shenzhen Kaifa Technology Co., Ltd., is based in Xiamen, China. The systems will be added to KaiStar's current installed base of Veeco MOCVD systems as part of their 2013 capacity expansion plan.

MJ Jou, President of Epistar Corporation, comments, "This latest capacity expansion is based on our customers' growing

demand for LEDs for backlighting and general illumination applications. We have been delighted with the performance of Veeco's production-proven MOCVD systems, which provide high productivity and low cost of ownership. Combined with their excellent service and support, it was an easy decision for us to again turn to Veeco for our manufacturing ramp."

William J. Miller, Veeco's Executive Vice President, adds, "We are gratified that KaiStar has again chosen Veeco as their MOCVD supplier of choice as they ramp production. As always, we are committed to help them achieve their manufacturing goals."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System is one of the industry's highest footprint efficiency MOCVD systems designed to manufacture high quality, high brightness LEDs. The MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers flexible layout configurations compared to the original MaxBright.

KaiStar has registered capital of \$120 million. The company plans to focus on the lighting market through the production of InGaN LEDs for lighting and backlighting applications, lamps and automotive products.

## Meaglow to upgrade ALD nitride deposition tool in Turkey

The hollow cathode plasma source reduces the oxygen contamination in ALD systems and increases the quality of thin III-nitride films during growth

Meaglow is to install a hollow cathode plasma source for the group of Necmi Biyikli, a professor at the Institute of Materials Science and Nanotechnology, at Bilkent University in Turkey.

The plasma source is being used to upgrade their Atomic Layer Deposition (ALD) system by replacing an inductively coupled plasma source. This enhancement will reduce the oxygen contamination in ALD systems and increase the quality of nitride thin films grown.

The III-nitrides grown at the university with the ALD system are used for LEDs and power electronic applications. The actual materials grown using the system are AlN, GaN and InN.

Bilkent University researchers will be presenting some of their findings about suitable applications for these products at the ALD 2013 conference on Wednesday.

The presentation will take place from 9:00 - 9:15am and is entitled, "Characterization and Electronic Device Applications of III-nitride Thin Films Deposited by Plasma-enhanced ALD," and will be presented by student finalist C. Ozgit-Akgun from Bilkent.

"The Bilkent system was easy to retrofit and the Meaglow Plasma source was the perfect solution for their oxygen

contamination problem,” says Butcher, Chief Scientist of Meaglow.



ALD system converted with a hollow cathode plasma source

Initial results show a significant reduction of oxygen content in compound nitride films grown. Results will be presented October 27th to November 1st at the 224th ECS Fall Meeting in San Francisco, California at an invited talk presented at the symposium on “Atomic Layer Deposition Applications”.

Meaglow is now focused on commercialising its hollow cathode plasma technology which also has the advantage of scalability to large deposition areas. Meaglow is seeking additional ALD system owners and suppliers interested in removing the oxygen contamination in their films.

## Kyma uses Nanotronics tool to classify defects in GaN

The newly installed inspection system will be used in the characterisation of Kyma’s growing III-nitride semiconductor materials product line

In May of 2013, Nanotronics Imaging installed an nSPEC system at Kyma Technologies in Raleigh, North Carolina.

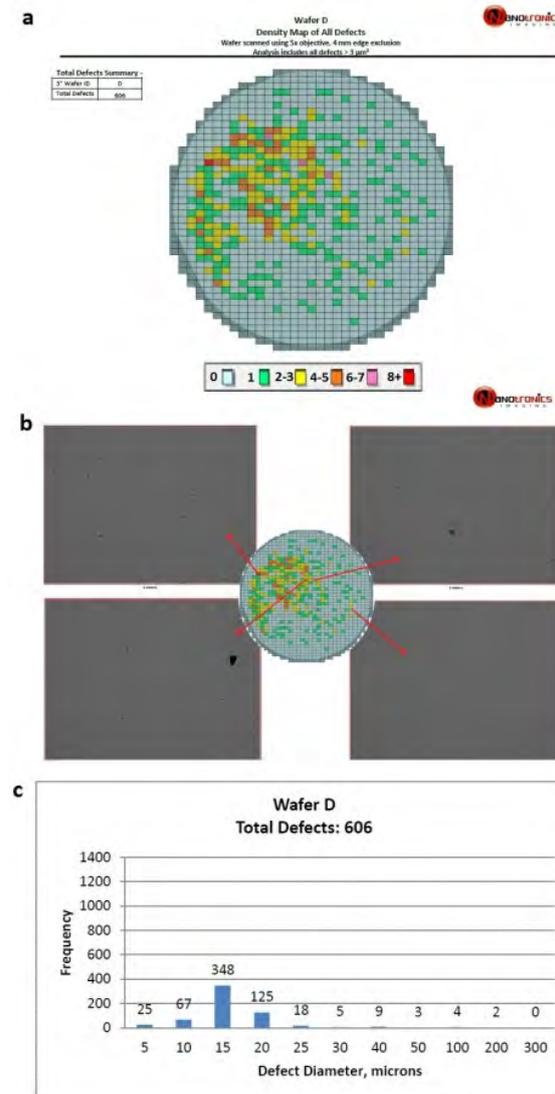


nSPEC system

Kyma and Nanotronics began discussing how the nSPEC tool might benefit Kyma’s nitride semiconductor materials production effort in early 2013. A collaborative partnership was quickly spawned which led to Kyma’s purchase of the nSPEC

tool.

The nSPEC enables Kyma to inspect their wafers via powerful image analysis software. This includes the ability to store high resolution images, capture particular features and areas of interest while translating the acquired visual information into quantifiable data.



nSPEC data: a) Density map of all defects ; b) Examples of some of the defects on the map compared to microscope images ; c) Histogram showing quantities of each defect size

“Working with the Nanotronics Imaging team has been an exciting and highly productive experience,” says Keith Evans, Kyma’s president & CEO. “Our technical team, led by our Chief Scientist Jacob Leach, pushed the nSPEC tool in about a dozen different directions. The response of the Nanotronics team was superb and the result is that we can now routinely sense several different important characteristics of our materials better than ever before.”

He adds “We are very pleased with the kinds of inspection that the nSPEC is giving us, which has already given us significant new insight into our processes here at Kyma.”

Kyma Technologies has graciously agreed to open its doors for people to observe the nSPEC in action. This is an ideal opportunity for semiconductor groups and Universities in the South Eastern region of the U.S. to learn about the powerful capabilities of nSPEC and its value to their respective applications.

“This is really a great partnership and opportunity for us, we are so thrilled that Kyma is happy with their purchase of an nSPEC and are excited to bring interested people and future partners to Kyma to see the nSPEC there,” says Matthew Putman, CEO of Nanotronics Imaging.

The nSPEC is an automated, optical, inspection device geared toward defect detection and characterisation of semiconductor wafers, dies and devices. It is a scanning optical microscope fully integrated with patented, image analysis processing.

It is claimed that never before has there been an automated machine that provides such crisp images and rich information about defects and features on semiconductor wafers.

## Bridgelux Vero LED arrays raise the industry bar in flexibility

The capabilities of the Vero series arrays lead to shorter product development times, lower inventory requirements, reduced costs and more light with less energy

Bridgelux's recently released Vero Series of LED Array products are now shipping.

These products have a performance efficacy of 120 lm/w nominal and 110 lm/w minimum average. This performance enhancement delivers energy savings of approximately 11 percent over the prior product generation and provides a significantly accelerated return on investment.

What's more, the Vero Series arrays are now available with 2SDCM MacAdam and 3 SDCM options - raising the industry bar in colour control precision and uniformity.



Vero LED arrays

The featured 120 lm/w efficacy is an average performance across all form factors in the Bridgelux Vero Array Series based

on 3000K 80 CRI configurations driven at nominal currents. With some Vero configurations driven at lower currents, users can readily achieve efficacies up to 140 lm/w. The Vero arrays also deliver average minimums of 110 lm/w and provide designers with excellent design and manufacturable flexibility.

The Vero platform enables plug & play connectivity for lighting manufacturers, enabling leading solid state lighting product performance capabilities while streamlining production processes for lighting manufacturers. These capabilities lead to shorter product development times, lower inventory requirements, reduced costs and more light with less energy.

Beyond saving energy, the Bridgelux Vero Series of LED arrays provide customers with a standard option of choosing either 2SDCM or 3SDCM MacAdam colour control. Having more precise colour control options improves the quality of light by providing greater consistency and uniformity between adjacent light sources. This exciting advancement in colour control options with the Vero Array Series enables clean and consistent lighting installations with both high quality colour rendering and appearance. The Vero Series also exceeds California Energy Commission R9 requirements for luminaires and lamps.

Since the launch of the Vero platform just 4 months ago, XAL, Licht + Design, Amerlux, and Dongmyung have joined a rapidly growing list of the world's most highly recognised global lighting manufacturers to incorporate Vero LED arrays into products for retail, commercial and other applications.

“The innovative feature set on-board in Vero Series arrays provides us with tremendous flexibility, particularly in designing new products for manufacturability,” said Harald Dimberger, CEO of XAL in Austria. “The efficiency and lumens per watt performance that Bridgelux regularly delivers helps keep XAL products competitive in the marketplace and helps drive broader adoption of solid state lighting.”

Vero arrays are compatible with a wide variety of standard drivers (350mA increments) and optical components, providing manufacturers with greater flexibility and a wide range of options, shortening product development times, lowering inventory requirements and reducing costs. Electrical connections can be established with thermally isolated solder pads or by using a solder-less on-board connector port. The solder free connector port simplifies manufacturing processes, reduces production time/cost, and eliminates the potential for solder failures.

“The Vero arrays have been one of our most successful product offerings in our ten year history,” said Aaron Merrill, Director, Product Line Management of Bridgelux. “Solid state lighting is making huge gains in virtually every segment and geography, but we must continue to find ways to drive down total system costs, while increasing performance. Vero arrays will play an instrumental role in bringing new methodologies and technologies to the solid state lighting market, and provide a platform for the convergence of technologies required for smart lighting.”

### Product Availability

The Vero Series Arrays are available now in four different sizes with performance specifications to fit a broad spectrum of residential, commercial, industrial and interior/exterior

applications.

Other features include:

1. Lumen output performance ranges from 240 to 16,400 lumens
2. Broad range of CCT options from 2700 to 5000K
3. CRI options include 70, 80, 90, and 97 CRI Décor products
4. 3SDCM standard for 2700K - 4000K CCT with 2SDCM options now available
5. Reliable operation at up to 2x rated drive current
6. Radial die pattern improves lumen density and beam control
7. Thermally isolated solder pads reduce manufacturing time and complexity
8. Solder-less connector port enables plug & play connectivity and field upgradability
9. Top side product marking and 2D bar code improve inventory management

## BluGlass in the money with \$3 million grant

The company now hopes to increase efforts into gallium nitride (GaN) on silicon substrates R&D for LEDs

Australian firm BluGlass Ltd. has received a major vote of confidence in its technology by being awarded a (AUS)\$3 million (US\$2.75 million) grant.



The award comes under the Australian Federal Government's 'Clean Technology Innovation Program'.

The funding was specifically allocated to the company's 'Versatile prototype deposition machine for higher efficiency, energy saving, lower cost LEDs on various substrates including silicon' project. This project aims to reduce the amount of greenhouse gas emissions generated in the production of these energy saving LED devices.

BluGlass has invented a new process using Remote Plasma Chemical Vapour Deposition (RPCVD) to grow semiconductor materials such as GaN and InGaN.

This could prove crucial to the production of high efficiency devices such as next generation lighting technology LEDs with advanced low cost potential.

The company will now be able to expedite research and

development into GaN on silicon substrates.

Of interest to potential manufactures, BluGlass' unique low temperature RPCVD technology offers significant performance and cost advantages, and it is estimated that for each RPCVD tool put into production there could be a reduction in greenhouse gas emissions of more than 39,000 t CO<sub>2</sub> equivalent per RPCVD unit (based on 3.5 million LED lamps per annum).

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

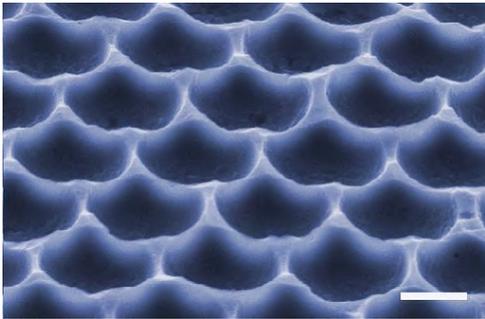
Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. "The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs." The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium

films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP Crystals



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3 μm thick InP thin-films on molybdenum foils with ultra-large grain size up to 100 μm. The researcher say this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500 cm<sup>2</sup>/V-s and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*,<sup>3</sup>, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and

Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

"Compound semiconductors are widely acknowledged

as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors.”

IQE expects to report its interim results around mid-September 2013.

## Seoul Semi LED 180 lm/W reaches new heights

The firm has also slashed costs by 50 percent with its new mid-power LEDs

Seoul Semiconductor's 5630 mid-power packaged LED efficacy is now 180 lm/W which it says is world class performance for solid state lighting. The 3030 mid-power LED reaches cost points 50 percent lower than existing high-power packaged LEDs.

Seoul Semiconductor, a global LED manufacturer, has revealed two new mid-power packaged LED lighting products, the 5630C and the 3030. These packaged LEDs have been improved dramatically in terms of luminance efficacy (lm/w) and cost efficiency (lm/\$).



5630 packaged LED



3030 packaged LED

The 5630 package is one of the world's best performance in light output with 180 lm/W efficacy and is an extension of the mid-power LED lighting family that Seoul Semiconductor released as one of the first mid-power LEDs in the world for solid state lighting products.

When it was released, the performance was better than existing high-power packaged LEDs. In the past 2 years, it became the best selling item among Seoul's product portfolio. The new 5630C is targeting the high growth segment of LED lighting including bulbs, tubes and panel lights in the US, Japan, and

Europe.

The new 3030 LED being introduced extends the Seoul mid-power offering up to the high-power one watt range by enhancing both the LED chip and package in terms of heat resistance. Even though traditional 3030 packaged LEDs were mid-power, the new versions can be used in high power applications with the additional benefit of reducing costs by up to 50 percent.

Marten Willemsen, Vice President of Marketing for Seoul Semiconductor, says, "The 3030 and 5630 packages are LED products which focus on both price competitiveness (lm/\$) and luminance efficiency (lm/W). We have already sold billions of pieces in China, USA, and Europe for various LED lighting products."

He adds, "If you use these two LEDs properly, you can chase two rabbits at the same time in terms of 'lm/W' and 'lm/\$' which most lighting designers consider the most important factors."

The products are in mass production and are globally available now through Seoul Semiconductor's distributors.

## 1000Bulbs.com forms MR16 distribution partnership with Soraa

Soraa's MR16 bulbs made using gallium nitride on gallium nitride (GaN-on-GaN) technology will be solely distributed by 1000Bulbs.com

The ideal lamp is one that puts out almost no heat, cuts energy bills, and emits a perfect beam of bright, even light with high colour rendering.

Soraa, a California-based lighting company on the cutting edge of LED technology, has created a lamp that does just that. 1000Bulbs.com has announced that it is now the premiere online distributor of Soraa's innovative, new MR16 lamps.



Soraa MR16 lamp

Founded by Shuji Nukamara, Jim Speck, and Steven DenBaars, Soraa is one of the world's leading developers of solid state lighting. The Wall Street Journal recently called Soraa, "a startup pursuing a novel way to make energy efficient light bulbs, with plans to sharply raise the bar on their

brightness.”

What sets eco-friendly Soraa apart from all other lighting companies is its patented GaN on GaN technology. This technology produces a cleaner and brighter light while also cutting power consumption by 80 percent compared to a standard halogen lamp. A Soraa lamp puts out more light with one LED chip than competing lamps do with four chips. These lamps are so powerful; they create a laser line like sharpness that is visibly noticeable in shadows.

“The quality of light that is emitted from Soraa’s lamps is breathtaking; the crispness it brings to anything it touches is something you have to experience. We are ecstatic to be Soraa’s premiere online distributor for these extremely high quality MR16s,” says 1000Bulbs.com CEO Kim Pedersen.

The Soraa MR16 is one of the highest performance LED MR16 halogen replacement lamps on the market. The Sun has a CRI of 100, while Soraa’s LED has a CRI of 95 in their vivid series offerings; this creates brighter brights and whiter whites. To top it off, Soraa has developed a heat adjustment technology that ensures the lamp will not overheat in any environment.

With LEDs built from pure gallium nitride substrates, the lamp consists of a single light source, producing crisp, clean lines with minimal light scatter. This makes them ideal for use with track lighting systems in museums, art galleries, and retail stores. They also serve as an excellent light source for office or home recessed lighting fixtures as well as landscape applications.

Available in 2700K and 3000K colour temperatures, they have a life span of up to 30,000 hours and come with a 3-year warranty.

## EpiLEDs orders more Aixtron CRIUS II-L tools

The company will use the reactors to make more LED wafers and chips ranging from 365 to 940 nm

Aixtron has announced another repeat order from Taiwan’s EpiLEDs Co., Ltd. to support ramp-up of GaN-based LED production for lighting applications.

The order for two CRIUS II-L 69 x 2-inch systems was made in the first quarter of 2013 for delivery in the third quarter of 2013. EpiLEDs is exclusively producing with MOCVD equipment from Aixtron.



CRIUS II-L 69 x 2-inch system

MingSen Hsu, President at EpiLEDs, comments. “We want a smooth ramp-up of production based on existing, proven technology. The CRIUS II-L meets our requirements for high throughput enabled by semi-automated loading and best cost-of-ownership in class. Further, the system is already fully qualified for production of EpiLEDs’ high-end LED power chips. Naturally, we plan to continue to work closely with Aixtron in meeting our future MOCVD needs.”

Christian Geng, Aixtron’s Vice President Southeast Asia, adds, “Our relationship with EpiLEDs goes a long way. It is a good example how close collaboration creates win-win; EpiLEDs has been very successful on every generation of Aixtron tools, strengthening its technology leadership.”

The CRIUS II-L systems are delivered with Aixtron’s ARGUS Topside Temperature Control (TTC) system. The method eliminates temperature variation within each run and run-to-run, enabling high production yields.

EpiLEDs develops, designs and manufactures a wide range of blue, green, red, and white light LED wafers and chips at its production facility in Tainan Science Park.

The company’s LED wafers and chips are featured with high efficacy, low power consumption, long life expectancy and full range of wavelength ranging from 365 to 940 nm suitable for a wide range of applications, such as indicators of consumer electronics, light source of fax machines and scanners, indoor or outdoor display boards, automotive lightings, traffic signals and illuminators.

## Glasgow University awarded grant for research using Oxford Instruments tools

The systems will be used in the fabrication of high performance electronic and optical devices including LEDs and lasers

The University of Glasgow has been awarded a £3 million share of £85 million new government funding for equipment to support pioneering research to improve the efficiency of electronic and optical components.

This research includes developing advanced processes on multiple commercial micro- and nano-fabrication tools manufactured in the UK by Oxford Instruments Plasma Technology that can be transferred directly into companies for production.

Announced by UK Minister for Universities and Science David Willetts at an event this week in London, the award from the Engineering and Physical Sciences Research Council (EPSRC) will support work undertaken by researchers from the University of Glasgow's College of Science and Engineering in collaboration with Oxford Instruments Plasma Technology, the National Physical Laboratory, the National Microelectronics Institute and Gas Sensing Solutions.

The funding will allow the University to purchase new equipment including several Oxford Instruments Plasma Technology's tools to etch semiconductor materials and deposit electrically insulating layers, techniques used to fabricate high performance electronic and optical devices including transistors, LEDs and lasers.

The equipment will support a range of new research projects including:

*The development of more efficient power electronics, which could improve the lifespan of batteries in many consumer electronic devices as well as reduce their carbon footprint*  
*Improving the efficiency and durability of solar collection technology, creating a dramatic reduction in the cost of large-scale exploitation of solar energy*

*The development of a 'superspectral' imaging camera which will integrate visible, infrared and mid-infrared imaging sensors on a single chip for the first time, with applications for security and medical sensing technology*

Douglas Paul, Director of the University's James Watt Nanofabrication Centre, who led the funding bid, says, "Glasgow has a long history of successful exploitation of research which goes all the way back to James Watt's invention and commercialisation of the condenser for the steam engine, and this award will help us continue that proud tradition. We're pleased that the EPSRC accepted our funding bid and we're looking forward to helping support the UK's efforts to become a more energy-efficient nation."

Minister for Universities and Science David Willetts adds. "For Britain to get ahead in the global race we have to back emerging technologies and ensure our universities have the latest equipment. This capital investment will help scientists make new discoveries and take their research through to commercial success. It will drive growth and support the Government's industrial strategy."

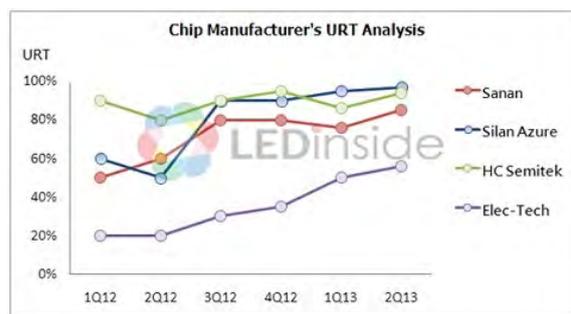
## LED chip price currently stable but may fall in H2 2013

In the long term, only invalid production capacity in China can help the LED industry to return to supply and demand balance

In accordance with statistics in Gold membership reports of LEDinside, Green Energy Division of the Global market research firm TrendForce, thanks to strong demand in the global LED lighting market in the first half of this year, the utilisation rate of MOCVD machines that the major chip manufacturers have installed and debugged shows rising trend.

The chip price has been stable this year, but with the increasing capacity of chip manufacturers, it remains to be seen whether the LED chip price will be falling in the second half of this year. But in the long term, only invalid production capacity in China can help LED industry to return to supply and demand balance.

### Chinese Major LED Chip Manufacturers MOCVD Utilisation Rate



The rise of LED lighting market has directly stimulated the upstream chip market to achieve rapid demand growth this year, the Chinese chip makers who have originally specialised in the production of display applications actively adjust product strategy and improve the ratio of lighting chips in the product segment.

HC SemiTek and Silan Azure used to have chip for LED display as core business, now they adjust production capacity in response to increasing market demand for LED lighting chips, all newly added MOCVD equipments are put into use for the production of lighting chips. Overall, the growth in display market has slowed down since 2012, more competitive, more difficult to make profit for manufacturers, which also is one the reasons why the chip manufacturers switched to produce LED chips for the lighting application.

Sanan Optoelectronics totally owns 149 units of MOCVD, currently, more than 90 percent of its MOCVD machines have completed the testing stage and have been put into operation, and utilisation rate also exceeds 80 percent.

ETI has 92 units of MOCVD as of 1H13, 45 units have been put into use for mass production, both its installation volume and mass production amount are the second in China. Due to less MOCVD machines, HC SemiTek's MOCVD machines and Silan Azure's MOCVD machines have already fully come into use. Other chip vendors also have achieved some growth in utilisation rate of equipments.

The growth in utilisation rate of MOCVD increases manufacturers' confidence to expand production; the manufacturers who delayed expansion plan because of poor market also restart the program.

According to the statistics in LEDinside Gold membership report, The number of MOCVDs in China reached 1,013 in late

2012, and it is estimated China will be adding more than 100 new MOCVD equipments (calculated according to the number of chambers) in 2013.

LEDinside says that in view of the current total number of MOCVD equipment in mainland China, overcapacity still exists. But looking carefully, many manufacturers have not put their newly added equipments into operation since the equipments were introduced. Also, most machines are old, performance and efficiency are far less than the new machines, these invalid capacities may exit the market after 2013, which is helpful for the market to return to supply and demand balance.

MOCVD Installation Volume □ Chambers □



## Cracks could affect GaN-on-silicon LED market

According to Lux Research, gallium nitride-on-sapphire remains the entrenched incumbent. The main challenger GaN-on-silicon will gain only a 10 percent market share

As LED lighting becomes an \$80 billion industry, the market for the epitaxial wafers LEDs are made from will grow to \$4 billion in 2020.

This is according to Lux Research's Energy Electronics Intelligence service report titled "Dimming the Hype: GaN-on-Si Fails to Outshine Sapphire by 2020."

Today, the vast majority of these epi-wafers are GaN-on-sapphire.

GaN-on-silicon is the leading emerging technology with a strong economic allure as silicon is just one-eighth the cost of a sapphire substrate.

But, according to Lux, technical challenges will limit it to only a 10 percent market share in 2020.

GaN-on-SiC, championed by Cree, will grow to 18 percent market share.

"Silicon is already widely used for electronics, and some LED die manufacturers are hoping to take advantage of silicon substrates," says Pallavi Madakasira, Lux Research Analyst and lead author of the report.

"But GaN-on-Si is more prone to cracking than GaN-on-

sapphire, and mitigating this mismatch is expensive," she adds.

However, growing AlN (aluminium nitride) as a nucleation layer with a buffer on top of it can reduce the mismatch between GaN and silicon.

Lux Research analysts studied the market for GaN-on-sapphire, GaN-on-SiC, GaN-on-bulk GaN, and GaN-on-Silicon epi-wafers, evaluating each technology's economic prospects as the industry moves to larger wafer sizes.

They said the choice and cost of LEDs will determine adoption. Where GaN-on-sapphire is suited to all applications, GaN-on-bulk GaN will be relegated to niche commercial lighting and GaN-on-Silicon, with unproven performance, will be better suited to cost-sensitive residential applications.

Lux also said four inch wafers will rule, although six inch wafers will start to come into vogue later on. Four inch wafers will peak at 62 percent market share with \$2.1 billion in 2017 sales.

Later, the LED industry will move towards 6" epi wafers, which will take a 35 percent share, equivalent to \$1.4 billion, in 2020.

According to Lux, technology will advance sapphire substrates.

Sapphire substrate manufacturing technology has advanced significantly with specialists such as Rubicon and Monocrystal demonstrating substrates up to 12" in diameter.

New methods will further improve throughput and cut costs, keeping sapphire highly competitive for the rest of the decade.

For example, using its Remote Plasma Chemical Vapour Deposition (RPCVD) technology, Australian based firm BluGlass has grown *p*-GaN on a commercially 456nm blue multi quantum well structure.

## SemiLEDs may be sued by private shareholder

Pricing issues and violations of the Securities Exchange Act regarding Class periods have led someone to take on the major GaN LED manufacturer

Shareholder rights attorneys at Robbins Arroyo LLP have announced that a private shareholder of SemiLEDs Corporation has filed a complaint in the U.S. District Court for the Southern District of New York.

The complaint alleges that the company and certain of its officers and directors violated the Securities Exchange Act of 1934 between December 9th, 2010 and July 12th, 2011 which they refer to as the "Class Period".

According to the complaint, SemiLEDs made false and/or misleading statements and failed to disclose material adverse facts about the company's business, operations, and financial performance throughout the Class Period.

In particular, the complaint alleges that SemiLEDs failed to

disclose that prices for its products were experiencing extreme pricing pressure from its customers, significantly reducing the average selling price of its products.

The complaint further alleges that SemiLEDs released financial statements that were not indicative of future operating results because the company failed to disclose known events and uncertainties, including a decline in product demand, the likely loss of a significant customer, and the decline in the value of its inventory.

As a result of these so-called false and misleading statements and omissions, SemiLEDs shares traded at artificially inflated prices during the Class Period, reaching a high of \$32.12 per share on December 21st, 2010.

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## Soraa's gallium nitride LED technology spurs expansion

Its GaN on GaN LED MR16 lamps have encouraged the firm to expand its global sales team

A surge in demand for Soraa's full visible spectrum has led the company to appoint two new leaders to its sales organisation - George Stringer and Nick Farraway.

Stringer joins the company as Senior Vice President of North America Sales and Farraway joins as Senior Vice President of International Sales. Both will report to Tom Caulfield, President and COO of Soraa.

"The Soraa VIVID LED MR16 lamp is widely regarded as the best in the world in terms of brightness and colour rendering - this has fuelled sales growth over the past year and created the need to expand our sales organisation," says Caulfield. "Both George and Nick bring energy, ingenuity and industry insight to help us chart a successful course for the company in the coming years."



*George Stringer, Senior VP of North America Sales, Soraa*

Stringer comes to Soraa following 16 years with Acuity Brands Lighting in a variety of senior level sales and sales management roles.

His last role at Acuity was as Vice President and General Manager for Corporate Accounts, Renovation, and Government; where he revitalised the National Account organisation.

He brings to Soraa considerable expertise in all sales

channels and motions; direct, distribution, manufacturer's representatives, and national and regional accounts.

"Response to Soraa's products from the marketplace has been extraordinary and I'm excited to be part of its seasoned and professional management team," says Stringer.



*Nick Farraway, Senior Vice President of International Sales, Soraa*

An internationally recognised lighting expert with over 30 years of global industry experience, Nick Farraway brings a wide range expertise in lamps, fixtures and applications to the Soraa team.

He previously held senior executive roles at Sylvania, Thorn and Zumtobel Lighting; working through all channels from international project specification to general wholesale distribution and retail.

He led the successful bid teams on several prominent international projects, including London Heathrow Airport Terminal 5 and Wembley International Football Stadium. Farraway holds a BEng from Middlesex University.

"Soraa maintains a rare agility that consistently outperforms the competition, not only in the inventiveness and quality of its products, but also in their ability to manoeuvre within the marketplace to create new business opportunities. I'm thrilled to join the company at such an exciting time," comments Farraway.

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## Farnell and Würth Elektronik sign exclusive LED agreement

Farnell element14 will exclusively stock Würth Elektronik's new range of LEDs

LED's primary applications are as signals for status indication in electronic equipment and in the industrial electronics sector.

But they are also used in many other applications such as scoreboards, keyboards, display panels, vending machines, audio and HiFi equipment, toys, background lighting for mobile applications.

Würth Elektronik says its LED's advantages include low energy consumption, high reliability, low current, and fast switching times. Also with design flexibility and no UV/IR radiation, the compact devices are ideal for miniature applications. They also

offer different radiation angles and colours.

Lars Fahrback, Global Distribution Manager of Würth Elektronik, says, "We are very happy to cooperate with our partners at Farnell element14 with the launch of our exciting new range of LEDs."

Fahrback continues, "After entering the semiconductor sector with TVS diodes four years ago, this sector has now been expanded with the manufacture of LEDs. The focus is on SMD components and additional to the classic single-colour components, various bi-colour and full colour (RGB) components are available. Our new range also includes different reverse-mount LEDs, side LEDs (90°) as well as selected THT types."

Mike Buffham, Global Head of Product and Pricing, Farnell element14, adds "We are pleased to partner with Würth Elektronik to launch its new range of LEDs, which offers a well balanced range with exceptional value for our customers."

## Cree LED street luminaire suited to challenging environments

The firm's XSP IP66 delivers improved performance and payback on new and retrofit installations

Cree has introduced XSP IP66 LED Street luminaires that are optimised for European and other global environmental requirements.



*XSP street light*

The advanced LED street luminaire provides metropolitan and other municipal areas a durable luminaire that protects critical electrical components from dust, water jets and other potentially damaging environmental factors.

Cree says its XSP Street Luminaire is the first real alternative to high-pressure sodium street lights with better payback, better performance and better price. Compared to its predecessor, the XSP IP66 uses nearly 50 percent less energy and is designed to last more than three times longer.

Beyond saving energy and reducing maintenance due to longer lifetime, Cree achieves better control over luminaire output with its NanoOptic Precision Delivery Grid technology compared to a traditional street light. The new XSP IP66 features similar aesthetics as a traditional HPS street light while achieving excellent target illumination.

"XSP IP66 is the ideal choice for metropolitan and other municipal areas looking to save money and reduce maintenance costs," says Massimo Targetti, managing director, Cree Europe S.r.l. "Designed to meet the demanding needs of global markets, the XSP IP66 represents the perfect combination of high-performance design and advanced LED technology. The optimised LED Street Luminaire design makes it easy for municipalities to upgrade from incumbent technologies for both retrofit and new construction applications."

The XSP IP66 has a ten year warranty and is available in both single and double module configurations. The luminaire also features state-of-the-art thermal management and electronics critical to high reliability operation in the most challenging applications.

The result is a high performance luminaire that delivers superior value without compromising longevity or light quality at the cost of performance. The new luminaire delivers a range of lumen packages and distributions optimised for the most common street light applications.

## SemiLEDs suffers 62 percent loss in revenues

The III-nitride innovator says it has borne the brunt of a series of one-time events

SemiLEDs Corporation, a developer and manufacturer of LED chips and LED components, has announced its financial results for the third quarter of fiscal year 2013, ended May 31st, 2013.

Revenue for the third quarter of fiscal 2013 was \$3.5 million, a 62 percent decrease compared to \$9.2 million in the third quarter of fiscal 2012.

GAAP net loss attributable to SemiLEDs stockholders for the third quarter of fiscal 2013 was \$11.0 million, or a net loss of \$0.40 per diluted share, compared to GAAP net loss attributable to SemiLEDs stockholders of \$10.0 million, or a net loss of \$0.36 per diluted share, for the third quarter of fiscal 2012.

"Unfortunately the combination of a series of one-time events greatly impacted our business performance this quarter," said Trung Doan, Chairman, President and CEO. "Despite this brief set-back, we remain confident we have the right strategy in place, focusing on profitable market segments where the performance and quality of our products continues to differentiate us," concluded Doan.

GAAP gross margin for the third quarter of fiscal 2013 was negative 129 percent, compared with gross margin for the third quarter of fiscal 2012 of negative 11 percent. Operating margin for the third quarter of fiscal 2013 was negative 278 percent compared with negative 87 percent in the third quarter of fiscal 2012.

Margins for the third quarter of fiscal 2013 were negatively impacted by a reduction in revenues, excess capacity charges

for our LED chips, and impairment charges on goodwill and intangible assets that arose from the acquisition of a majority owned subsidiary in August 2011.

The company's cash and cash equivalents were \$41.4 million at the end of the third quarter of fiscal 2013, compared to the second quarter fiscal 2013 ending balance of \$43.9 million. Cash used in operating activities was \$2.3 million in the third quarter of fiscal 2013.

SemiLEDs held a webcast discussing these results yesterday. A replay of the webcast will be available on the Investors section of the company's website and will remain available for approximately 90 calendar days.

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## Cree LEDs to light up North Carolina University

Seventeen UNC system institutions or affiliates will implement innovative Cree LED lighting

As part of its ongoing efforts to reduce energy usage by at least \$25 million over seven years, the University of North Carolina (UNC) General Administration has selected high-performing LED lighting by Cree to help system institutions operate more efficiently and cost-effectively.

Energy consumption per gross square foot for all state buildings in total is to be reduced by 30 percent by 2015 based on energy consumption for the 2002-2003 fiscal year.

An alliance of 13 UNC campuses and several affiliated organisations, spanning 27 million square feet, will leverage Cree LED luminaires, including the revolutionary CR24 architectural LED troffers, to deliver fast payback, energy efficiency and superior light quality.

"This University-wide lighting project will help advance our energy reduction goals, lower maintenance expenses and improve ROI," says Miriam Tripp, special projects officer at UNC General Administration. "Reducing energy consumption is the right thing to do for our environment, our students and the taxpayers who support us. Ultimately, the related cost savings enable UNC institutions to focus on our core mission of great teaching and research."

Designed to last up to 100,000 hours, Cree CR24 troffers feature dimming capabilities for easy lighting-control integration. CR24 LED troffers are powered by Cree TrueWhite Technology, delivering beautiful white light with superior colour accuracy and consistency.

"The UNC lighting installation will be a great showcase for how entire university systems can leverage LED lighting to reduce operating expenses and create well-illuminated spaces from classrooms to dormitories and beyond," says Mike Bauer, vice president of lighting sales, Cree. "We're pleased to work with UNC to help deliver the energy savings necessary to meet their sustainability goals."

Campuses and other UNC institutions involved include:

Appalachian State University; East Carolina University; Fayetteville State University; North Carolina A&T State University; North Carolina Central University; North Carolina School of Science and Mathematics; UNC Asheville; UNC Charlotte; UNC Greensboro; UNC Pembroke; UNC School of the Arts; Western Carolina University; Winston-Salem State University; UNC General Administration; UNC Centre for Public Television; NC Arboretum; NC Department of Commerce Energy Office

UNC, together with Johnson Controls, conducted an extensive energy audit and identified lighting and lighting controls as avenues to help meet their energy goals. Johnson will oversee the program and will leverage Cree LEDs across the system-wide contract.

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## New subsidiary expands wet processing division at ClassOne

The firm has expanded the division to enhance its sales and support of Semitool equipment worldwide as well as to design and manufacture new upgrades and platforms that address emerging markets such as LED and RF power devices

ClassOne Equipment has made significant investments in the growth and expansion of its Wet Processing Division in response to increased market demand. A Design and Development Centre has been opened in Kalispell, Montana, staffed with several industry veterans who represent over 200 years of cumulative industry experience, who will focus on new product design and development. Corporate and refurbishment activities will remain at ClassOne's headquarters in Atlanta, Georgia. "We are thrilled with the strong customer response to ClassOne's industry-leading products and support. We have expanded the division to enhance our sales and support of legacy Semitool equipment worldwide as well as to design and manufacture new state-of-the-art upgrades and platforms that address emerging markets such as MEMS, Nanotech, LED and RF Power Devices," says Byron Exarcos, ClassOne's President. He adds, "Semitool's acquisition left a void in the market for mature fabs and emerging technologies that use 75 to 200mm substrates.

ClassOne is meeting the growing demand for cost effective, reliable, and long-term support for popular tools such as the Spray Solvent, Spray Acid and Equinox tools. The wide-spread adoption of our lift-and-rotate and robot refurbishment programs gives testimony to that fact." The new facility in Kalispell will be operated under the name of ClassOne Technology as a wholly owned subsidiary of ClassOne Equipment. The executive team includes: Win Carpenter, a 33-year veteran in the semiconductor industry, VP Wet Process Division; Tim McGlenn (26 years experience, including leading the software and electronics development of Semitool's 101, 102, 202, 302, 402 and 502 controllers), VP of Operations; and Kevin Witt (25 years focused on the development and commercialisation of new wet chemical processing platforms), VP Technology; all of whom previously held leadership positions at Semitool. Their appointment further strengthens the division, positioning

it for enhanced growth and continued market leadership. ClassOne Technology's first product, the Polaris controller, is an advanced, PLC-based, field-retrofitable control system that replaces the aging 302 control system used in many Semitool legacy tools.

## Future Electronics to distribute Bridgelux products worldwide

Future Lighting Solutions' marketing and technical expertise along with Bridgelux's LED technology portfolio is expected to accelerate the worldwide transformation to solid-state lighting

Bridgelux Inc., a developer and manufacturer of LED lighting technologies and solutions, has signed a global distribution agreement with Future Electronics.

Under the new agreement, Future Electronics' lighting division, Future Lighting Solutions, will provide global sales, design support and fulfillment services for Bridgelux's portfolio of LED products sold through distribution.

"We are very pleased to partner with a respected global partner that will broaden our reach into the rapidly emerging markets for LED lighting," says Max Hong, Executive Vice President of Sales and Marketing for Bridgelux.

"With a world-class web platform, deep lighting application knowledge and leading global distribution capabilities, Future Lighting Solutions has distinguished itself as an innovative and extremely customer-focused organization, with strong demand creation programs. Combining Future Lighting Solutions' leading-edge selling, marketing and technical support strengths with Bridgelux's high performance LED technology portfolio will produce an alliance to accelerate the worldwide transformation to solid-state lighting," adds Hong.

"Bridgelux's innovative product offering targets the rapidly increasing demand for high quality, energy efficient internal and external LED lighting solutions for retail, commercial and residential environments," comments Jamie Singerman, Corporate Vice-President, Worldwide of Future Lighting Solutions.

"The partnership with Bridgelux presents Future Lighting Solutions with significant growth opportunities by delivering access to an even broader base of customers. Innovative new Bridgelux products, such as the Vero array platform, complement our SSL product line, increasing our ability to deliver design solutions across a wider range of applications and markets for our global customers."

## Pall to unveil latest filtration and purification technologies

The firm's new products will help semiconductor device and wafer manufacturers detect certain key contamination levels, and clean and maintain control of their fluids to enhance yields

The new technologies include:

**The Gaskleen High-Bright purifier:** This will help ensure consistent, cost-effective delivery of the pure ammonia needed to make LEDs with the highest luminosity. The purifier is a highly efficient product designed to remove molecular contaminants from ammonia used in the manufacture of HB LEDs.

Featuring twice the service life of other commercially available technologies, the new purifiers will help ensure consistent, cost-effective delivery of pure ammonia needed to make LEDs with the highest luminosity.

The Gaskleen purifier assemblies combine Pall's proprietary purification materials and Ultramet-L stainless steel filter media. They remove moisture and other oxygenated compounds from ammonia to sub ppb levels, while providing 3 nm or 0.4 micron filtration. What's more, they do not release metal ions into the process stream, further increasing luminosity.



*Gaskleen High-Bright purifier*

**Advanced 12 nm Filtration Membrane for Wet Chemical Processing:** This is a key addition to Pall's chemical filter lineup is the new 12 nm XpressKleen filter and all PFA disposable assemblies. This filter uses an advanced molecular surface tailoring (MST) process to remain wet in critical aqueous chemicals like SC1 and SC2.

It also features an improved patent-pending PTFE membrane that easily stands up to the conditions of new, higher temperature processes. This new filter maintains critical fluid purity with guaranteed claims for ultra-low metal ion extractables (< 3 ppb), particle rinse-up and organics. Advanced manufacturing, incorporating statistical process controls, assures repeatable and reliable performance.

**Gaskleen Pico1000 Analyser for Moisture in Nitrogen:** This measures trace moisture in nitrogen process gas streams, with a limit of detection of 1 part per billion (ppb). It is ideally suited for qualifying and certifying ultra-high purity (UHP) process gas lines, as well as for detecting end-of-life when deployed downstream of our Gaskleen purifiers. The robust, compact design of the analyser is readily portable, allowing users to easily move it around the fab for quick checks of process gas

quality at many points. In addition, the Pico1000 consumes up to 70 percent less process gas, compared to competitive analysers, and for a cost saving of 30 percent over traditional 1 ppb moisture analysers.

100 nm Filtration Medium for Point-of-Use Chemical Mechanical Planarisation: Pall will feature its new CMP StarKleen™ Nano filter capsule specifically designed for the classification of ceria and low solids, colloidal silica CMP slurries.

The CMP StarKleen 100 nm filter performs 30 percent better in terms of defectivity reduction than its predecessor for both shallow trench isolation (STI) and barrier copper processes. The product utilises Pall's most advanced melt blown technology and is manufactured using a proprietary process that enables greater control of pore sizes and gradient. The capsule is available in multiple lengths thus allowing for usage over a wide range of flow rates.

The Pall Microelectronics team supports customers in the semiconductor, data storage, fibre optic, display, LED and solar energy materials industries with innovative detection, filtration, and purification products, and deep applications expertise, for chemical, gas, water, chemical mechanical polishing and photolithography processes.

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## InfiniLED's Brian Corbett wins Intel's Outstanding Researcher award

The award is in recognition of outstanding contributions that Corbett and his team have made in the field of Photonics and Material Science over a number of years

Brian Corbett of the Tyndall National Institute has received an Intel Outstanding Researcher Award for 2013.

The work by Corbett and his research group on MicroLEDs led to the formation of InfiniLED.



*A MicroLED coupled to an ultra-thin Plastic Optical Fibre (POF).*

InfiniLED was formed in 2010 on the basis of research carried out in the III-V Materials and Devices group. In 2009 Brian Corbett won the Enterprise Ireland Commercialisation Award for his work on the applications of photonics devices.

Commenting after the awards ceremony, Bill Henry, Chief Commercial Officer of InfiniLED said, "The InfiniLED team is

delighted to hear of this award. Brian is very deserving of it and his selection was an excellent choice by Intel. He has made substantial contributions to both the fundamental understanding of photonic materials and the applications of photonic devices."

"The range of both academic and industrial collaborators that the III-V Group has worked with over the years highlights the breadth of their work. As a former member of Brian's team, I am particularly happy to hear of this award. InfiniLED have an on-going relationship with Tyndall and specifically with Brian's group. We see value in these collaborations," continued Henry.

The award was presented by Kelin Kuhn from Intel. Kuhn is an Intel fellow and director of Advanced Device Technology. Also in attendance at the award presentation was Anita Mcguire, Vice President of Research at University College Cork.

InfiniLED continue to have a strong on-going relationship with Corbett's research group and the Tyndall National Institute. As well as an access agreement with Tyndall, InfiniLED have a number of research project focussed on new developments and industrial applications of the MicroLED technology.

InfiniLED develops a range of LED light source modules based on the patented  $\mu$ LED (MicroLED) technology, which it has licensed from Tyndall. The technology brings a number of performance benefits over widely available normal LEDs; the most significant being the big reduction the illumination area and in battery power required to run the LED. InfiniLED has a number of development contracts with international customers. The areas of application for the technology range from diagnostic testing devices to consumer products.

Brian Corbett received the B.A. Mod degree Experimental Physics and Mathematics and the M.Sc. degree in Theoretical Physics from Trinity College Dublin. Since 1991 he has been a scientist at Tyndall researching the physics and technology of III-V based light emitting semiconductors. He has led and been a member of a large number of EU and Irish research projects.

His research interests are in the realisation of devices and advancing their performance through fabrication processes. Area of applications for this devices have included telecommunications, data communications, data-storage, sensing, medical and energy conversion. Corbett has over 150 academic publications and numerous patents which have been licensed to both Irish and international companies.

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## Plessey branches out with Mouser

The firm's gallium nitride based LEDs will be one of the products distributed by Mouser

Mouser Electronics has signed a global distribution agreement for Plessey's complete range of products including Plessey's award winning products such as the EPIC sensor and MAGIC GaN LEDs.

"Mouser is pleased to partner with Plessey to distribute their innovative semiconductor products to our customers

across the globe,” says Mike Scott, Mouser Vice President of Semiconductors. “We always aim to provide design engineers with the latest technologies so that they can create state of the art solutions. Plessey has built its global brand recognition over the decades by being one of the true innovators in the electronics industry always pushing the boundaries to deliver novel and clever solutions.”

Michael LeGoff, Plessey’s CEO, comments, “Mouser is one of the leading distributors in the world and thus enables us to reach out to customers everywhere so that they can find out about our technologies and how they can use them to do things that could not be done any other way.”

With its broad product line, Mouser caters to design engineers and buyers by delivering What’s Next in advanced technologies.

## Telecoms

### GigOptix bites back at MACOM patent allegations

GigOptix will be filing a response with the United States District Court for the Northern District of California in accordance with applicable rules

GigOptix, a supplier of semiconductor and optical communications components, says it has reviewed the complaint for patent infringement filed against it by M/A-COM Technology Solutions (MACOM).

In its review of the complaint filed by MACOM, GigOptix notes that the complaint references a December 2008 lawsuit filed in the Superior Court of Los Angeles County, California entitled Pacific Wave Industries, Inc. v. University of Southern California which named GigOptix’ wholly-owned subsidiary, Lumera Corporation as a defendant.

According to GigOptix, neither Lumera nor GigOptix had any knowledge of this earlier lawsuit, and records of the Superior Court of Los Angeles County, California contain no proof of service of the lawsuit on Lumera, but do contain a filing by plaintiff Pacific Wave Industries stating that it had not served Lumera.

Shortly after making that filing, in June 2009, plaintiff Pacific Wave Industries dismissed Lumera as a defendant and also dismissed the entirety of the lawsuit.

According to the records of the U.S. Patent and Trademark Office, Pacific Wave Industries executed on August 10th 2013, a written assignment to MACOM of the two patents at issue in the MACOM complaint, just as the Superior Court of Santa Clara County, California was continuing from August 26th, 2013 to September 23rd, 2013 for administrative reasons the trial date in the lawsuit brought by GigOptix against MACOM, its subsidiary Optomai, Inc., and three of GigOptix’ former employees for misappropriation of confidential information

and trade secrets and breach of the contractual and legal obligations to GigOptix of the former employees, and while certain of the individuals named as defendants by GigOptix are being investigated also by the United States Attorneys’ Office for the Northern District of California.

GigOptix does not believe that Pacific Wave Industries ever developed products practicing the claims in the two patents, and is unaware of MACOM having any such or related developments or products in the marketplace, more so during the few weeks since its assignment.

In light of MACOM’s assertion that it has made an “investment in innovation”, GigOptix expects that there will be discovery regarding MACOM’s intention in acquiring these two patents and the contribution of them to the enrichment of its “innovation” portfolio.

GigOptix will continue to review the two patents at issue in the complaint filed by MACOM. However, while GigOptix is continuing its investigation, and recognising that the outcome is not presently known, in light of the initial discovered facts, the claims and the products, GigOptix doesn’t believe that MACOM’s actions will have any material impact on GigOptix’ financial position.

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, defense and avionics industries.

### Unveiling strange magnetic behaviour at semiconductor interfaces

A new discovery could one day lead to electronic materials that provide both computation and data storage

Alone, neither lanthanum aluminate nor strontium titanate exhibit any particularly notable properties. But when they are layered together, they become not only conductive, but also magnetic.

In the current online edition of *Nature Physics*, researchers at The Ohio State University report what they say is the first-ever theoretical explanation to be offered for this phenomenon since it was discovered in 2004.

Understanding how these two semiconductors interact at their interface could someday lead to a different kind of material - one that provides a single platform for computation and data storage, says Mohit Randeria, co-author of the paper and professor of physics at Ohio State.

“The whole question is, how can you take two materials which do not conduct electricity and do not have magnetic properties, make a sandwich out of them and - lo and behold - at the interface between them, charge begins to flow and interesting magnetic effects happen?” he says.

“It’s like taking two pieces of bread and putting them together and having the sandwich filling magically appear.”

By making calculations and modelling the basic physical properties of both materials, Randeria’s team has hit upon an explanation for the behaviour that seems ironic: the interface between two non-magnetic materials exhibits magnetism.

“Randeria’s team has hit upon an explanation for the behaviour that seems ironic: the interface between two non-magnetic materials exhibits magnetism.”

The team showed how the elemental units of magnetism, called “local moments,” are formed at the interface of the two materials. They then demonstrated how these moments interact with the conducting electrons to give rise to a magnetic state in which the moments are arranged in an unusual spiral pattern.

If the physicists’ explanation is correct, then perhaps someday, electronic devices could be constructed that exploit the interface between two oxides. Theoretically, such devices would combine the computational abilities of a silicon chip with the magnetic data storage abilities of permanent magnets like iron.

“If you had conduction and magnetism available in the same platform, it could be possible to integrate computer memory with data processing. Maybe different kinds of computation would be possible,” Randeria comments.

But those applications are a long way off. Right now, the physicists hope that their theoretical explanation for the strange magnetic behaviour will enable other researchers to perform experiments and confirm it.

This work is described in detail in the paper, “Ferromagnetic exchange, spin-orbit coupling and spiral magnetism at the LaAlO<sub>3</sub>/SrTiO<sub>3</sub> interface,” by Sumilan Banerjee *et al* in *Nature Physics* (2013) published online on 25th August 2013. doi:10.1038/nphys2702

This research was sponsored by the U.S. Department of Energy, the National Science Foundation (NSF), and Ohio State’s Centre for Emergent Materials, one of a network of Materials Research Science and Engineering Centres funded by NSF.

## Vishay launches AlGaAs 940nm IR emitter

The aluminium gallium arsenide device is suited to fast gesture remote control applications

Vishay Intertechnology is broadening its optoelectronics portfolio with the introduction of a new high-power, high-speed 940 nm infrared emitter for gesture remote control applications.

The AlGaAs VSLB9530S module offers a radiant power of 40 mW at 100 mA, and is offered in a clear molded, leaded TELUX package with an oval lens designed to support an angle of half

intensity of +/- 18° in the vertical direction and +/- 36° in the horizontal direction.



The VSLB9530S is built on AlGaAs multi-quantum well (MQW) technology. The device’s angular distribution makes it ideal for gesture remote control of televisions and gaming systems, where it provides excellent spectral matching with silicon photodetectors.

The IR emitter’s wider angle in the horizontal view helps maintain position flexibility for users, while the narrower angle in the vertical plane focuses the distributed radiant intensity.

The TELUX package of the VSLB9530S measures 7.62 mm by 7.62 mm by 4.6 mm and provides a low thermal resistance of 200 K/W.

Vishay says while standard IR emitters typically offer drive currents to 100 mA, the low thermal resistivity of the VSLB9530S allows continuous drive currents up to 150 mA, which pushes the achievable radiant intensity to 60 mW/sr at 150 mA. The device offers high modulation bandwidth of 24 MHz and is suitable for high pulse current operation.

The infrared emitter offers fast switching speeds down to 15ns, low forward voltage down to 1.31 V at 150 mA, and an operating temperature range from -40°C to +95°C. Compatible with wave solder processes according to CECC 00802, the VSLB9530 is compliant to RoHS Directive 2011/65/EU, halogen-free per JEDEC JS709A, and conforms to Vishay’s “Green” standards.

Samples and production quantities of the new infrared emitters are available now, with lead times of six to eight weeks for large orders.

Vishay Intertechnology, Inc., manufactures discrete semiconductors (diodes, MOSFETs, and infrared optoelectronics) and passive electronic components (resistors, inductors, and capacitors).

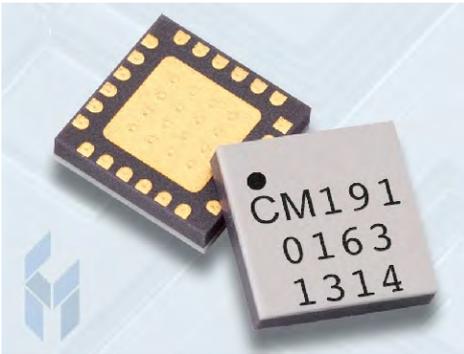
## Custom MMIC releases 4 to 10GHz GaAs driver amplifier

The gallium arsenide MMIC device is suited for communications systems requiring small size and high linearity. These include WiLAN, C and X Band communications systems,

and military applications

Custom MMIC, a developer of performance-driven monolithic microwave integrated circuits (MMICs), has added a new product to its portfolio.

The CMD191C4 is a GaAs MMIC driver amplifier housed in a leadless, RoHs compliant, 4 x 4 mm surface mount package. It offers high output power and low current consumption.



Custom MMIC CMD191C4 device

Ideally suited for complex communications systems where small size and high linearity are needed, the device operates from 4 to 10 GHz and delivers 20 dB of gain with a corresponding output 1 dB compression point of greater than +21 dBm. It is a 50  $\Omega$  matched design, which eliminates the need for external DC blocks and RF port matching.

The CMD191C4 is biased with a single 5V positive drain supply. RF power can be applied at any time.

Suitable applications include WiLAN, C and X Band communications systems, and military end-use.

## GigOptix and MACOM still at loggerheads

MACOM has filed patent infringement claims against GigOptix regarding optical communication areas, including the use of polymer thin films for light modulation



GigOptix has been filed a lawsuit in the United States District Court for the Northern District of California from MACOM.

The lawsuit alleges that GigOptix' polymer technology is infringing on two patents in which MACOM claims rights.

This latest lawsuit was filed without any prior demands or notice by MACOM. This is even though the GigOptix lawsuit in the Superior Court of Santa Clara County, California against MACOM, its subsidiary Optomai, Inc., and three of GigOptix' former employees for misappropriation of confidential information and trade secrets and breach of the contractual and legal obligations to GigOptix of the former employees is scheduled for a jury trial on September 23rd, 2013.

This will be just after the Superior Court has denied motions filed by the defendants to stay the GigOptix lawsuit on the basis that certain individual defendants employed by MACOM and previously employed by GigOptix are being investigated by the United States Attorneys' Office for the Northern District of California.

GigOptix has not been served with a copy of the complaint filed by MACOM, but intends to vigorously defend its innovations in various optical communication areas, including the use of polymer thin films for light modulation.

Once GigOptix has been served with a copy of the complaint, it will review the claims made by MACOM and assess its response.

## Asymmetric topological insulators accelerate computers

Researchers have progressed in their understanding of topological insulators such as the tellurides of mercury, bismuth and antimony. These materials have the potential to be the building blocks of a quantum computer



New research shows that a class of materials being eyed for the next generation of computers behaves asymmetrically at the sub-atomic level.

This could be a key step towards understanding topological insulators that may have the potential to be the building blocks of a super-fast quantum computer running on almost no electricity.

A topological insulator is a material that behaves like an insulator in its interior but whose surface contains conducting states.

The study performed by scientists from the Energy Department's National Renewable Energy Laboratory (NREL) used calculations based on first principles and co-authored the paper which appears in the current issue of *Nature Physics*.

In the paper, researchers explain how the materials act differently above and below the Dirac point and how the orbital and spin texture of topological insulator states switched exactly at the Dirac point.

The Dirac point refers to the place where two conical forms - one representing energy, the other momentum - come together at a point.

In the case of topological insulators, the orbital and spin textures of the sub-atomic particles switch precisely at the Dirac point. The phenomenon occurs because of the relationship between electrons and their holes in a semiconductor.

This research is a key step toward understanding topological insulators like bismuth selenide ( $\text{Bi}_2\text{Se}_3$ ), bismuth telluride ( $\text{Bi}_2\text{Te}_3$ ), antimony telluride ( $\text{Sb}_2\text{Te}_3$ ), and mercury telluride ( $\text{HgTe}$ ) that may have the potential to be the building blocks of a quantum computer, a machine with the potential of loading the information from a data centre into the space of a laptop and processing data much faster than today's best supercomputers.

"The energy efficiency should be much better," notes NREL Scientist Jun-Wei Luo, one of the co-authors. Instead of being confined to the on-and-off switches of the binary code, a quantum computer will act more like the human brain, seeing something but imagining much more, he said. "This is entirely different technology."

Topological Insulators are of great interest currently for their potential to use their exotic properties to transmit information on electron spins with virtually no expenditure of electricity, said Luo. NREL's Xiuwen Zhang is another co-author as are scientists from University of Colorado, Rutgers University, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, and the Colorado School of Mines.

Luo and Zhang work in NREL's Centre for Inverse Design, one of 46 Energy Frontier Research Centres established around the nation by the Energy Department's Office of Science in 2009 to accelerate basic research on energy.

The finding of orbital texture switch at Dirac point implies the novel backwards spin texture - right-handed instead of left-handed, in the short-hand of physicists - comes from the coupling of spin texture to the orbital texture for the conserved quantity is total angular momentum of the wave function, not spin. The new findings, supported partly by observations taken at the Advanced Light Source at Lawrence Berkeley National Laboratory, were surprising and bolster the potential of the topological insulators.

"In this paper, we computed and measured the profile of the topological states and found that the orbital texture of topological states switches from tangential to radial across the Dirac point," Zhang says. Equally surprising, they found that phenomenon wasn't a function of a unique material, but was common to all topological insulators.

The topological insulators probably won't be practical for solar cells, because at the surface they contain no band gap. In other words, there is no gap from the material being in a conducting state and an inert state. A bandgap is essential for solar cells to free photons and have them turn into energy carrying electrons.

But these topological insulators could be very useful for other kinds of electronics-spintronics. The electrons of topological insulators will self-polarise at opposite device edges. "We usually drive the electron in a particular direction to spatially separate the spin-up and spin-down electrons, but this exotic property suggests that electrons as a group don't have to move," Luo says.

He adds, "The initial idea is we don't need any current to polarize the electron spins. We may be able to develop a spin quantum computer and spin quantum computations."

In theory, an entire data centre could operate with virtually no electricity. "That's probably more in theory than reality," Luo continues, noting that other components of the centre likely would still need electricity. "But it would be far more energy efficient." And the steep drop in electricity would also mean a steep drop in the number of coolers and fans needed to cool things down.

Luo cautions that this is still basic science. The findings may have limited application to renewable energy, but he points out that another of NREL's key missions is energy efficiency.

The researchers' work is described in detail in the article, "Mapping the orbital wavefunction of the surface states in three-dimensional topological insulators," by Yue Cao *et al* in *Nature Physics* 9, 499 - 504, (2013). [DOI:10.1038/nphys2685](https://doi.org/10.1038/nphys2685)

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## Emcore unveils 1550 nm directly-modulated CATV transmitter

The GaInAsP (gallium indium arsenide phosphide) device comes in a number of fixed fibre length options up to 25 km. They are ideal for extending traditional hybrid fibre coaxial CATV systems

The Medallion 8000 is the latest addition to Emcore's 1550 nm CATV fibre optic transmitter portfolio.



It is designed for wideband applications that require both CATV and Satellite-Intermediate Frequency (SAT-IF) signals to be transmitted over fibre lengths up to 30 km.

This facilitates network designs that use a single transmitter to carry multiple signals, while lowering costs, system complexity

and rack space requirements.

The Medallion 8000 supports 79-channel NTSC analogue signals and/or a combination of Quadrature Amplitude Modulation (QAM) and SAT-IF signals with a reduced number of CATV analogue channels.

It features fixed fibre length options of 0 - 10 km, 5 - 15 km, 10 - 20 km and 15 - 25 km with a maximum of 18 dBm Stimulated Brillouin Scattering (SBS) suppression, and is also available with a selectable fibre length option.

The selectable fibre length option allows the user to set the Medallion 8000 for best optimized CSO (Composite Second Order) distortions at any fibre length from 0 - 30 km in 1 km increments and has a maximum SBS suppression of 20 dBm.

The Medallion 8000 family of transmitter products is designed to support various CATV transmitter applications with a common platform. A 75 ohm CATV RF video input supports frequencies up to 1002 MHz. Design features including low chirp control, noise suppression circuitry, and patented pre-distortion technology that provides outstanding performance with Emcore's wide range of cooled broadband directly-modulated lasers. A second 75 ohm RF input supports frequencies up to 2700 MHz for FTTP (Fibre-To-The-Premises), SAT-IF, and wireless applications.

«The new Medallion 8000 directly-modulated transmitter family builds on the strengths of our popular Medallion 6000 externally-modulated series and augments our offering for concurrent transmission of CATV and SAT-IF signals over fibre,» says Jaime Reloj, Vice President of Business Development for Emcore.

«Network providers are demanding high-quality, economical delivery of video to their customers, while extending capacity and improving network management intelligence. The Medallion 8000 series transmitters are ideal for extending traditional hybrid fibre coaxial CATV systems, for RF overlay for FTTP, and for RfOG (Radio Frequency over Glass) projects in countries around the world.»

Monitoring and configuration of the Medallion 8000 is supported by Emcore's latest generation Web GUI, Telnet and Simple Network Management Protocol (SNMP) software via a convenient front panel display, RS-232 port, and Ethernet port.

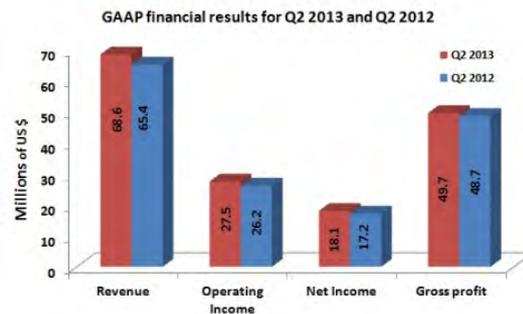
The feature-rich WEB GUI and latest SNMP enhancements bring a whole suite of advanced operator monitoring and configuration options to the platform, allowing for secure, simplified and future-ready functionality for the next generation of intelligent networks.

The Medallion platform is mechanically designed for flexibility and space efficiency including universal rack-mount features, modular front panel design for private label convenience, and optional front and rear port placement. Dual-redundant field-replaceable fans and power supplies are standard.

## Hittite Microwave on the rise in Q2 2013

The company has shown robust financial results in revenues, profits and incomes

Hittite Microwave Corporation has reported revenues for the second quarter ended June 30th, 2013 of \$68.6 million, an increase of 4.9% compared with \$65.4 million for the second quarter of 2012.

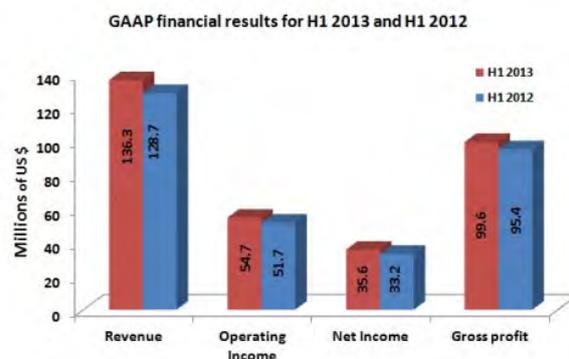


Net income for the quarter was \$18.0 million, or \$0.58 per diluted share, an increase of 5.1% compared with \$17.2 million, or \$0.56 per diluted share, for the second quarter of 2012.

For the second quarter of 2013, revenue from customers in the United States was \$30.2 million, or 44.0% of the company's total revenue, and revenue from customers outside the United States was \$38.4 million, or 56.0% of total revenue.

Gross margin was 72.4% for the second quarter of 2013, compared with 74.5% for the second quarter of 2012 and 73.7% for the first quarter of 2013. Operating income for the second quarter of 2013 was \$27.5 million, or 40.1% of revenue, compared with \$26.2 million, or 40.1% of revenue, for the second quarter of 2012 and \$27.1 million.. Total cash and marketable securities at June 30th, 2013 was \$438.2 million, an increase of \$8.8 million for the quarter.

Results for the first half of 2013 and 2012 are depicted in the graph below.



### Business Outlook

The company expects revenue for the third quarter ending September 30th, 2013 to be in the range of \$66.5 million to \$68.5 million and net income to be in the range of \$16.7 million to \$17.7 million, or \$0.54 to \$0.57 per diluted share.

The company hosted a conference call to discuss its financial results and a webcast replay is available by visiting the Investors page at [www.hittite.com](http://www.hittite.com).

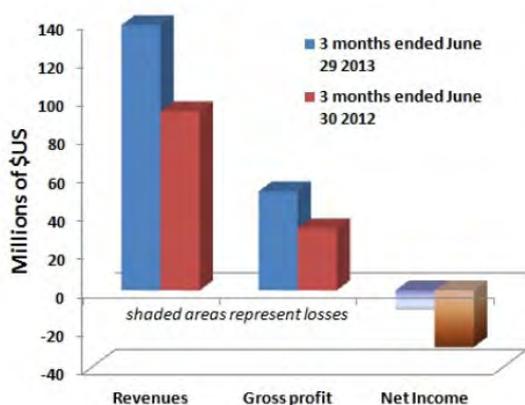
Hittite Microwave Corporation is an innovative designer and manufacturer of high performance integrated circuits, or ICs, modules, subsystems and instrumentation for technically demanding digital, RF, microwave and millimetrewave applications covering DC to 110 GHz. The company also started marketing GaN power amplifiers earlier this month.

## Infinera revenues inflate by 48 percent thanks to DTN-X

The indium phosphide telecoms specialist has had a fruitful 3 months with three new customers deploying its DTN-X platform

Infinera Corporation, an innovator in InP Intelligent Transport Networks, has released financial results for the second quarter ended June 29th, 2013.

GAAP results for Q2 2013 & Q2 2012



GAAP revenues for the second quarter of 2013 were \$138.4 million compared to \$124.6 million in the first quarter of 2013 and \$93.5 million in the second quarter of 2012.

GAAP gross margin for the second quarter of 2013 was 37 percent compared to 34 percent in the first quarter of 2013 and 35 percent in the second quarter of 2012. GAAP net loss for the quarter was \$10.0 million, or \$0.09 per share, compared to net loss of \$15.3 million, or \$0.13 per share, in the first quarter of 2013 and net loss of \$29.5 million, or \$0.27 per share, in the second quarter of 2012.

### Management Commentary

“We continued to increase momentum in the second quarter, delivering strong revenue growth, improved gross margin, and positive cash flow from operations,” said Tom Fallon, chief executive officer. “Customer acceptance of the DTN-X platform also continues to grow. During the quarter, we received seven new purchase commitments, including three from customers new to Infinera, bringing the total number of commitments to 34 since the platform was introduced a year ago.”

“Our success reflects the strategic commitment of our customers to a new architecture as they face massive traffic growth, operational complexity and increasing demand for instant delivery of services. Infinera’s recently announced Intelligent Transport Network offers a clear path for service providers to address these challenges, while providing a compelling economic value proposition.

“We remain focused on winning new network deployments and expanding our market presence to generate sustainable revenue growth and profitability in the future while we help our customers prepare for the Terabit Era.”

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

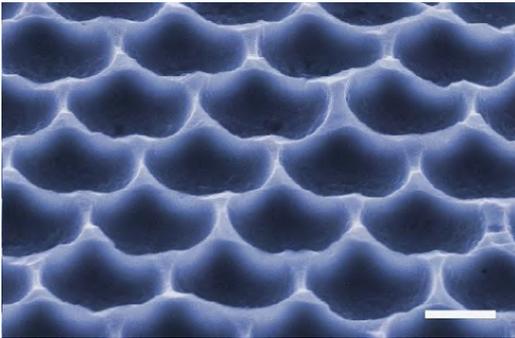
Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, Nature’s peer-reviewed open access journal. “Performance is everything in the solar cell industry, but performance at a reasonable cost is key,” says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. “The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs.” The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They

demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3 µm thick InP thin-films on molybdenum foils with ultra-large grain size up to 100 µm. The researcher say this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500 cm<sup>2</sup>/V-s and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*,<sup>3</sup>, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63

million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass

and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

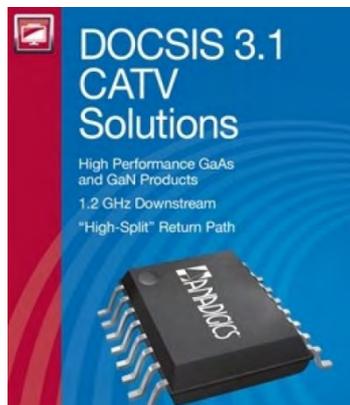
"Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors."

IQE expects to report its interim results around mid-September 2013.

## Anadigics reveals GaAs and GaN amplifiers for network upgrades

The 1.2 GHz gallium arsenide and gallium nitride devices are optimised to help CATV service providers increase their system bandwidth, allowing them to offer additional digital services

Anadigics has unveiled a new family of CATV infrastructure products that is optimised for the proposed data over cable service interface specification (DOCSIS) system standard version 3.1.



These solutions are optimised to help CATV service providers increase their system bandwidth, allowing them to offer additional digital services, including high-definition television and video on demand, and enable higher speed data services. The first product in this family is the ACA2429 GaN power doubler, the industry's first 1.2 GHz surface mount line amplifier.

"Anadigics' DOCSIS 3.1 amplifiers demonstrate our commitment to innovation and product excellence, which are key drivers behind our infrastructure growth strategy," says Tim Laverick, vice president of Infrastructure Products at Anadigics. "By helping manufacturers achieve industry-leading performance and reliability in new 1.2 GHz downstream equipment, we are enabling MSOs to take advantage of this upcoming standard and offer a wider array of exciting services."

Anadigics' newest generation of infrastructure solutions will

include power doubler and push-pull line amplifiers, Edge QAM amplifiers, reverse path amplifiers, and optical receivers. These products are designed to support outstanding picture quality and higher data rates by offering exceptional linearity and noise figure. This level of performance ensures high signal fidelity over extended frequencies up to 1.2 GHz with a "high-split" return path.

The company's DOCSIS 3.1 solutions will also deliver higher output power levels to achieve drop-in upgrades to existing hybrid fibre coax infrastructure systems. The new family of products will leverage Anadigics' proven high linearity GaAs process with exceptional reliability and mean-time-to-failure along with GaN HEMT technology for high output power and optimum power efficiency.

The firm's ACA2429 1.2 GHz GaN power doubler combines Anadigics' MESFET technology with a GaN HEMT output stage. This solution delivers 25 dB gain with +60 dBmV output power and only 10 W of power consumption in a surface mount package. The ACA2429 line amplifier offers exceptional bit error rate, composite triple beat, composite second order, cross modulation, and carrier-to-intermodulation noise characteristics for optimal performance in a fully-loaded spectrum.

## Skyworks not flying so high with new stock repurchase program

The company currently expects to fund the repurchase program using its working capital

Skyworks Solutions, Inc. has authorised the repurchase of up to \$250 million of the company's common stock from time to time prior to July 16th, 2015 on the open market or in privately negotiated transactions,

This is in compliance with applicable securities laws and other legal requirements.

This newly authorised stock repurchase program replaces in its entirety the \$200 million stock repurchase program which was approved by the Board of Directors on November 8th, 2012, and had \$35.6 million of repurchase authority remaining.

The timing and amount of any shares of the company's common stock that are repurchased will be determined by the company's management based on its evaluation of market conditions and other factors. The repurchase program may be suspended or discontinued at any time.

Any repurchased shares will be available for use in connection with its stock plans and for other corporate purposes.

The company currently expects to fund the repurchase program using the company's working capital. As of June 28th, 2013, the company says it had cash and cash equivalents of approximately \$400.3 million.

## Skyworks honoured by Lenovo

The company has been awarded for innovation, reliability and scalability

Skyworks Solutions, Inc. has received the "Outstanding Supplier and Perfect Quality" award from Lenovo for product innovation, delivering perfect quality solutions and serving as a strategic partner.

Skyworks is Lenovo's main provider of analogue and RF solutions, having supported the company through several major product launches and growth in market share. Lenovo leverages a variety of Skyworks' products including SkyHi front-end solutions, multimode, multiband power amplifiers, switches, diodes and global positioning system devices, amongst others.

"Lenovo congratulates Skyworks for their outstanding support and commitment to perfect quality," says David Wang, vice president of procurement at Lenovo. "Over the past few years Skyworks and Lenovo have forged a strong relationship, one that has grown even stronger as Lenovo has become much more than a PC company. We are delighted with Skyworks' reliable, high quality and turnkey solutions, and look forward to collaborating with them for years to come particularly as Lenovo expects to grow its market share in China and abroad."

"At Skyworks we realise the success of our customers depends upon the strength of our services and reliability of our products and we appreciate Lenovo's recognition of our journey towards perfect quality," adds Kenneth J. Huening, vice president of quality at Skyworks.

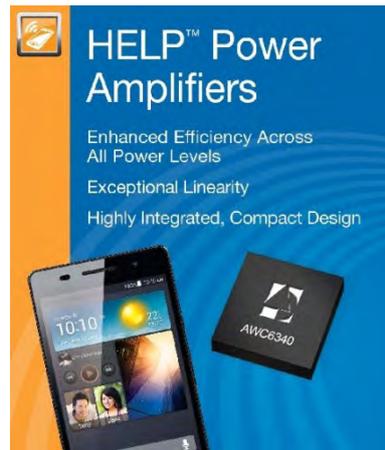
"We are delighted to be partnering with Lenovo to enable a variety of personal technology platforms including smartphones, tablets and smart television with an increasing number of our analogue and connectivity solutions. We also recognise that delivering perfect quality is a key differentiator in today's competitive market."

With sales growing in India, Indonesia, the Philippines, Russia and Vietnam, Gartner predicts that Lenovo will become China's top smartphone vendor in 2013. According to IDC, Lenovo already has the third highest worldwide market share for "Smart Connected Devices" which combines PC, smartphones and tablets.

## Anadigics InGaP technology powers Huawei Ascend P6

The company's HELP 3G indium gallium phosphide power amplifier provides low-power mode efficiency for longer talk time and battery life

Anadigics is shipping production volumes of its AWC6340 HEL (High-Efficiency-at-Low-Power) power amplifier (PA) to Huawei for the new Ascend P6.



This ultra-slim smartphone features a 4.7-inch HD display, 1.5 GHz quad-core processor, 8 megapixel camera, and Android 4.2.2 Jelly Bean operating system.

"We are very pleased to enable 3G connectivity in the Ascend P6, the world's slimmest smartphone," says Navi Miglani, director of product marketing for Cellular Products at Anadigics.

"The selection of Anadigics' AWC6340 power amplifier for this flagship smartphone not only exemplifies the strength of our relationship with Huawei, but also the space-saving and total battery-life benefits across all power levels delivered by our RF solutions. We look forward to working closely with Huawei to continue advancing the fit, form, and function of mobile communications," adds Miglani.

Anadigics' HELP 3G power amplifiers utilise the company's patented InGaP-Plus technology to achieve higher efficiency at low and high power levels and minimize quiescent current, thereby helping to extend battery life in smartphones.

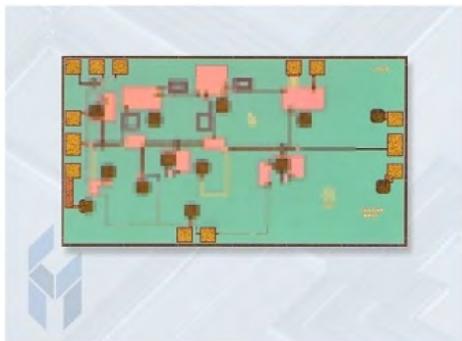
HELP power amplifiers also deliver exceptional linearity to ensure a stable connection for clear voice and high-speed data. The compact 3 mm x 3 mm AWC6340 power amplifier features an internal voltage regulator and integrated RF coupler to simplify design and phone calibration requirements. This level of integration reduces external component requirements and saves valuable PCB space.

## Custom MMIC reveals GaAs low noise amplifier

The gallium arsenide amplifier operates from 33 to 45 GHz and is suited for point-to-point and point-to-multipoint radios

Custom MMIC, a developer of monolithic microwave integrated circuits (MMICs) has added the CMD190 to its MMIC library of standard products.

The CMD190 is an efficient GaAs MMIC ultra low noise amplifier for applications from 33 to 45 GHz. This amplifier delivers over 19 dB of gain with a corresponding noise figure of 2.1 dB at 36 GHz.



CMD190 GaAs MMIC

The CMD190 has an all-positive bias design, and eliminates the complicated and costly negative bias sequencing circuits while also simplifying board layout.

What's more, the use of an on-chip pinch-off tracking circuit ensures consistent performance over temperature and process variation.

The CMD190 is a 50  $\Omega$  matched design, which eliminates the need for external DC blocks and RF port matching. It offers full passivation for increased reliability and moisture protection.

## Nujira mass produced silicon chips rival GaAs for 4G smartphones

Using envelope tracking, these devices reduce power consumption to extend battery life

Nujira has extended its partnership agreement with TowerJazz, as its new NCT-L1300 ET chip is geared up for volume production.

With Envelope Tracking (ET) technology heading towards a 100 percent attach rate in 4G smartphones by 2014, Nujira is building a network of supply chain partners to ensure its chip enters the market seamlessly and is able to meet volume and quality demands.

ET is the leading technology being developed to reduce power consumption of 4G smartphones in order to extend battery life. ET dynamically adapts the Power Amplifier (PA) supply voltage to the signal amplitude, and thus dramatically reducing the power consumption of the PA that transmits the signal to the antenna.

Annual revenue for analogue application specific ICs for 4G mobile handsets forecast to grow from \$827 million in 2012 to \$2.9 billion by 2017, an estimated CAGR of 29 percent.

Anyone who uses 4G phones experiences an empty battery much earlier than with 3G, sometimes in the middle of the day. There are several technologies being developed in order to reduce power consumption of such phones. But recently, ET interfaces have become standardised on LTE basebands, paving the way to a very high adoption rate of this technology.

Nujira believes it is well positioned to take a large portion of the ET market. According to global information provider, IHS, the annual revenue for analogue application specific ICs for 4G mobile handsets is forecast to grow from \$827 million in 2012 to \$2.9 billion by 2017, a compound annual growth rate (CAGR) of 29 percent for the next five years.

Nujira selected TowerJazz, a specialty foundry and fifth largest foundry worldwide, as its manufacturing partner in early 2012.

The NCT-L1300 is fabricated in TowerJazz's 0.18  $\mu\text{m}$  RF CMOS technology, used in hundreds of millions of RF front end devices, with additional uniquely fitted HV modules. Nujira's NCT-L1300 delivers power conversion efficiencies in excess of 80 percent, effectively doubling the efficiency of existing solutions.

Tim Haynes, CEO, Nujira says, "Over the last year we've built an excellent relationship with TowerJazz; its processes offer us the ideal combination of high performance analogue and power management capabilities. Nujira's ET ICs have the highest bandwidth, widest voltage range, fastest slew rates, and lowest output impedance in the market, placing significant demands on the underlying process technology. TowerJazz meets all of these stringent requirements and works closely with us to ensure a high success rate and competitive time to market."

"As the world's largest specialty analogue foundry, TowerJazz offers us the experience and capacity to address the high volume smartphone market, and enables us to meet the price points demanded by the world's largest smartphone vendors. Moving our new IC into volume production is a critical step for our business, and with its process expertise, wafer capacity and security of supply across multiple fabs, TowerJazz is the right foundry partner for Nujira," adds Haynes.

"Nujira's technology has huge potential, with ET technology heading towards a 100 percent attach rate in LTE smartphones in 2014. We are excited to be their partner and to be supporting them in volume production of their NCT-L1300. Nujira's chips combine wireless communications and smart energy, which are two high growth focus areas for TowerJazz," notes Russell Ellwanger, TowerJazz CEO.

"As one of the world's largest foundries and with capacity on three continents, TowerJazz offers a unique combination of specialty processes and wafer capacity, enabling high growth fabless IC companies like Nujira to rely on us as their silicon supplier."

The NCT-L1300 is packaged in a low-profile Wafer-Level Chip Scale Package, and started sampling to lead customers in June.

# RF Electronics

## TriQuint recruits new distributor in Korea

L&K Tech and TriQuint will work together to deliver the benefits of TriQuint's technology to customers throughout the region

TriQuint Semiconductor has appointed L&K Tech Inc. as its new distributor in Korea for its entire RF product portfolio.

"We see Korea as a significant market for growth so it is imperative for us to select a partner with a successful track record," says S.J. Kim, TriQuint Korea Country Manager.

"L&K has an excellent reputation for working closely with its partners and customers to quickly resolve problems and meet customers' unique needs. We believe L&K's strong sales and support team will lead to significantly increased revenues and market share for both TriQuint and L&K," he continues.

"We are delighted to represent TriQuint in Korea. TriQuint is recognised as a leader in providing advanced, high-performance RF products. Its innovative solutions boost performance and extend reach while reducing size and bill of materials. We look forward to partnering closely with TriQuint to deliver the benefits of its technology to customers throughout our region," adds Young-Ik Hwang, CEO of L&K Tech, Inc."

L&K, located in Seoul, Korea, delivers innovative and the latest technology products, engineering services and customised technical solutions based on their talented application design team.

With this new partnership, TriQuint's customers in Korea now have an expanded channel to access the industry's broadest RF product lines.

## Skyworks powers MediaTek's dual-core smartphone platforms

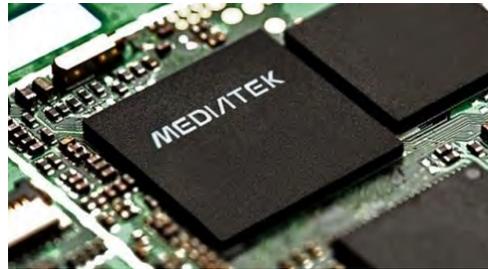
III-V and silicon integrated chips work together for smartphones

Skyworks Solutions has announced that MediaTek is leveraging several of Skyworks' front-end solutions in its dual-core MT6572 platform.

This platform supports multiple tier-one smartphone manufacturers in emerging markets.

MediaTek, a fabless semiconductor company is supplying complete chipset solutions that couples its own baseband processor, radio, software, multimedia and connectivity product offerings, with front-end solutions to offer a turnkey approach to manufacturers who supply handsets to consumers around the world.

The MT6572 is said to be the world's first dual-core, system-on-a-chip platform with high-speed-packet-access, integrated WiFi, FM, GPS and Bluetooth functionality delivered in a cost-effective, four-layer printed circuit board.



MT6572 SOC chip

This system-level design reduces bill-of-material costs, simplifies the product development cycle and enhances time to market.

"MediaTek is excited to be extending its collaboration with Skyworks Solutions," says Jeffrey Ju, general manager of the MediaTek's smartphone business.

"Skyworks is a proven innovator and their leading-edge, best-in-class solutions make them the ideal partner as we look to deliver next-generation smartphones with features and performance associated exclusively with high-end platforms."

"As the transition to smartphones in the emerging markets continues to accelerate, Skyworks is pleased to be working with MediaTek, a leader in system-on-chip cellular platforms," continues Bradley C. Byk, senior vice president of worldwide sales at Skyworks.

He continues, "As the solutions provider of choice, Skyworks looks forward to capitalising on the exploding smartphone growth in emerging markets."

Industry analysts expect future smartphone growth to come from emerging markets where consumers are upgrading from feature phones to entry-level platforms. According to IDC, 1.7 billion smart connected devices (tablets, smartphones and PCs) will be shipped worldwide in 2014.

Of those 1.7 billion units, 1 billion will be delivered to emerging markets, with smartphones and tablets comprising more than the majority of units. Specifically, IDC estimates emerging markets will see a compound annual growth rate of 17 percent from 2012 to 2017 for connected devices.

The new MT6572 integrates a power-efficient, dual-core Cortex-A7 central processing unit sub-system with speeds up to 1.2 gigahertz in 28nm. The new platform also integrates MediaTek's advanced, multimode Rel. 8 HSPA+/TD-SCDMA modem, 3G graphics, support up to HD 720p video playback and record, 5 megapixel camera and up to qHD displays.

Supporting the leading picture quality technologies inherited from MediaTek's extensive experience in the digital television market, the MT6572 delivers an innovative solution that offers the finest visual quality and outstanding user experience for high-end smartphone consumers.

The fully matched, 14-pad SKY77758 power amplifier (PA) module packs full coverage for Bands I, II, V, VIII into a single, compact 3.0 x 4.2 x 0.9 mm package.

The small and efficient surface mount module meets stringent spectral linearity requirements for WCDMA, HSDPA, HSUPA, HSPA+ transmission with high power-added efficiency. A directional coupler integrated into the module eliminates the need for any external coupler.

The single GaAs, microwave monolithic integrated circuit (MMIC) contains all active circuitry in the module. The MMIC contains on-board bias circuitry, as well as input and interstage matching circuits.

Output match into a 50Ω load is realised off-chip within the module package to optimise efficiency and power performance.

The SKY77590-11, SKY77590-21, SKY77590-51, SKY77590-61, SKY77593, SKY77594, SKY77595 and SKY77596 are transmit (Tx)/receive front-end modules designed in a very low profile (0.9 mm) and 6 x 6 mm compact form factor for quad-band cellular handsets comprising GSM850/900, DCS1800 and PCS 1900 operation.

The complete transmit VCO-to-antenna and antenna-to-receive, surface acoustic wave filter modules consist of Tx harmonic filtering, a high linearity/low insertion loss switch, and a complementary metal-oxide semiconductor, PA control block.

A custom silicon integrated circuit contains decoder circuitry to control the RF switch while providing a low current, external control interface.

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## TriQuint endorses awards along with CAP Wireless acquisition

TriQuint's Board of Directors approved 67,900 stock options and 46,760 RSU awards to former CAP Wireless employees

TriQuint's Board of Directors' Compensation Committee has approved stock options and restricted stock unit (RSU) awards in conjunction with the firm's acquisition of California based CAP Wireless, Inc.

Terms of the acquisition were not disclosed and the impact to earnings this year is expected to be immaterial.

The directors approved 67,900 stock options and 46,760 RSU awards to former CAP Wireless employees under the 'TriQuint 2008 Inducement Plan'.

The awards were granted August 7th, 2013. The stock options will expire on August 7th, 2023 and will vest 25 percent on August 7th, 2014 with the remaining 75 percent vesting quarterly over the next three years, and have an exercise price equal to 100 percent of the closing price of TQNT common stock on Aug 7th, 2013.

The RSUs will vest 25 percent on August 1st, 2014 with the remaining 75 percent vesting annually over the next three years.

TriQuint's Compensation Committee, which is solely comprised of independent directors, approved the grant of the awards on August 7th, 2013 in accordance with NASDAQ Listing Standard 5635(c)(4).

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## TriQuint acquires CAP Wireless and its spatium technology

TriQuint estimates that the TWTA market opportunity will be about \$600 million by 2015.



TriQuint Semiconductor, Inc has announced that it has acquired CAP Wireless (Newbury Park, CA) and its patented Spatium RF power combining technology that replaces traveling wave tube amplifiers (TWTAs) in communications and defence systems.

TriQuint estimates that the TWTA market opportunity will be about \$600 million by 2015.

The acquisition leverages TriQuint's position as a gallium nitride (GaN) pioneer and CAP Wireless' high power RF solid state amplifier system expertise. The combined company now offers a wider selection of high power / high frequency products. CAP Wireless' Spatium technology adds to the exceptional bandwidth, efficiency and ruggedness of TriQuint's product portfolio.

Spatium technology dramatically improves broadband RF power efficiency through the use of patented coaxial spatial combining techniques. Spatium provides other performance advantages including solid-state reliability, smaller form factors, higher power densities and reduced weight compared to either TWTA-based systems or conventional planar power combining products. Spatium can provide faster time-to-market and can seamlessly incorporate GaN MMIC performance breakthroughs while reducing product lifecycle costs.

TriQuint Vice President and General Manager for Infrastructure and Defence Products, James L. Klein, noted that TriQuint's acquisition of CAP Wireless merges a unique approach to high power RF amplifier system design with the benefits of TriQuint GaN device technology.

“CAP Wireless initially developed its Spatium amplifier platform using gallium arsenide-based (GaAs) MMICs. GaN-based products from TriQuint can elevate Spatium to new levels of efficiency, power density, frequency coverage and output power.”

CAP Wireless' Spatium products are currently being sold and designed into several U.S. and international defense and commercial programs. TriQuint will focus Spatium technology development as a solution for high efficiency power applications in commercial and defence markets, including electronic warfare (EW), communications and radar. TriQuint's reliable supply of high performance MMICs, combined with its volume manufacturing expertise will benefit immediate and long-term customer requirements for Spatium-based and conventional amplifier products.

TriQuint is continuing operation of CAP Wireless product sales and contracts while it develops new devices based on Spatium technology using TriQuint GaN and GaAs MMIC amplifiers.

## Samsung Selects Anadigics for Galaxy Mega

Anadigics provide the wireless connectivity in the new Galaxy Mega

Anadigics Inc. has announced that the Company's AWT6751 and AWT6755 dual-band ProEfficient-Plus WCDMA power amplifiers (PAs) enable wireless connectivity in the new Galaxy Mega by Samsung Electronics. This phablet features either an expansive 6.3 or 5.8-inch display blending the functionality and form factor of both a smartphone and tablet. The Galaxy Mega offers up to a 1.7 GHz dual-core processor, 8 megapixel camera, and Android 4.2.2 Jelly Bean operating system.

“The selection of Anadigics' AWT6751 and AWT6755 power amplifiers for the Galaxy Mega demonstrates the tremendous strength of our relationship with Samsung, and the compelling advantages enabled by ProEfficient-Plus technology,” said Jerry Miller, senior vice president of Cellular Products at ANADIGICS. “Our dual-band ProEfficient-Plus solutions not only help to extend battery life in power-hungry, large-screen mobile devices, but also deliver space-saving integration to provide greater design flexibility. We are extremely pleased to work closely with Samsung and look forward to powering the next-generation of feature-rich smartphones, phablets and tablets.”

Anadigics' dual-band ProEfficient-Plus solutions utilize the Company's exclusive InGaP-Plus technology and patented design architectures to deliver exceptional performance and integration. These power amplifiers deliver industry-leading efficiency in low-power mode for greater talk time and high-power mode for longer data application use. This level of performance, combined with exceptionally low quiescent currents without the use of a DC/DC converter, maximizes battery life in 3G mobile devices. ProEfficient-Plus power amplifiers are also compatible with average power tracking (APT) to further increase efficiency and reduce current consumption at medium and low operating powers. The complete family of dual-band ProEfficient-Plus solutions are

offered in compact 3 mm x 4 mm x 0.9 mm packages and feature internal voltage regulation to save valuable PCB space.

ANADIGICS Dual-Band ProEfficient-Plus Family Key Facts and Highlights:

- Industry-leading efficiency across all power levels and exceptionally low quiescent current to maximize battery life, including longer talk time and data use
- Two independent amplification chains to provide industry-leading performance for each band
- Compact 3 mm x 4 mm x 0.9 mm package with internal voltage regulation and integrated DC blocks on the RF ports to reduce PCB space requirements
- Best-in-class linearity to maintain stable, high-throughput 3G connections
- RF matching optimized for output power, efficiency, and linearity in a 50-Ohm system

## TriQuint half yearly incomes nose dive

On a positive note, the company's quarterly results were mainly an improvement over the same quarter last year

TriQuint Semiconductor, an RF solutions supplier and technology innovator, has announced its financial results for the quarter ending June 29th, 2013.

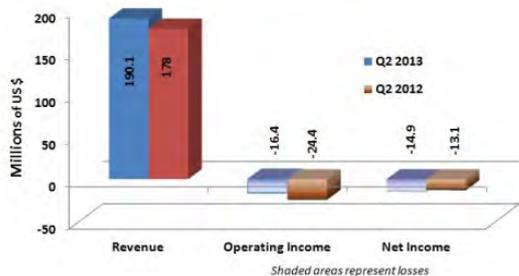
GAAP results for Q2 2013

Revenue for the second quarter of 2013 was \$190.1 million, up 7 percent from the second quarter of 2012 and up 3 percent sequentially. Revenue grew in all three markets from the second quarter of 2012. For example, the mobile devices market revenue grew 5 percent over the same period a year ago.

Cash and investments decreased by \$51.8 million to \$89.3 million in the quarter due primarily to the share buyback and planned growth in inventory. The company repurchased 7.7 million shares for \$51.1 million and also the company doubled BAW capacity compared to last year's levels.

Gross margin for the second quarter of 2013 was 29.8 percent, up sequentially from 21.0 percent due to the absence of a now resolved Q1 quality issue, higher revenue, higher factory utilisation and better yields. Operating expenses for the second quarter of 2013 were \$73.1 million, consistent with the previous quarter.

GAAP financial results for Q1 2013 and Q2 2012

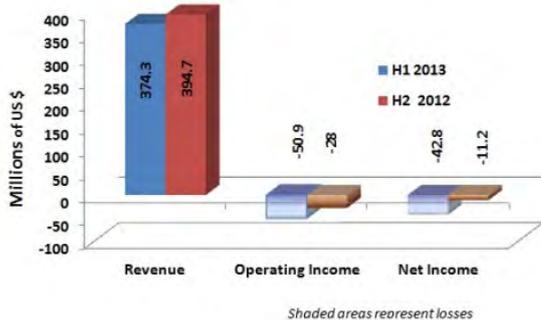


GAAP results for H1 2013

Looking at the first half of the year, financials were not as good as for just the quarter. Revenues decreased by 5.4 percent from \$394.7 million in H1 2012 to \$374.3 million in H1 2013. For the same periods, operating income fared much worse, with losses increasing by 45 percent, while even worse, net losses increased by a massive 74 percent.

A graph below summarises the results for the first half of 2013 as compared to the first half of 2012.

GAAP financial results for H1 2013 and H1 2012



Commenting on the results, Ralph Quinsey, President and Chief Executive Officer, stated, "It is an exciting time for TriQuint. Our results exceeded our April guidance, but more importantly, this marks the beginning of the next phase of growth at TriQuint. In Q3 2013, I expect revenue to jump 30 percent sequentially, bringing significantly improved margins and profitability. I believe Q3 is the beginning of a stronger period of performance for TriQuint, built on a differentiated strategy that is defensible and sustainable. Our strategic focus is on innovation, technology and a comprehensive RF capability. Our investments in proprietary GaN, BAW and advanced SAW are examples of where we set ourselves apart from the competition and I believe our Q3 outlook validates our path."

Net loss for the second quarter of 2013 was \$14.9 million or \$(0.09) per share, compared with a net loss of \$27.9 million, or \$(0.17) per share, in the previous quarter.

Non-GAAP Results

Gross margin for the second quarter was 31.3 percent, up sequentially from 22.8 percent due to the absence of a now resolved Q1 quality issue, higher revenue, improved factory utilisation and better yields. Operating expenses for the quarter were \$69.6 million, up 2 percent sequentially.

Net loss for the second quarter of 2013 was \$10.9 million, or \$(0.07) per share, improved sequentially from a net loss of \$27.2 million or \$(0.17) per share.

Outlook:

The company believes third quarter 2013 revenue will be between \$245 million and \$255 million and is currently 90 percent booked to the midpoint of this guidance.

Non-GAAP gross margin is expected to be between 34 percent and 36 percent, driven primarily by higher expected revenue. Third quarter non-GAAP net income is expected to be between \$0.09 and \$0.11 per diluted share. Solid results in the second quarter and our current expectation for the remainder of the year lead us to believe non-GAAP earnings of at least \$0.05 per diluted share for fiscal 2013 is a reasonable expectation.

The company did not discuss its outlook based on GAAP measures.

TriQuint hosted a conference call discussing the results for the quarter and its future expectations for the company. The call can be heard via webcast accessed through the "Investors" section of TriQuint's web site at: <http://invest.triquint.com>.

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks.

The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory.

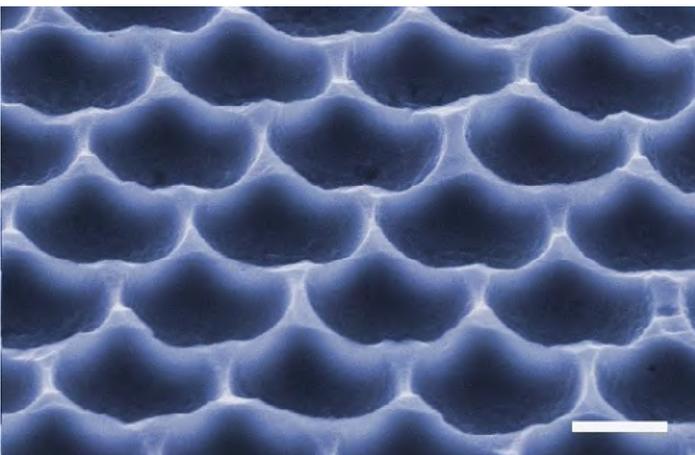
"The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs."

The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3 µm thick InP thin-films on molybdenum foils with ultra-large grain size up to 100 µm. The researcher says this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500 cm<sup>2</sup>/V-s and minority carrier lifetimes as long

as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*,<sup>3</sup>, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## RFMD to sell GaAs manufacturing facility to Compound Photonics

The selling of the UK plant, which manufactures gallium arsenide wafers, will save the firm \$20 million per year

RF Micro Devices has agreed to sell its GaAs semiconductor manufacturing facility in Newton Aycliffe, in the U.K. to Phoenix-based Compound Photonics.

The facility is Europe's largest GaAs manufacturing facility.

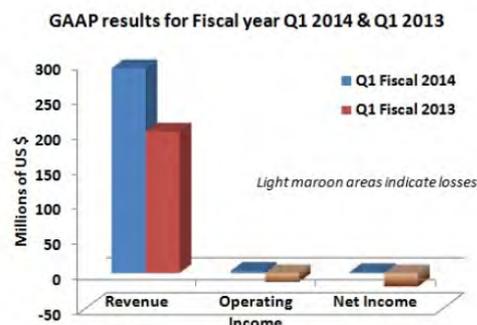
Terms of the transaction were not disclosed.

The transaction and product transition are expected to provide RFMD \$20 million in annual cost savings, or \$5 million per quarter. RFMD expects to realise the full benefit of savings beginning in the December quarter.

### RFMD quarterly revenues grow 45 percent

Delivering a record revenue of \$293.0 million, the company forecasts diversified revenue growth and margin expansion in the September quarter

RF Micro Devices, Inc. a designer and manufacturer of high-performance radio frequency solutions, has reported financial results for the company's fiscal 2014 first quarter, ended June 29th, 2013.



Quarterly revenue increased approximately 4.4 percent sequentially and 45 percent year-over-year to a record \$293.0 million, compared to \$280.6 million in the prior quarter and \$202.7 million in the corresponding period of fiscal 2013. The sequential and year-over-year increases in revenue reflected

broad-based adoption of RFMD's best-in-class RF solutions.

GAAP gross margin for the June 2013 quarter was 31.9 percent, quarterly operating income was \$3.2 million, and quarterly net income was \$1.6 million, or \$0.01 diluted EPS versus \$(0.07) in Q1 Fiscal 2013.

#### Financial Outlook and Business Commentary

RFMD's financial outlook reflects the company's current expectations for the timing of key customer program ramps. The company currently believes the demand environment in its end markets for the September 2013 quarter to increase to approximately \$305 million to \$310 million and sequential gross margin expansion

Bob Bruggeworth, president and CEO of RFMD, said, "RFMD is capitalising on the expanding demand for data-rich mobile applications, and our products are at the heart of the high-speed data connections enabling always-on, broadband mobility - both in the devices and consumer premises equipment, and within the supporting network infrastructure. We are executing on multiple opportunities to increase our dollar content generation-over-generation in the world's leading smartphones, and we are benefiting from increasing participation in the highest volume entry-level platforms and reference designs.

"Looking forward, we believe we are strategically well positioned this fiscal year to deliver record revenue and improving financial performance, given our expectations for diversification, content growth, category expansion, and market share gains, combined with the benefit of new customer product ramps."

Dean Priddy, CFO and vice president of administration of RFMD, added, "RFMD is delivering diversified revenue growth and margin expansion. In the September quarter, we expect to see continued revenue growth, margin expansion, and operating leverage. Our key margin improvement initiatives are all either on or ahead of schedule and we remain confident in achieving 300 to 400 basis points in gross margin improvement this year. We expect this will result in significant financial leverage throughout the year."

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## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent,

and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he

adds.

“Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors.”

IQE expects to report its interim results around mid-September 2013.

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## Skyworks not flying so high with new stock repurchase program

The company currently expects to fund the repurchase program using its working capital

Skyworks Solutions, Inc. has authorised the repurchase of up to \$250 million of the company’s common stock from time to time prior to July 16th, 2015 on the open market or in privately negotiated transactions,

This is in compliance with applicable securities laws and other legal requirements.

This newly authorised stock repurchase program replaces in its entirety the \$200 million stock repurchase program which was approved by the Board of Directors on November 8th, 2012, and had \$35.6 million of repurchase authority remaining.

The timing and amount of any shares of the company’s common stock that are repurchased will be determined by the company’s management based on its evaluation of market conditions and other factors. The repurchase program may be suspended or discontinued at any time.

Any repurchased shares will be available for use in connection with its stock plans and for other corporate purposes.

The company currently expects to fund the repurchase program using the company’s working capital. As of June 28th, 2013, the company says it had cash and cash equivalents of approximately \$400.3 million.

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## Skyworks honoured by Lenovo

The company has been awarded for innovation, reliability and scalability

Skyworks Solutions, Inc. has received the “Outstanding Supplier and Perfect Quality” award from Lenovo for product innovation, delivering perfect quality solutions and serving as a strategic partner.

Skyworks is Lenovo’s main provider of analogue and RF solutions, having supported the company through several major product launches and growth in market share. Lenovo leverages a variety of Skyworks’ products including SkyHi front-end solutions, multimode, multiband power amplifiers, switches, diodes and global positioning system devices, amongst others.

“Lenovo congratulates Skyworks for their outstanding support and commitment to perfect quality,” says David Wang, vice president of procurement at Lenovo. “Over the past few years Skyworks and Lenovo have forged a strong relationship, one that has grown even stronger as Lenovo has become much more than a PC company. We are delighted with Skyworks’ reliable, high quality and turnkey solutions, and look forward to collaborating with them for years to come particularly as Lenovo expects to grow its market share in China and abroad.”

“At Skyworks we realise the success of our customers depends upon the strength of our services and reliability of our products and we appreciate Lenovo’s recognition of our journey towards perfect quality,” adds Kenneth J. Huening, vice president of quality at Skyworks.

“We are delighted to be partnering with Lenovo to enable a variety of personal technology platforms including smartphones, tablets and smart television with an increasing number of our analogue and connectivity solutions. We also recognise that delivering perfect quality is a key differentiator in today’s competitive market.”

With sales growing in India, Indonesia, the Philippines, Russia and Vietnam, Gartner predicts that Lenovo will become China’s top smartphone vendor in 2013. According to IDC, Lenovo already has the third highest worldwide market share for “Smart Connected Devices” which combines PC, smartphones and tablets.

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## Raytheon awarded \$279 million to develop US Navy attack systems

The firm is leveraging its gallium nitride (GaN) based AESA technologies to provide warfighters with enhanced electronic attack capabilities

Raytheon Company has been awarded a \$279.4 million cost-plus-incentive-fee contract by the U.S. Navy to conduct the Technology Development phase of the Navy’s Next Generation Jammer program.

“We believe the Navy’s choice validates Raytheon’s leadership in advanced electronic attack systems and technologies,” says Rick Yuse, president of Raytheon’s Space and Airborne Systems business. “Raytheon looks forward to building on our long-standing relationship with the U.S. Navy as we provide the warfighter with innovative and reliable Next Generation Jammer solutions now and for many years to come.”

Raytheon leveraged knowledge and experience as a leading tactical weapon systems integrator to provide an affordable,

low-risk, comprehensive NGJ solution to the U.S. Navy. Raytheon also leveraged its GaN based AESA technologies to provide warfighters with enhanced electronic attack capabilities.

“Raytheon provided the U.S. Navy with an innovative and efficient design capable of jamming current and future threats,” adds Yuse. “Our technology approach met the program requirements and leveraged our industry team’s extensive experience in combat-proven, high-reliability agile-beam RF systems designed for demanding carrier-based aircraft environments.”

NGJ will replace the ALQ-99 tactical jamming system currently on the Navy’s EA-18G Growler tactical airborne electronic attack aircraft.

Raytheon’s Space and Airborne Systems business, based in McKinney, Texas, will lead the Technology Development phase of the NGJ program with collaboration from Raytheon facilities in El Segundo, California; Forest, Mississippi; Dallas, Texas; Fort Wayne, Indiana; Largo, Florida.; and Andover, Massachusetts.

## Lasers

### Nanoplus orders Oxford Instruments tool for laser etching

The Ionfab300 Plus will be used for laser bar facet coating with anti-reflective and high-reflection multilayers, and the PlasmaPro System100 RIE system will be used for GaAs and InP compound etching

Oxford Instruments Plasma Technology (OIPT) has just received an order from Nanoplus in Germany for an ion beam deposition and a plasma etch system for use on novel types of semiconductor laser production.

Nanoplus produces semiconductor lasers over several wavelength ranges (some exclusively) for many different customers with a wide range of applications.

The Ionfab300 Plus ion beam deposition is a multi-batch cassette loading tool allowing many devices to be produced for several applications and various customers in one load. The Ionfab300 Plus will be used for laser bar facet coating with anti-reflective and high-reflection multilayers, and the PlasmaPro System100 RIE system will be used for GaAs and InP compound etching.

David Pearson, OIPT’s Senior Ion Beam Technologist, comments, “Our Ionfab optical coating tools are becoming the tools of choice for many types of precision optical coatings worldwide, in particular in laser applications.”

“Nanoplus is an internationally leading supplier of single mode DFB lasers for sensing, metrology, spectroscopy and

telecom applications. We even have one of our sensors on NASA’s Mars Curiosity Rover’, say sAlfred Forchel, founder of Nanoplus, “We chose Oxford Instruments systems for their versatility, superior process capabilities and excellent customer support.”

Frazer Anderson, Business Group Director at Oxford Instruments concludes, “Our tools offer the ideal platform for production as well as research & development in many new application areas, and Laser Bar facet coating is just one of these. Our excellent process applications team and global service support ensure that our customers are supported in every respect and can count on their Oxford Instruments systems for maximum uptime and reliability.”

### Optimising InGaAs metamorphic buffer for laser diodes

Using Laytec’s EpiCurve TT, NTT has improved its thin InGaAs buffer layer to exhibit lower thermal resistance

Temperature characteristics of laser diodes (LDs) on a GaAs substrate depend on the quality and the thermal resistance of the InGaAs metamorphic buffer layer.

Ryo Nakao from NTT used LayTec’s *in-situ* metrology system EpiCurve TT to improve layer thickness and indium content in order to fabricate a thin InGaAs metamorphic buffer with low thermal resistance.

The *in-situ* tool helps understand the MOCVD growth conditions and shows the changes in wafer curvature caused by residual strain during MOCVD growth.

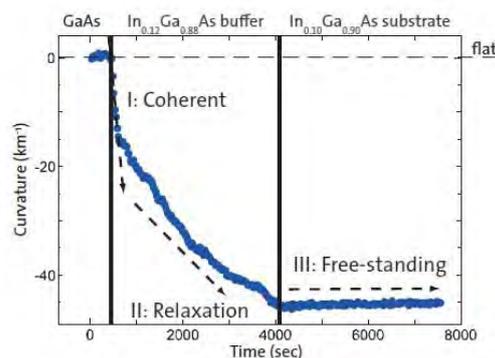


Fig. 1: *In-situ* curvature data of InGaAs buffer and quasi-InGaAs substrate on GaAs substrate

Fig. 1 shows *in-situ* curvature data for a 1250 nm metamorphic InGaAs buffer layer and a quasi-InGaAs substrate layer. The growth can be separated into 3 parts: I - Coherent (pseudomorphic) growth of the buffer, II - Growth with relaxation, III - Free-standing (unstrained) growth.

During relaxation, the in-plane lattice constant of the  $\text{In}_{0.12}\text{Ga}_{0.88}\text{As}$  layer increases. After the buffer has reached 1250 nm, its lattice constant exactly matches the lattice

constant of In<sub>0.1</sub>Ga<sub>0.9</sub>As. As a result, the wafer curvature does not change during the subsequent growth of In<sub>0.1</sub>Ga<sub>0.9</sub>As layer.

The authors call this final growth phase “free-standing” because the In<sub>0.1</sub>Ga<sub>0.9</sub>As layer grows with its natural lattice constant and creates a quasi-substrate similar to an In<sub>0.1</sub>Ga<sub>0.9</sub>As wafer for the later device growth.

With a buffer thickness of 1000 nm, further experiments with the same indium content and different buffer thicknesses showed that if the relaxation is not sufficient, the quasi-In<sub>0.1</sub>Ga<sub>0.9</sub>As substrate growth is compressively strained.

However, over-relaxation (1600 nm) results in a tensile strain.

The researchers plotted these changes to obtain a map of the correlation between thickness and curvature. For a free-standing quasi-InGaAs substrate, they choose a buffer thickness with no further variation in curvature over time during In<sub>0.1</sub>Ga<sub>0.9</sub>As growth.

This work shows that *in-situ* curvature measurements are a decisive part of an innovative technology that is developed to improve characteristics of LDs.

Ryo Nakao *et al* describe further details of this work in the EMS-32 proceedings (2013).

## Sharp and Osram to take LEDs and lasers to the next level

A patent agreement between the two firms is expected to boost R&D in these markets and others

Sharp and Osram have entered into a patent cross-licensing agreement covering LEDs and laser diodes.

This cross-licensing agreement grants each party the right to use inventions related to LED and laser diodes covered by the patents owned by the respective companies around the world.

Both companies expect that this will spur their R&D and contribute to further advances in LEDs, laser diodes, and related industries.

Sharp began mass-production of LEDs in 1970 and the world's first production of infrared laser diodes for CDs in 1982.

With these LED and laser diode technologies built up over the years, the company has recently come out with numerous unique devices, including a high-efficiency, high-brightness 100 W-class LED for lighting, and a red laser diode that can be used as a light source for displays.

Under this agreement, the companies' mutual licensing of patents will allow each party to complement its respective technologies. Sharp and Osram believe this will accelerate development of high-performance LEDs and laser diodes and

have a positive effect on the creation of devices that match the needs of worldwide markets.

## Measuring light amplification with polymers for next generation lasers

Using picosecond laser pulses diminishes thermal degradation to get a more accurate measurement of a material's optical gain; this is vital for laser development

Researchers from North Carolina State University have developed more accurate measurements of how efficiently a polymer called MEH-PPV amplifies light.

This should advance efforts to develop a new generation of lasers and photonic devices.

“By improving our understanding of this material, we get closer to the longstanding industry goal of using MEH-PPV to create cheaper, more flexible photonic technologies,” says Lewis Reynolds, a teaching associate professor of materials science and engineering at NC State and senior author of a paper describing the research.

MEH-PPV is a low-cost polymer that can be integrated with silicon chips, and researchers have long sought to use the material to convert electricity into laser light for use in photonic devices such as optical amplifiers and chemical sensors. At issue is MEH-PPV's ‘optical gain,’ which is a way of measuring how effectively a material can amplify light. Understanding a material's optical gain is essential to laser development.

Researchers determine the optical gain of MEH-PPV by pulsing laser light into the material and measuring the light that the MEH-PPV then produces in response.

The NC State team used extremely short laser pulses – 10 laser pulses per second, with each pulse lasting only 25 picoseconds (25 trillionths of a second).

Previous efforts to determine MEH-PPV's optical gain produced inaccurate results because they used laser pulses that lasted one thousand times longer.

“The longer pulses caused thermal degradation in the MEH-PPV, meaning they led to structural and molecular changes in the material,” says Zach Lampert, a former Ph.D. student at NC State and lead author of the paper. “Essentially, the longer laser pulses were heating the polymer. We were able to minimize these thermal degradation effects, and get a more accurate measurement, by using the picosecond pulses.”

“Our new approach is fairly straightforward and can be easily implemented elsewhere,” Reynolds says.

This work is described in detail in the paper, “Intrinsic optical gain in thin films of a conjugated polymer under picosecond excitation,” by Zach E. Lampert *et al* in *Applied Physics*

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

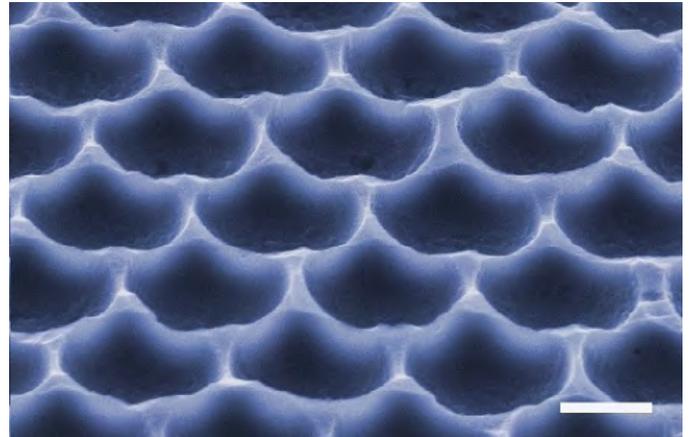
Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. "The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs." The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced

into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3  $\mu\text{m}$  thick InP thin-films on molybdenum foils with ultra-large grain size up to 100  $\mu\text{m}$ . The researcher says this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500  $\text{cm}^2/\text{V}\cdot\text{s}$  and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*,<sup>3</sup>, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

"Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance

data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors."

IQE expects to report its interim results around mid-September 2013.

## Glasgow University awarded grant for research using Oxford Instruments tools

The systems will be used in the fabrication of high performance electronic and optical devices including LEDs and laser.

The University of Glasgow has been awarded a £3 million share of £85 million new government funding for equipment to support pioneering research to improve the efficiency of electronic and optical components.

This research includes developing advanced processes on multiple commercial micro- and nano-fabrication tools manufactured in the UK by Oxford Instruments Plasma Technology that can be transferred directly into companies for production.

Announced by UK Minister for Universities and Science David Willetts at an event this week in London, the award from the Engineering and Physical Sciences Research Council (EPSRC) will support work undertaken by researchers from the University of Glasgow's College of Science and Engineering in collaboration with Oxford Instruments Plasma Technology, the National Physical Laboratory, the National Microelectronics Institute and Gas Sensing Solutions.

The funding will allow the University to purchase new equipment including several Oxford Instruments Plasma Technology's tools to etch semiconductor materials and deposit electrically insulating layers, techniques used to fabricate high performance electronic and optical devices including transistors, LEDs and lasers.

The equipment will support a range of new research projects including:

*The development of more efficient power electronics, which could improve the lifespan of batteries in many consumer electronic devices as well as reduce their carbon footprint*

*Improving the efficiency and durability of solar collection technology, creating a dramatic reduction in the cost of large-scale exploitation of solar energy*

*The development of a 'superspectral' imaging camera which will integrate visible, infrared and mid-infrared imaging sensors on a single chip for the first time, with applications for security and medical sensing technology*

Douglas Paul, Director of the University's James Watt Nanofabrication Centre, who led the funding bid, says, "Glasgow has a long history of successful exploitation of

research which goes all the way back to James Watt's invention and commercialisation of the condenser for the steam engine, and this award will help us continue that proud tradition. We're pleased that the EPSRC accepted our funding bid and we're looking forward to helping support the UK's efforts to become a more energy-efficient nation."

Minister for Universities and Science David Willetts adds. "For Britain to get ahead in the global race we have to back emerging technologies and ensure our universities have the latest equipment. This capital investment will help scientists make new discoveries and take their research through to commercial success. It will drive growth and support the Government's industrial strategy."

## Veeco wins R&D 100 award

The firm has been awarded for its SPECTOR-HT system which is used to create precision thin film coatings for laser machining, telecoms, laser diode manufacturing and laser guidance systems

Veeco Instruments has been honoured with an R&D 100 Award for its SPECTOR-HT Ion Beam Deposition (IBD) System.



Initiated in 1962 and called the "Oscars of Innovation," the R&D Awards, issued by R&D Magazine, recognise and celebrate the top 100 technology products of the year.

The SPECTOR-HT is used to create precision thin film coatings for the optical market for applications such as laser machining, telecommunications, manufacturing of laser diodes, heads up displays and laser guidance systems.

"Veeco is honoured to receive this R&D 100 Award that recognises excellence and innovation in technology, and celebrates achievement," says William J. Miller, Veeco's Executive Vice President.

"The SPECTOR-HT provides manufacturers the advantages of ion beam sputtering technology - stable deposition rates, high purity, high density and low roughness films; combining for stable low optical loss films - in a robust package that significantly boosts throughput and lowers cost of ownership," adds Miller.



Launched in 2012, the SPECTOR-HT Ion Beam Deposition System provides up to 400 percent increase in throughput, 300 percent increase in target utilisation and 50 percent improvement in material uniformity compared to previous generations of ion beam sputtering equipment. It also offers exceptional film quality, and a cost-effective manufacturing platform.

Veeco says it is the industry's first fully automated ion beam deposition system to achieve accelerated deposition rates at speeds comparable to competing optical deposition technologies, such as physical vapour deposition (PVD), evaporative coatings or ion assisted deposition, while maintaining high quality, optimal films.

## Solar

### Cheaper and more accessible solar cells

New research paves way for nanoparticle-based 'ink' to make printable or spray-on solar cells

(Edmonton) University of Alberta researchers have found that abundant materials in the Earth's crust can be used to make inexpensive and easily manufactured nanoparticle-based solar cells.

The discovery is an important step forward in making solar power more accessible to parts of the world that are off the traditional electricity grid or face high power costs, such as the Canadian North, says researcher Jillian Buriak.

Buriak is a chemistry professor and senior research officer of the National Institute for Nanotechnology based on the U of A campus.



UAlberta researcher Jillian Buriak (centre) worked with post-doctoral fellows Erik Lubber (right) and Hosnay Mobarok to create nanoparticles that could lead to printable or spray-on solar cells

Buriak and her team have designed nanoparticles that absorb light and conduct electricity from two very common elements: phosphorus and zinc. Both materials are more plentiful than scarce materials such as cadmium and are free from manufacturing restrictions imposed on lead-based nanoparticles.

“Half the world already lives off the grid, and with demand for electrical power expected to double by the year 2050, it is important that renewable energy sources like solar power are made more affordable by lowering the costs of manufacturing,” Buriak says.

Her team’s research supports a promising approach of making solar cells cheaply using mass manufacturing methods like roll-to-roll printing (as with newspaper presses) or spray-coating (similar to automotive painting). “Nanoparticle-based ‘inks’ could be used to literally paint or print solar cells or precise compositions,” Buriak continues.

Buriak collaborated with U of A post-doctoral fellows Erik Lubber of the U of A Faculty of Engineering and Hosnay Mobarok of the Faculty of Science to create the nanoparticles. The team was able to develop a synthetic method to make Zn<sub>3</sub>P<sub>2</sub> nanoparticles, and demonstrated that the particles can be dissolved to form an ink and processed to make thin films that are responsive to light.

Buriak and her team are now experimenting with the nanoparticles, spray-coating them onto large solar cells to test their efficiency. The team has applied for a provisional patent and has secured funding to enable the next step to scale up manufacture.

This work is described in detail in the paper, “Solution-Processed Zinc Phosphide ( $\alpha$ -Zn<sub>3</sub>P<sub>2</sub>) Colloidal Semiconducting Nanocrystals for Thin Film Photovoltaic Applications,” by Erik J. Lubber *et al* in *ACS Nano*. DOI: 10.1021/nn4034234

The research was supported by the Natural Sciences and Engineering Research Council of Canada.

### GaP bridges the gap in extracting fuel from solar power

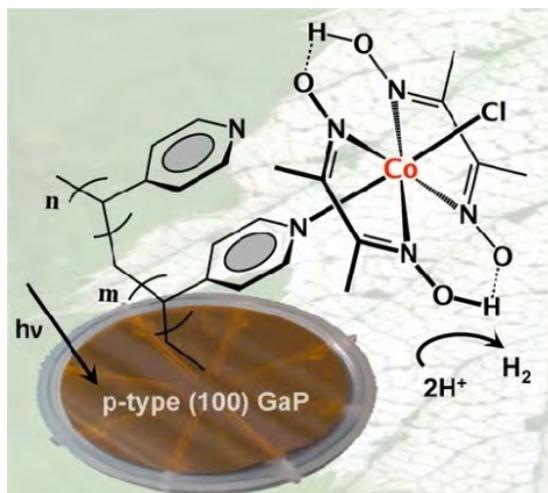
A novel gallium phosphide/catalyst structure can be used to absorb visible light



In the search for clean, green sustainable energy sources to meet human needs for generations to come, perhaps no technology matches the ultimate potential of artificial photosynthesis.

Bionic leaves that could produce energy-dense fuels from just sunlight, water and atmosphere-warming carbon dioxide, with no by products other than oxygen, represent an ideal alternative to fossil fuels.

But they also pose numerous scientific challenges.



For more than two billion years, nature, through photosynthesis, has used the energy in sunlight to convert water and carbon dioxide into fuel (sugars) for green plants. (Photo by Roy Kaltschmidt)

A major step toward meeting at least one of these challenges has been achieved by researchers with the U.S. Department of Energy (DOE)’s Lawrence Berkeley National Laboratory (Berkeley Lab) working at the Joint Centre for Artificial Photosynthesis (JCAP).

“We’ve developed a method by which molecular hydrogen-producing catalysts can be interfaced with a semiconductor that absorbs visible light,” says Gary Moore, a chemist with Berkeley Lab’s Physical Biosciences Division and principal investigator for JCAP. “Our experimental results indicate that the catalyst and the light-absorber are interfaced structurally as well as functionally.”

Moore is the corresponding author, along with Junko Yano and Ian Sharp, who also hold joint appointments with Berkeley Lab and JCAP, of a paper describing this research.

Earth receives more energy in one hour's worth of sunlight than all of humanity uses in an entire year.

Through the process of photosynthesis, green plants harness solar energy to split molecules of water into oxygen, hydrogen ions (protons) and free electrons. The oxygen is released as waste and the protons and electrons are used to convert carbon dioxide into the carbohydrate sugars that plants use for energy. Scientists aim to mimic the concept but improve upon the actual process.

JCAP, which has a northern branch in Berkeley and a southern branch on the campus of the California Institute of Technology (Caltech), was established in 2010 by DOE as an Energy Innovation Hub.

Operated as a partnership between Caltech and Berkeley Lab, JCAP is the largest research program in the United States dedicated to developing an artificial solar-fuel technology.

While artificial photosynthesis can be used to generate electricity, fuels can be a more effective means of storing and transporting energy. The goal is an artificial photosynthesis system that's at least 10 times more efficient than natural photosynthesis.

To this end, once photoanodes have used solar energy to split water molecules, JCAP scientists need high performance semiconductor photocathodes that can use solar energy to catalyse fuel production.

In previous efforts to produce hydrogen fuel, catalysts have been immobilised on non-photoactive substrates. This approach requires the application of an external electrical potential to generate hydrogen. Moore and his colleagues have combined these steps into a single material.

"In coupling the absorption of visible light with the production of hydrogen in one material, we can generate a fuel simply by illuminating our photocathode," Moore says. "No external electrochemical forward biasing is required."

The JCAP photocathode consists of gallium phosphide (GaP) and a molecular cobalt-containing hydrogen production catalyst from the cobaloxime class of compounds.

As an absorber of visible light, GaP can make use of a greater number of available solar photons than semiconductors that absorb ultraviolet light, which means it is capable of producing significantly higher photocurrents and rates of fuel production.

However, GaP can be notoriously unstable during photo electrochemical operations.

Grafting molecular cobalt-containing hydrogen production catalysts to a visible-light-absorbing semiconductor exploits the UV-induced immobilization chemistry of vinylpyridine to *p*-type (100) GaP.

Moore and his colleagues found that coating the surface of GaP with a film of the polymer vinylpyridine alleviates the instability

problem, and if the vinylpyridine is then chemically treated with the cobaloxime catalyst, hydrogen production is significantly boosted.

"The modular aspect of our method allows independent modification of the light-absorber, linking material and catalyst, which means it can be adapted for use with other catalysts tethered over structured photocathodes as new materials and discoveries emerge," Moore says.

He continues, "This could allow us, for example, to replace the precious metal catalysts currently used in many solar-fuel generator prototypes with catalysts made from earth-abundant elements."

Despite its promising electronic properties, GaP has a mid-sized optical band gap which ultimately limits the total fraction of solar photons available for absorption.

Moore and his colleagues are now investigating semiconductors that cover a broader range of the solar spectrum, and catalysts that operate faster at lower electrical potentials. They also plan to investigate molecular catalysts for carbon dioxide reduction.

"We look forward to adapting our method to incorporate materials with improved properties for converting sunlight to fuel," Moore says.

"We believe our method provides researchers at JCAP and elsewhere with an important tool for developing integrated photocathode materials that can be used in future solar-fuel generators as well as other technologies capable of reducing net carbon dioxide emissions."

The paper, "Photofunctional Construct That Interfaces Molecular Cobalt-Based Catalysts for H<sub>2</sub> Production to a Visible-Light-Absorbing Semiconductor," by Alexandra Krawicz *et al* in the *Journal of the American Chemical Society*, 2013, 135 (32), pp 11861- 11868 describes this work in detail.

DOI: 10.1021/ja404158r

This research was funded by the U.S. DOE Office of Science.

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## New nanomaterial may boost solar cell yield

Lead selenide could revolutionise solar cells

Researchers from the FOM Foundation, Delft University of Technology, Toyota Motor Europe and the University of California have developed a nanostructure, using PbSe, that could vastly improve solar cell efficiency.

The researchers published their findings on 23rd August 2013 in the online edition of *Nature Communications*.

Smart nanostructures can increase the yield of solar cells. The team of researchers have now optimised the nanostructures

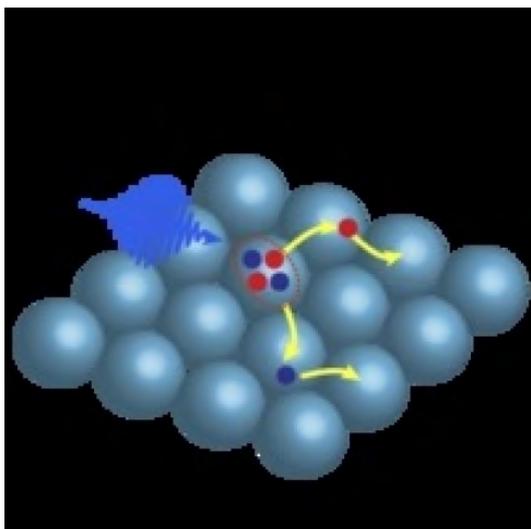
so that the solar cell provides more electricity and loses less energy in the form of heat.

A conventional solar cell contains a layer of silicon. When sunlight falls on this layer, electrons in the silicon absorb the energy of the light particles (photons). Using this energy the electrons jump across a 'band gap', as a result of which they can freely move and electricity flows.

The yield of a solar cell is optimised if the photon energy is equal to the bandgap of silicon. Sunlight, however, contains many photons with energies greater than the band gap. The excess energy is lost as heat, which limits the yield of a conventional solar cell.

Several years ago the researchers from Delft University of Technology and other physicists, demonstrated that the excess energy could still be put to good use.

In small spheres of a semiconducting material the excess energy enables extra electrons to jump across the band gap. These nanospheres, the so-called quantum dots, have a diameter of just one ten thousandth of a human hair.



*Linked quantum dots - In the new nanomaterial two or more electrons jump across the band gap as a consequence of just a single light particle (arrow with waves) being absorbed. Using special molecules the researchers have strongly linked the nanospheres (quantum dots) as a result of which the electrons can freely move and an electrical current develops in the solar cell*

If a light particle enables an electron in a quantum dot to cross the band gap, the electron moves around in the dot. That ensures that the electron collides with other electrons that subsequently jump across the band gap as well. As a result of this process a single photon can mobilise several electrons thereby multiplying the amount of current produced.

Contact between quantum dots

However, up to now the problem was that the electrons remained trapped in their quantum dots and so could not contribute to the current in the solar cell. That was due to the large molecules that stabilise the surface of quantum dots. These large molecules hinder the electrons jumping from one

quantum dot to the next and so no current flows.

In the new design, the researchers replaced the large molecules with small molecules and filled the empty space between the quantum dots with aluminium oxide. This led to far more contact between the quantum dots allowing the electrons to move freely.

Using laser spectroscopy the physicists saw that a single photon caused the release of several electrons in the material containing linked quantum dots. All of the electrons that jumped across the bandgap moved freely around in the material.

As a result of this, the theoretical yield of solar cells containing such materials rises to 45 percent, which is more than 10 percent higher than a conventional solar cell.

This more efficient type of solar cell is easy to produce say the researchers; the structure of linked nanospheres can be applied to the solar cell as a type of layered paint. Consequently the new solar cells will not only be more efficient but also cheaper than conventional cells.

The Dutch researchers now want to work with international partners to produce complete solar cells using this design.

This study has been further described in the article, "High Charge Carrier Mobility Enables Exploitation of Carrier Multiplication in Quantum-Dot Films," by S. Sandeep, *et al* in *Nature Communications*, 4, Article number: 2360. . DOI: 10.1038/ncomms3360

## Ascent Solar to debut the thinnest 1350mAh ever power bank

The CIGS based Jumpr Mini is a thin and lightweight battery, capable of boosting most smartphones' batteries by 55 to 85 percent on a single charge

Ascent Solar Technologies is to debut the Jumpr Mini, the newest product in the company's Jumpr line of power banks.



### *Jumpr Mini module*

Ascent says at only 6mm thick, the Jumpr Mini is by far the thinnest and lightest battery of its kind available. Equipped with an expandable USB port, the Mini is able to store 1350 mAh of power while remaining thinner than a standard USB outlet.

The Jumpr Mini is immediately available for purchase via Ascent's locations in the Denver area, as well as online at [www.goenerplex.com](http://www.goenerplex.com).

Ascent Solar's Manager of Branding & Marketing, Justin Jacobs, says, "The Jumpr Mini is a perfect complement to our current line of Jumpr batteries, small enough to fit into a wallet or purse, yet powerful enough to provide a boost whenever needed. The Jumpr Mini is perfect for those who need a quick charge while they are on the go and a lifesaver for those who do not always have easy access to an outlet."

Ascent Solar claims its modules can be directly integrated into consumer products and off-grid applications, as well as aerospace and building integrated applications.

The EnerPlex brand represents Ascent's line of consumer products. These products, many of which are integrated with Ascent'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.

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## Solar Junction beats its own record with 44.1% cell efficiency

Solar Junction has surpassed its previous world record on IQE's production qualified wafers

IQE says that its high-volume, production qualified material has been independently certified as achieving 44.1 percent cell efficiency by the National Renewable Energy Laboratory (NREL).

This surpasses Solar Junction's previous world record for a standard triple junction CPV cell.

The wafers, produced using IQE's high-volume MBE tools, were processed by IQE's strategic partner Solar Junction Corporation, a developer of high efficiency multi-junction solar energy cells for the concentrated photovoltaic (CPV) market.

The standard three-junction III-V solar cells are believed to set a new world record for production scale CPV wafer technology and demonstrate improved efficiency over Solar Junction's previous world record reported in October 2012.

Vijit Sabnis, CEO at Solar Junction comments, "Breaking a world record is a major achievement, but improving on our most recent record using high-volume production equipment produced in conjunction with our manufacturing partner IQE, and Solar Junction's fabrication line in Sunnyvale, California, is dramatically more significant. This result is a testament to

our close partnership with IQE; Solar Junction's dilute nitride technology and our exceptional team. We continue to be the benchmark for multi-junction solar cell production efficiency to assist our customers in driving CPV costs down."

Drew Nelson, IQE Chief Executive, says, "Following our recent announcement of full qualification of our high volume 4" and 6" CPV technology, surpassing Solar Junction's previous cell efficiency record is a massive achievement. Improvements in CPV cell efficiencies translate to highly significant overall cost reduction in terms of installation and energy generation in utility scale solar farms. The fact that this has been achieved on production-qualified platforms is a major milestone."

Nelson continues, "Furthermore, the transfer of wafer production to IQE's manufacturing tools enables the Solar Junction team to focus on further improving efficiencies on lattice-matched, multi-junction CPV solar cells using a combination of their unique dilute nitride technology, combined with pre existing IQE IP. This will facilitate seamless technology transfer into high volume manufacture of ultra efficient CPV cells as the conversion efficiency improves further."

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## First Solar and Ingenero unite to deliver solar PV projects

The partnership will bring CdTe solar module technology to the Australia and Asia Pacific region

First Solar and Ingenero are collaborating to provide a joint offering to the commercial and off-grid solar markets.

The partnership will combine Ingenero's design, development and integration experience with First Solar's thin film photovoltaic CdTe module technology to better meet market requirements within Australia and the Asia Pacific region.

Ingenero has an established footprint in the commercial and off-grid space having constructed Australia's largest rooftop solar PV system at the University of Queensland in Brisbane and a number of ground-mounted solar PV systems in Queensland, the Northern Territory and the Pacific Islands.

First Solar brings international experience in constructing utility-scale solar projects, including Australia's first utility-scale solar farm, the Greenough River Solar Farm, and has established a strong local supply chain in Australia.

The collaboration will combine the best of both company's capabilities to increase the number of ground-mounted solar projects in Australia. First Solar and Ingenero will also jointly target diesel fuel replacement opportunities in Australia's off-grid sector, reducing operating costs for mining companies and providing an alternative source of power generation for communities throughout regional Australia and the Pacific Islands.

"Today we celebrate another milestone in our company's short but dynamic history. A collaboration agreement with First Solar

and the opportunity to utilise its thin-film PV module technology brings with it the increased capability and flexibility needed to be successful in a growing market," says Ingenero CEO, Steve McRae.

"This year we made the leap into the international solar market, building a complex hybrid off-grid solar power plant on the island of Vava'u, Tonga. These kinds of off-grid applications, as well as commercial and utility scale applications, hold significant growth opportunities internationally," adds McRae.

"Partnering with a company of this calibre means Ingenero will continue to grow its commercial and utility solar business within Australia and broaden its international footprint while continuing to deliver high quality, innovative solar solutions to its existing and future customer base," he adds

"In collaborating with Ingenero, Australia's leading integrator in the small to medium scale solar sector, First Solar is better positioning itself to meet the needs of the commercial and off-grid solar markets in Australia and Asia Pacific," says First Solar's Asia Pacific Vice President of Business Development Jack Curtis.

"First Solar's primary focus has been utility-scale projects and we continue to be the world leader in this market segment. This collaboration will provide us with additional origination and execution diversity in medium-scale projects that will allow us to broaden our accessible demand pool across the region and meet the needs of customers that are looking to utilise our thin-film PV module technology in these types of applications," he adds.

The First Solar/Ingenero collaboration will provide bankable and economically viable solutions to existing and future customers through the delivery of high-quality service and components as well as innovative, fully-engineered solutions tailor-designed for each project.

## Amonix III-V solar cell hits 35.9 percent module efficiency

Data for the rating was generated by an Amonix module under outdoor test at NREL from late February to April of this year.

Amonix has manufactured a III-V based solar cell which achieved a National Renewable Energy Laboratory (NREL) efficiency rating of 35.9 percent under recently adopted CPV IEC test conditions of 1000 W/m<sup>2</sup> and 25°C cell temperature.

Amonix says the result is the highest ever independently rated module efficiency for any PV technology and is the first time NREL quantified the rating for a concentrator module with the cells at 25°C instead of at operating temperature.

Amonix worked with NREL to help mature this measurement process. Amonix's last solar module set a an efficiency of 34.9 percent at CSOC (concentrator standard operating conditions) in April, 2013. The firm claims this was the first to break 33

percent CSOC module efficiency in May 2012.

"This 35.9 percent IEC CSTC module efficiency is a direct comparison to PV module efficiencies, which are often reported at IEC standard test conditions," says Vahan Garboushian, Amonix Founder and CTO.

Garboushian continues, "With the advent of higher efficiency cells from companies like Solar Junction, Amonix anticipates achieving considerably higher module efficiencies and breaking our currently standing world records in the very near future."

## First Solar to construct CdTe plant in California

In its first 10 year PPA for a municipal utility, the cadmium telluride cell manufacturer will create up to 200 jobs at its California factory

First Solar and the City of Roseville, California have signed a power purchase agreement (PPA) for 32MWAC of solar electricity to be generated at the Lost Hills photovoltaic power plant that First Solar is developing and will construct in Kern County, California.

The 10-year PPA is First Solar's first such agreement with a municipal utility, and is effective in 2015. The PPA was approved by the Roseville City Council on July 17th, 2013.

The Lost Hills project construction could start in early 2014, and is expected to create up to 200 jobs at its peak.

"We are proud to add this project to Roseville Electric's portfolio," says Brian Kunz, First Solar's Vice President of Project Development. "It will help the city reach its state renewable energy goals, while giving residents the benefit of clean, affordable electricity."

Roseville Electric purchased 325,000 MWH of renewable energy for \$24 million for 10 years. The contract cost \$6.5 million less than similar renewable energy purchase offers in 2012.

"We are pleased to acquire renewable electricity to help us reach the state's requirement for 33 percent by 2020," comments Roseville Electric Utility Director Michelle Bertolino. "As a community-owned utility, contracts such as this help minimise the cost impact on our customers while maintaining highly reliable service."

Under the agreement, Roseville will receive 100 percent of the Lost Hills power plant's output for the first four years of the agreement; it will then decline to a smaller percentage of the output. First Solar has an additional PPA for Lost Hills' output with Pacific Gas and Electric, which goes into effect in 2019.

In its first year, Lost Hills will produce enough clean, renewable energy to power more than 11,000 homes, offsetting more than 20,000 metric tons of CO<sub>2</sub> annually, which is the equivalent of taking about 4,000 cars off the road each year, and displacing over 18,000 metric tons of water consumption.

## Stion`s CIGS solar modules better than ever

The company's latest solar modules demonstrated no degradation in their first year

In April 2012, Stion installed a 60 kW demonstration array in Hattiesburg, Mississippi comprised of some of the very first CIGS modules produced at the company's high-volume factory in Mississippi.

After 1 year of field production in the hot and humid Mississippi delta, Stion's modules showed zero degradation in power output. A random sample of modules was removed from the array and tested; they performed at or above the STC (an irradiance of 1000 W/m<sup>2</sup>, an air mass of 1.5 and a module temperature of 25°C) flash test result that was recorded at time of production.

This may be a surprise to those in the solar industry that expect at least 1 to 2 percent loss in power in just the first year with silicon-based modules.

This stable performance confirms that Stion's modules match the stability seen in CIGS modules that have been stable for nearly 8 years in a test array at the National Renewable Energy Lab.

Stion's CIGS modules have a dual glass / glass construction providing significantly improved moisture resistance and lifetime durability over the traditional polymer based backsheets used in traditional PV modules.

The firm's modules are resistant to potential induced degradation, light-induced degradation, and provide a durable solution engineered to survive in harsh environments and out-perform in non-ideal situations.

Stion COO Marty Finkbeiner says, "We at Stion are excited to offer a product line with improved laboratory performance and industry-leading technology that out-performs other technologies from day 1 to day 10,000."

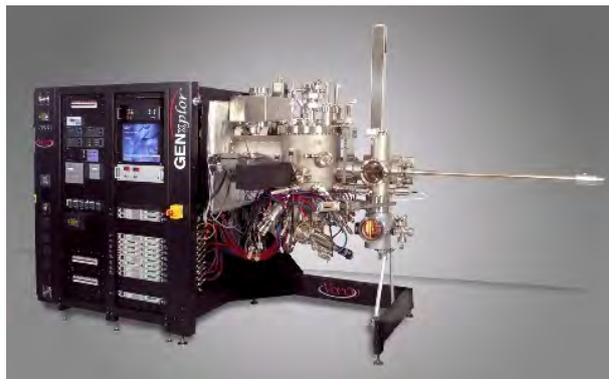
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## Veeco to reveal compact MBE tool

The company says its latest molecular beam epitaxy reactor is the industry's first integrated MBE System for the compound semiconductor R&D market

Veeco Instruments has introduced the GENxplor Molecular Beam Epitaxy (MBE) deposition system.

The GENxplor can create high quality epitaxial layers on substrates up to 3" in diameter and is ideal for cutting edge research on a wide variety of materials including GaAs, nitrides, and oxides.



Latest GENxplor R&D MBE System

"The compound semiconductor R&D community asked for a more affordable, flexible, and easy-to-use MBE system and Veeco has delivered with the GENxplor," says Jim Northrup, Veeco's Vice President and General Manager. "We have repackaged Veeco's industry-leading MBE technology into a novel 'all-in-one' design that combines the reactor and electronics on a single frame. It will change the way researchers use MBE."

The GENxplor uses Veeco's GEN10 growth chamber design and features process flexibility, ideal for materials research on emerging technologies such as UV LEDs, high-efficiency solar cells, and high-temperature superconductors.

Its efficient single frame design combines all vacuum hardware with on-board electronics to make it up to 40 percent smaller than other MBE systems, saving valuable lab space. And as the manual system is integrated on a single frame, installation time is reduced.

Veeco says the open architecture design of the GENxplor also improves ease-of-use and provides convenient access to effusion cells. And it also allows easier serviceability when compared to other MBE systems. When coupled with Veeco's recently introduced retractable sources, the system is ideally suited to oxide materials research.

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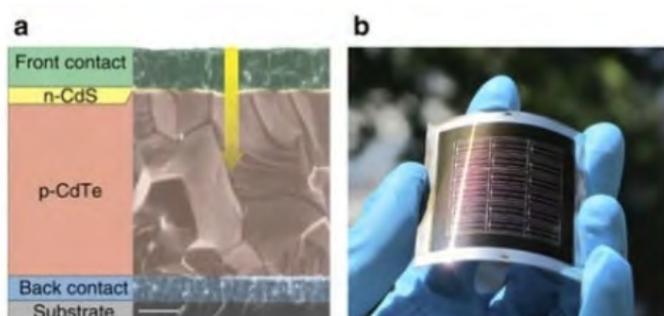
## P-doping CdTe boosts solar efficiency

Doping cadmium telluride with copper increases solar cell efficiency from 8 to 11.5 percent

Flexible thin film solar cells that can be produced by roll-to-roll manufacturing are a highly promising route to cheap solar electricity.

Now scientists from research institute Empa, the Swiss Federal Laboratories for Materials Science and Technology, have made significant progress in paving the way for the industrialisation of flexible, light-weight and low-cost cadmium telluride (CdTe) solar cells on metal foils.

They succeeded in increasing their efficiency from below eight to 11.5 percent by doping the cells with copper, as reported in the current issue of *Nature Communications*.



(a) Scanning electron micrograph and schematic of the cross section of a CdTe solar cell in the substrate configuration which allows the use of opaque substrates like metal foils. (b) Photo of CdTe solar cell

In order to make solar energy widely affordable scientists and engineers all over the world are looking for low-cost production technologies. Flexible thin film solar cells have a huge potential in this regard because they require only a small amount of material and can be manufactured in large quantities by roll-to-roll processing. One such technology relies on CdTe to convert sunlight into electricity.

With a current market share that is second only to silicon-based solar cells, CdTe cells are currently one of the cheapest to manufacture. But grown mainly on rigid glass plates, these so-called 'superstrate' cells have, however, one drawback. They require a transparent supporting material that lets sunlight pass through to reach the light-harvesting CdTe layer, thus limiting the choice of carriers to transparent materials.

The inversion of the solar cell's multi-layer structure, the so-called substrate configuration, would allow further cost-cuttings by using flexible foils made of, say, metal as supporting material. Sunlight now enters the cell from the other side, without having to pass through the supporting substrate.

The problem, though, is that CdTe cells in substrate configuration on metal foil thus far exhibited infamously low efficiencies well below eight percent - a modest comparison to the recently reported record efficiency of 19.6 percent for a lab-scale superstrate CdTe cell on glass. Commercially available CdTe superstrate modules reach efficiencies of between 11 and 12 percent.

#### Copper doping for solar cells

One way to increase the low energy conversion efficiency of substrate CdTe cells is *p*-doping the semiconductor layer with minute amounts of metals such as copper (Cu). This would lead to an increase in the density of "holes" (positive charge carriers) as well as their lifetimes, and thus result in a high photovoltaic power, the amount of sunlight that is turned into electrical energy.

A perfect idea but only if CdTe weren't so notoriously hard to dope. "People have tried to dope CdTe cells in substrate configuration before but failed time and again," explains Ayodhya Nath Tiwari, head of Empa's laboratory for Thin Films and Photovoltaics.

His team decided to try nonetheless using high-vacuum copper evaporation onto the CdTe layer with a subsequent

heat treatment to allow the Cu atoms to penetrate into the CdTe. They soon realised that the amount of copper had to be painstakingly controlled: if they used too little, the efficiency wouldn't improve much; the very same happened if they "over-doped".

The electronic properties improved significantly, however, when Lukas Kranz, a PhD student in Tiwari's lab, together with Christina Gretener and Julian Perrenoud fine-tuned the amount of Cu evaporation so that a mono-atomic layer of copper would be deposited on the CdTe. "Efficiencies increased dramatically, from just under one percent to above 12", says Kranz. Their best value was 13.6 percent for a CdTe cell grown on glass; on metal foils Tiwari's team reached efficiencies up to 11.5 percent.

Increasingly ambitious targets: hitting the 20 percent ceiling

For now, the highest efficiencies of flexible CdTe solar cells on metal foil are still somewhat lower than those of flexible solar cells in superstrate configuration on a special (and expensive) transparent polyimide foil, developed by Tiwari's team in 2011. But, says co-author Stephan Buecheler, a group leader in the lab: "Our results indicate that the substrate configuration technology has a great potential for improving the efficiency even further in the future."

Their short-term goal is to reach 15 percent. "But I'm convinced that the material has the potential for efficiencies exceeding 20 percent."

The next steps will focus on decreasing the thickness of the so-called window layer above the CdTe, including the electrical front contact. This would reduce light absorption and, therefore, allow more sunlight to be harvested by the CdTe layer. "Cutting the optical losses" is how Tiwari calls it.

This work has been described in detail in the paper, "Doping of polycrystalline CdTe for high efficiency solar cells on flexible metal foil," by L. Kranz *et al* in *Nature Communications*, 4, Article number: 2306. [DOI 0.1038/ncomms3306](https://doi.org/10.1038/ncomms3306)

The study was supported by the Swiss National Science Foundation (SNSF) and the Competence Centre Energy and Mobility of the ETH Domain (CEM-Dursol).

## First Solar may beat the rest with 1GW worth of projects

IHS believes that in 2013, the cadmium telluride (CdTe) innovator could be the first EPC firm to install 1GW of solar power

First Solar is certainly living up to its name.

Research analyst IHS ranks the CdTe panel manufacturer as the No.1 company expected in 2013 to become the first engineering, procurement and construction (EPC) firm ever to install 1 gigawatt worth of solar or photovoltaic (PV) power systems in a single year.

The US based company is forecast to install 1.1 gigawatts (GW) of solar systems in 2013, more than double the 516 megawatts (MW) in 2012, says IHS.

This high rate of growth will allow First Solar to maintain its leadership in the EPC business for the year, despite even faster growth from Chinese rivals, No. 2 China Power Investment Corp. (CPIC) and third-ranked GD Solar.

EPCs, or system integrators, are vertically integrated contractors that build large-scale solar projects. Companies like First Solar are capable of a full range of installation tasks, including designing installation projects, procuring materials and building assignments.

First Solar and a number of companies build projects developed in-house, generating revenue from the sale of completed PV power plants. Others focus on EPC for third-party developers, sometimes in combination with in-house development.

First Solar's growth is built on its strategy to cultivate a pipeline of PV projects, in which it takes on major undertakings, sells them to other firms and then uses the proceeds to buy other large-scale installations.

For example, in May, First Solar announced the sale of the Campo Verde Solar Project, which is under construction in Southern California. Campo Verde will have a nameplate capacity of 139 MW of alternating current (MWac) when it is completed at the end of 2013.

With the money it made from the sale, First Solar expanded its pipeline with the acquisition of three other projects under development with a total capacity of 260 MWac, due for completion by the end of 2015.

"First Solar's successful strategy of acquiring, installing and divesting projects will keep the company among the world's leading solar system integrators over the next years," says Josefin Berg, senior analyst for downstream solar research at IHS. "This approach not only offers a sales outlet for modules, but more importantly also generates project-sales revenue that cushion the company when seeking new growth markets."

In January, First Solar took a major step toward expanding its business outside the United States when it acquired Chilean PV developer Solar Chile and its early-stage 1.5 GW project.

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## EU bites back at China for dumping solar in Europe

German firm CdTe manufacturer Calyxo welcomes new regulations after the company was able to survive the years of Chinese dumping in Germany

Many manufacturers of CdTe and CIGS thin film solar panels in Europe are welcoming the agreements between the EU and China over imports of Chinese Solar panels.

New laws will apply to Chinese modules offering a minimum

price of EUR (€) 0.56/Wp in the European region in the near future.

For customers of Chinese companies, which will buy at lower prices, punitive tariffs in a range from 37.2 to 67.9 percent will apply, as EU Trade Commissioner De Gucht has declared.

As one of few companies in the European Union, Calyxo was one of the firms able to survive the years of Chinese dumping in Germany.

With a current capacity of 85 MW, Calyxo says it is the largest CdTe module manufacturer in Europe. The firm continues to provide affordable modules made in Germany based on an innovative atmospheric production process and also offers suitable mounting systems, complete design and installation of PV-systems.

"Module prices below €0.56 / Wp can be realised without any problem by Calyxo today and marginal higher BOS costs can be compensated by our customers based on a price advantage of the modules and additional yield of thin film modules. As a consequence, our customers not only have lower investment costs, but also a better return on their investment. Our capacity expansion at Thalheim comes online exactly at the right point in time," says CEO Florian Holzapfel.

Calyxo claims CdTe modules have a better yield - performance than crystalline modules due to excellent temperature coefficients and good performance under low light conditions.

With the production line expansion at Thalheim, Calyxo is now able to mass produce its low cost CdTe modules.

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## PacWest to bring DayStar's CIGS modules to Brazil

With the amount of solar potential, combined with its high electricity rates and desire to preserve the environment, Brazil is uniquely positioned for rapid growth in the solar sector

PaWest Equities has secured an invitation from the Brazilian government to install its DayStar's CIGS module production line to Brazil.

The CIGS line of solar manufacturing equipment in Brazil was acquired in a deal some analysts value at over US \$55 million.

PacWest Equities is expected to open a multi-product suite of solar products for production and distribution in Brazil and other South American countries.

DayStar Technologies, Inc. holds 51 patents, patents pending, international patents, and Intellectual Property.

The technology cost over \$100 million to develop, with \$67 million going to Research and Development, \$12 million to build the prototype line, and \$27 million going to the actual production line.

The aforementioned are now in possession of PacWest

Equities, Inc., and will address the construction market's need to replace typical tinted window panes in high-rise buildings with Solar Glass Panels that generate electricity at the same time as functioning as a window, a skylight, or any other type of building cover.

## GE and First Solar develop thin film partnership

New technology deal sees First Solar buy GE IP portfolio

GE and First Solar have announced a technology partnership to advance thin-film solar cells and modules. First Solar has acquired GE's global cadmium telluride (CdTe) solar intellectual property portfolio, setting a course for significant advancement of photovoltaic (PV) thin-film solar technology. GE received 1.75 million shares of First Solar common stock as part of this transaction. GE has agreed to retain the shares for at least three years.

The combination of the two companies' complementary technologies and First Solar's existing manufacturing capabilities are expected to accelerate the development of cadmium telluride (CdTe) solar module performance and improve efficiency at manufacturing scale. In addition, GE Global Research and First Solar R&D will collaborate on future technology development to further advance CdTe solar technology.

GE, which has 34GW of renewable energy installed globally, will enhance its presence in solar through access to purchasing and branding First Solar's modules for future global GE deployments, in addition to its investment in inverters, controls, balance of plant and ownership of utility scale systems.

Additionally, GE and First Solar have formed a commercial relationship around solar inverter technology. First Solar will continue to purchase inverters from GE Energy Management for use in First Solar's global solar deployments to optimize electrical balance of plant. By combining complementary technologies, the collaboration is expected to lead to an improvement in solar grid integration, more competitive cost structures and a roadmap for combined electrical equipment.

"We are creating an exciting synergy with this deal," said Jim Hughes, First Solar's Chief Executive Officer. "The addition of GE's PV thin film technology and R&D resources will advance our technology roadmap, while realizing cost reduction in our manufacturing process."

"To lead in today's solar industry, you must have the most competitive technology at the most competitive cost position," said Anne McEntee, president and CEO of GE's renewable energy business. "We're excited to partner with First Solar to accelerate innovation and bring our complementary technology and R&D to market faster through its manufacturing capabilities."

First Solar's existing manufacturing sites will be used to further advance CdTe technology and achieve an increasingly competitive cost position. GE has decided to discontinue the build-out of its Aurora, Colorado, solar manufacturing facility.

## First Solar to supply CdTe modules for large Australian projects

AGL has engaged First Solar to construct a 102MW [AC] solar plant at Nyngan and a 53MW solar project at Broken Hill

First Solar and AGL Energy Limited (AGL) have secured financial closing for two utility-scale solar photovoltaic (PV) projects.

First Solar has executed engineering, procurement and construction (EPC) contracts to supply the projects with its advanced thin-film photovoltaic (PV) CdTe modules.

What's more, First Solar will provide maintenance support for a period of five years once the solar farms are operational.

AGL has engaged First Solar to construct a 102MW [AC] solar plant at Nyngan and a 53MW solar project at Broken Hill - both located in New South Wales.

The projects are supported by \$166.7 million of Commonwealth Government funding through the Australian Renewable Energy Agency (ARENA) as well as an additional \$64.9 million in funding from the NSW Government. The total project cost is approximately \$450 million.

"The Nyngan and Broken Hill solar projects will be Australia's largest utility-scale solar projects, respectively, and demonstrate that utility-scale solar is a proven, bankable source of power generation in Australia today," explains Jack Curtis, First Solar's Vice President of Business Development for Asia Pacific.

"We are thrilled to be partnering with AGL in delivering the solar projects, both of which are of major significance for regional New South Wales and the Australian energy sector. These projects will play an important part in the growing acceptance of utility-scale solar PV, and we applaud the Commonwealth Government and the NSW Government for their vision and commitment to the sector," he continues.

Construction of the Nyngan project is expected to commence in January 2014, with commercial operation expected by mid-2015. Construction of the Broken Hill project will start approximately six months later, in July 2014, and is scheduled to reach commercial operation before the end of 2015.

On completion, the projects are expected to produce approximately 360,000 megawatt hours of electricity each year, which will be sufficient to meet the needs of over 50,000 average homes in NSW.

The Nyngan and Broken Hill solar plants are expected to provide significant value to regional New South Wales, adding nearly two percent to the gross regional product of each community.

First Solar is actively engaged with local companies looking to become involved in the projects, with over 100 local contractors attending the recent subcontractor forums hosted in Dubbo,

Nyngan and Cobar.

The projects will create approximately 300 construction jobs in Nyngan and approximately 150 in Broken Hill, providing valuable experience and capability to support the development of similar projects in future years.

"AGL is delighted to be working with First Solar and drawing on the team's global expertise in this industry," finishes Michael Fraser, AGL's Managing Director. "We are eager to get this nationally significant project underway, and together we will provide the experience and commercial stability to help ensure the successful construction of the two solar plants."

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## Hanergy continues to expand with Global Solar Energy acquisition

GSE is one of just a few producers able to manufacture flexible CIGS (copper indium gallium diselenide) solar cells on a commercial scale

Hanergy Holding Group Limited has completed the equity acquisition of Global Solar Energy, Inc..

GSE is a manufacturer of flexible CIGS solar cells based in Tucson, Arizona, USA.

The acquisition follows approval from the Committee on Foreign Investment in the United States and the National Development and Reform Commission, the regulators governing cross-border acquisitions in the U.S. and China respectively.

GSE's products are applied in a variety of areas including integrated photovoltaic (BIPV), rooftop solar systems, electronic vehicles and other portable solar products.

In the past year, Hanergy has acquired Solibro and MiaSolé; both leading players in the CIGS technology field. Those transactions took the conversion rate of Hanergy's thin-film PV modules to an unrivalled 15.5 percent.

The acquisition of GSE closes the loop of Hanergy's strategic consolidation of technologies that combine the competitive advantages of flexible thin-film PV modules and large scale production. It also demonstrates Hanergy's continued commitment to developing advanced thin-film technology is a further step in its investment in leading CIGS technology and efficient alternative cell materials.

Commenting on the acquisition, Li Hejun, Chairman of Hanergy, states, "Flexible and thin-film photovoltaic technology is the future and the trend of the industry. The acquisition of GSE marks another landmark deal for us after MiaSole and Solibro."

Hejun continues, "Together these complete the circle of Hanergy's global technology integration strategy, meaning we now have the ability to accelerate the development and large-scale application of our high-efficiency flexible CIGS modules.

The cost-effectiveness and wide application of this technology make it a great step forward for Hanergy's development in large-scale solar energy generation and distribution."

Jeff Britt, Chief Executive Officer of Global Solar, adds, "We are pleased to join with Hanergy, which we believe will best leverage our unique products and technologies to complement Hanergy's existing ones. Together we are well positioned to implement Hanergy's strategy of accelerating the growth of the flexible solar market and exploit new market potentials." |

Following the acquisition, GSE will become a wholly-owned subsidiary of Hanergy. GSE will continue its operation in the US.

Currently, Hanergy predominates seven of the world's leading thin-film technology lines, including amorphous SiGe and CIGS. The mass production of thin film solar modules conversion rate has reached 15.5 percent whereas research has reached the maximum conversion rate of 18.1 percent.

According to the data in "Global Renewable Energy Report 2013" published by Hanergy, China's investment in renewable energy is ranked first in the world. By 2013, China is expected to surpass Germany and become the world's largest PV application market.

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## Taking III-V growth into the next dimension

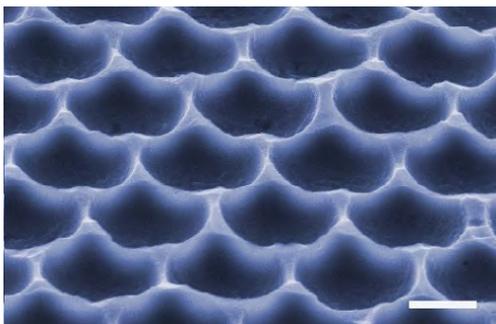
A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. "The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs." The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiOx) cap. The Mo/In/SiOx stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3  $\mu\text{m}$  thick InP thin-films on molybdenum foils with ultra-large grain size up to 100  $\mu\text{m}$ . The researcher says this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500  $\text{cm}^2/\text{V}\cdot\text{s}$  and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics,"

by Kapadia *et al* in *Scientific Reports*, 3, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a

platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

"Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors."

IQE expects to report its interim results around mid-September 2013.

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## First Solar to build another three CdTe plants in Mexico

These new cadmium telluride solar projects are in addition to five plants completed in 2011

First Solar has made an agreement with Public Service Company of New Mexico (PNM) to construct three CdTe solar power plants totalling 23 megawatts (MW) AC of generating capacity.

The solar firm is expected to provide engineering, procurement and construction (EPC) services, using its advanced thin-film photovoltaic (PV) modules. PNM is the largest electrical provider in New Mexico, serving more than 500,000 customers in dozens of communities across the state.

Contingent on approval from the New Mexico Public Regulation Commission, which PNM filed for earlier this month, the agreement establishes terms for the plants' EPC work. The projects are part of PNM's 2014 portfolio of renewable energy resources. These new projects are in addition to five plants completed in 2011 and an additional 21.5 megawatts of solar

PV to be completed this year; all totalling 67MW AC that First Solar has contracted or is expected to construct with PNM by the end of 2014.

The three projects, once approved, are expected to begin construction and be completed in 2014. Up to 300 local construction jobs are expected at peak.

"We are very pleased to be working with PNM on these new projects," says Dana Diller, First Solar's Vice President of U.S. Business Development. "PNM and the State of New Mexico continue to make great strides in meeting their renewable energy goals, and First Solar is excited to play a significant role in that effort."

The solar plants in total will generate enough clean energy to power up to 8,960 average New Mexico homes, displacing about 25,300 metric tons of CO2 annually. That's the equivalent of taking some 5,270 cars off the road, and displacing up to 14.5 million gallons of water consumption annually.

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## Ascent Solar to debut new CIGS product line at Outdoor Retailer

The products will be available to buy in August

Ascent Solar's Manager of Branding & Marketing, Justin Jacobs says, "We look forward to exhibiting the exciting new additions to our product lines and giving distribution partners an opportunity to get a behind the scenes look at our products before they become available for sale later in August."

Small enough to be attached to a belt loop yet powerful enough to make sure devices always have a charge, the Kickr line of personal solar chargers is uniquely enabled by the rugged, lightweight and flexible form factor of Ascent's CIGS solar cells.

Kickrs are perfect for consumers who desire a robust and rugged charging solution when off the grid. Unlike chargers produced using traditional mono-crystalline solar which is heavy, fragile and cumbersome, the Kickr line is light, user-friendly and built to withstand even the harshest conditions.

Jacobs also adds, "Our presence at Outdoor Retailer also includes an invitation to product designers to learn about how our unique, lightweight, flexible solar technology can be integrated into a wide variety of innovative consumer and specialty outdoor applications and we look forward to helping them innovate."

The EnerPlex brand represents Ascent's line of consumer products. These products, many of which are integrated with Ascent's transformational 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.

## Episolar founder recognised as White House “Champion of Change”

The CdTe (cadmium telluride) modules could be used for the development of low-cost, high-performance flexible photovoltaic panels

Siva Sivananthan was honoured as one of eleven Immigrant Innovator “Champions of Change.”

These pioneers strive to better the economy by creating American jobs in dynamic technology sectors to foster sustainable growth throughout the country.



*Siva Sivananthan*

Sivananthan was recognised for his work in the development of night vision technology.

A professor of Physics at the University of Illinois at Chicago (UIC), Sivananthan is also the founder of the Bell Labs-styled incubator, Sivananthan Laboratories, and the recipient of two awards under the Energy Department’s SunShot Initiative.

Born in Chavakacheri, Sri Lanka, Sivananthan came to the United States in 1982 as a master’s candidate at UIC, where he went on to earn his Ph.D. in physics.

His research allowed him to pioneer an approach for growing cadmium telluride (CdTe) - a high-performance semiconductor that is incredibly efficient at turning sunlight into electricity. Utilising this promising technology, his aim was to decrease the production cost of photovoltaic cells while maintaining high performance.

With the view of commercialising solar energy technologies, he founded Episolar, Inc.- a company incubated under the umbrella of Sivananthan Laboratories and enjoying access to its infrastructure and facilities. Episolar’s mission is to develop CdTe-based solar cells with a focus on efficient, inexpensive, flexible photovoltaic products.

Sivananthan always looked for opportunities to make a difference to the United States and the world. From his childhood days in Sri Lanka, he saw the need for powering villages, a dream that could be realised by harvesting solar energy using flexible sheets on thatched roofs.

With his work on devices based on II-VI semiconductors, such as infrared detectors and imagers, he saw employing photovoltaic technology based on II-VI materials as the medium for flexible solar cells.

He commenced fundamental research supported by the Department of Energy through awards such as the 2009 SunShot Incubator and a current SunShot BRIDGE to better understand how defects in crystals impact CdTe solar cell efficiencies.

Sivananthan says, “I am excited that EPIR will focus on commercialising infrared products and services, while Episolar will focus on CdTe-based photovoltaic solar.”

He recently recruited Ramesh Dhere to join the Episolar team. Dhere worked at the National Renewable Energy Laboratory for over 27 years and has been involved in research on CdTe solar cells for over 20 years.

He contributed to the development of high-efficiency polycrystalline CdTe, which led to a device with a record-setting 16.7 percent efficiency in 2001. Recently, he spearheaded work on substrate-structure CdTe devices which, after only two years’ work, yielded open-circuit voltages over 860 mV, comparable to the best of traditional superstrate-structure CdTe devices.

Flexible photovoltaic panels are ideal in applications requiring rapid deployment such as natural disasters and military operations. Lightweight flexible panels are attractive for Building Integrated PV (BIPV) applications such as roof-top installations.

The potential for this market is large and could be fully exploited with the development of low-cost, high-performance flexible photovoltaic panels - the focus of Episolar.

Flexible panels for roof-tops can reduce system costs by reducing transportation and installation costs, eliminating land acquisition costs, which are important in urban areas, and by producing energy close to the point of use, thus minimising the load on the grid. With Sivananthan’s experience in the development of high-performance CdTe-based infrared detectors and Dhere’s experience in developing polycrystalline CdTe devices.

Ramesh Dhere says, “I am looking forward to the challenging work of developing next generation CdTe solar cells at Episolar. It is a wonderful opportunity to work with Dr. Siva and the outstanding team he has assembled at Sivananthan Laboratories”.

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## Ascent Solar CIGS chargers to be distributed in the UK

The manufacturer of flexible thin-film photovoltaic modules is expanding in the UK & Ireland with West Coast Limited

Ascent Solar has formed a distribution partnership with West Coast Limited, an electronics distributor in the United Kingdom

and Ireland represented by PowerIT-2-Channel Ltd.

Founded in 1984 West Coast has become one of the leading distributors recently eclipsing €1 billion in annual revenue. West Coast also distributes Hewlett Packard, Samsung and Toshiba products.

Nick Amer, Business Development Director at West Coast, says, "Alternative power has become ever more popular, especially with the huge growth in portable devices like smartphones & tablets, but in the past many solutions have been very bulky and ineffective. Therefore we are very excited to be partnering with Ascent Solar to bring their superb products to the UK market, and helping to make depleted batteries a thing of the past."

John Maslanik, Ascent's Manager of Business Development, continues, "This agreement enables Ascent to leverage West Coast's considerable distribution capabilities to reach nearly every consumer in the United Kingdom and Ireland via both e-commerce, retail and direct channels, bringing Ascent's EnerPlex products to market in force in an incredibly short period of time. Consumers in the UK and Ireland have shown great interest in renewable energy products, a trend which the EnerPlex series of products is perfectly situated to immediately benefit from. Furthermore, this agreement represents a blueprint for Ascent's expansion into new international markets, taking advantage of entrenched distribution channels and relationships which enable rapid deployment of EnerPlex products to an attractive target market."

Ascent says the EnerPlex Product line has quickly changed the paradigm of solar-integrated consumer electronics, providing consumers with lightweight, powerful and extremely durable charging solutions for all their portable electronics.

Surfr, a line of solar and battery integrated phone cases, allows users to charge their phone anywhere and in cases of emergency. Kickr, a line of portable solar chargers, provides a charging solution for most USB enabled devices enabling power to be generated almost anywhere and in nearly every situation, suited for emergencies.

With the addition of the Jumpr line of portable batteries, consumers now have a complete, integrated, solar charging and storage solution for life on the go.

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## CIGS manufacturer SoloPower slashes work force

In a restructuring move, the firm is moving its head office to Oregon

SoloPower announced that an agreement in principle has been reached with its major secured creditors on a comprehensive restructuring plan as it continues to seek new strategic financing for future expansion.

SoloPower CEO, Rob Campbell, stated that, "This agreement will enable SoloPower to seek new strategic partners to enable continued production at the Portland, Oregon facility and advance our innovative light weight PV technology. We are confident that we are on the right path and appreciate the support of our secured creditors."

SoloPower also confirms reports that it is planning to move its head office location to Portland, Oregon, in order to further optimise operations.

The company's proprietary lightweight, flexible CIGS solar modules serve a unique and underserved market - commercial and industrial rooftops on which traditional solar panels cannot be installed due to their weight and rigidity.

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## RSI's CdTe solar modules have the power

The company claims its cadmium telluride 1.5 square metre cells add high power and lower installation cost to improve efficiency, reliability, sustainability and profitability

achieving a 1.5 square metre module.

The availability of low cost large-area CdTe panels coupled with localised manufacturing partners hastens the widespread achievement of grid parity for utility scale solar.



Image showing RSI solar module

Conventional CdTe measure 0.72 square metres, a limitation that stems from the use of high temperature CdTe deposition processes.

RSI has developed a proprietary tool and low temperature process, known as Rapid Efficient Electroplating on Large-areas (REEL), that both speeds the plating step and eliminates constraints on panel area. The company projects a manufacturing cost of less than 40 cents per peak watt in 2014.

The availability of low-cost, large-area CdTe panels coupled with a business model that leverages regional manufacturing partners promises the widespread acceleration of grid parity for utility scale solar.

"The math is simple for large-area modules," says RSI Co-founder and President Kurt Weiner, "At each step in the

manufacturing process we are moving more Watts for a given capex, materials and labour cost. At the end, our panels produce significantly more power so they're cheaper to install. When we founded the company we recognised that in thin-film, you needed larger panel sizes with higher power outputs, in addition to efficiency, to truly differentiate against silicon. We've achieved both at RSI."

"The solar industry is growing massively, but the only manufacturers who have made consistent profits are those with access to proprietary technology," adds RSI Chief Executive Ed Grady. "Incremental improvements to undifferentiated technology like crystalline silicon are not enough to prosper in this commoditised market. Manufacturers end up giving away their margin to survive. First Solar has shown how to make profits through technology and cost differentiation. RSI is delivering a step change improvement in the cost structure, while retaining all the characteristics that have made CdTe so successful."

"The combination of low capital need and a focus on solving the key manufacturing scale and capital cost issues made RSI stand out as an investment opportunity," continues RSI investor Matt Jones of Nth Power. "RSI had the highest profit and investor return potential of any solar module company we have seen."

Pedram Mokrian from Mayfield Fund is also bullish. "We believe that the solar industry is just beginning to hit its stride. RSI's large-area manufacturing technology based on the proven CdTe material system represents a step change in PV manufacturing costs. Most importantly, our investment focused on the strength of the RSI team, and their ability to execute against this vision," he says.

## Soitec lights up California with III-V based solar modules

A new plant in San Bernardino County uses Soitec's fifth generation Concentrix CX-S530 CPV systems

Soitec Solar Development, LLC has completed construction of the 1.5 MWAC Newberry Solar 1 project in San Bernardino County, California.

Renewable power generated by Newberry Solar 1 will be sold to Southern California Edison under a 20-year power purchase agreement. It is the largest concentrator photovoltaic (CPV) power plant in California, featuring Soitec's latest and most efficient technology with modules manufactured in nearby San Diego.

"This announcement represents a major milestone for Soitec in establishing its newest generation of CPV technology and a critical step in our ambitious deployment plans in the region," says Gaetan Borgers, executive vice president of Soitec's Solar Energy Division.

"Newberry Solar 1 is the first solar power plant constructed in

the U.S. with our most advanced CPV modules shipped directly from our new San Diego manufacturing facility. With a current production capacity of 280 MWp and a worldwide pipeline of solar power plant projects totalling hundreds of megawatts, we're very happy to show that our new product is now shipping and can be installed and operational in a very short timeframe."

The Newberry Solar 1 power plant connects directly to Southern California Edison's distribution network and will provide approximately 500 Southern California homes with clean, renewable energy while offsetting the emission of almost 2,300 tons of carbon dioxide each year.

The power plant uses Soitec's fifth generation Concentrix CX-S530 CPV systems, designed as Soitec's next step towards achieving a Levelised Cost of Electricity (LCOE) for utility-scale solar power plants in the sunniest regions of the world.



Soitec CX-S530-II CPV System

With a module area of over 100 square meters (1,130 square feet), one Soitec CX-S530 generates a capacity of 28 kWp. The size of the system is optimised to deliver high performance while drastically reducing costs for manufacturing, installation and maintenance.

The system utilises 12 of the large Soitec CX-M500 modules and delivers an efficiency of 30 percent, about twice the efficiency of conventional photovoltaic panels.

The 720 CX-M500 modules used at Newberry Solar 1 were manufactured in Soitec's new North American manufacturing headquarters in San Diego on fully automated assembly lines, ensuring high-precision manufacturing. The factory, commissioned in December 2012, is currently targeted to reach its full capacity of 280 MWp by October 2013, making Soitec the third largest solar module manufacturer in the U.S.

With installations in 18 countries around the world, Soitec's CPV technology is proving its competitiveness to generate solar power, largely due to its higher production yields throughout the sunlight hours.

What's more, CPV technology's ability to operate without cooling water, withstand hot ambient temperatures and have minimal environmental impact makes it well suited for use in

desert areas.

## Ascent Solar and Suqian JV to build CIGS manufacturing plant in China

Under the framework agreement, in the first phase, Ascent and Suqian will form a joint venture entity (JV) in which Ascent will have majority interest of up to 80 percent

Ascent Solar Technologies has signed a framework agreement for the establishment of a joint venture with the Government of the Municipal City of Suqian in Jiangsu Province, China (Suqian).

The agreement covers a multi-faceted, three-phase project over the next six years.

Suqian, is a prefecture-level city in northern Jiangsu Province with an area of 3,303 square miles and a population over 5 million. Strategically located between the Yellow River and the Yangtze River, Suqian is well connected to both Beijing and Shanghai in less than 3 hours by high-speed train. Suqian is one of the fastest growing prefecture-level cities in China, boasting a GDP of \$25 billion, in 2012, and growing nearly 13 percent annually.

The JV will build a factory to manufacture Ascent's proprietary Copper-Indium-Gallium-Selenium (CIGS) photovoltaic modules on flexible thin films. Ascent will contribute proprietary technology and intellectual property, approximately \$1.6 million in cash and certain equipment from its Colorado facility. Suqian will provide cash of approximately \$32.5 million as well as rent-free use of a 270,000 square foot factory that is currently being built in the Suqian Economic and Industrial Development Science Park.

This factory is expandable to 1,000,000 square feet for phases two and three of the agreement. The total project size of Phase one of the alliance is expected to be approximately \$160 million. Ascent will have the right to purchase the factory anytime within the first 5 years at the initial construction cost, as well as the right to purchase Suqian's ownership interest in the JV for a modest nominal cost above Suqian's cash investment.

Suqian will also provide a package of additional incentives including a multi-year corporate tax holiday, coverage of substantial operational costs for scientists, engineers and management personnel, and significant housing subsidies and tax incentives for key employees of the JV.

As Phase two and three of this program are implemented, Ascent will have the option to purchase approximately 1.3 million square feet of land zoned for commercial usage at a favorable cost, as well as the right to arrange sale or lease of land and factory rights to suppliers and support industries brought in by Ascent, which may generate additional meaningful cash flow for the JV.

"This partnership is a strong endorsement of Ascent's industry

leading flexible CIGS technology," says Victor Lee, President & CEO of Ascent. "This partnership enables us to accelerate our paradigm shift into consumer electronics and specialty market applications given China's very large and growing consumer base and readily available contract manufacturers for our EnerPlex range of consumer products," continues Lee.

"We are very excited and honoured to be partnering with Ascent Solar," states Lan Shao Min, Top Leader & Governor of the Municipal City of Suqian.

Lan continues, "The Suqian Government is fully committed to this partnership and shall provide the utmost support and incentives to Ascent. We are convinced that CIGS, and more specifically Ascent's proprietary CIGS technology utilising a flexible plastic substrate, is the next breakthrough in photovoltaics. The aim of our alliance with Ascent is to build a state of the art industrial park in Suqian for solar and solar-related products, anchored by the Ascent factory, but including equipment suppliers, contract manufacturers and other supporting industries."

Amit Kumar, Chairman of Ascent, adds, "We are pleased with our alliance with Suqian. The funding and other subsidies will enable Ascent to develop the scale of manufacturing needed to bring the cost of CIGS down substantially. The combination of cost reduction and our higher margin EnerPlex products and other specialty market applications will allow Ascent to carry on to its next stage as a high-growth company. The alliance with Suqian, as it develops over the next six years, will provide a means for Ascent to build positive cash flow from numerous sources, including control of the real-estate rights in the Suqian Economic and Industrial Development Science Park."

## Polish University orders another Aixtron tool for III-V solar research

Technological centre TECHNOLPOLIS is to develop high-efficiency multi-junction gallium arsenide based solar cells

The University of Wroclaw in Poland has successfully started-up a 3 x 2-inch Aixtron Close Coupled Showerhead (CCS) MOCVD reactor to create optoelectronic devices.

The tool will be mainly used to create high efficiency multi-junction solar cells, based on GaAs related materials.

Marek Tlaczala comments, "We decided to purchase the Aixtron system based on our good experience with the performance of our existing CCS 3 x 2-inch gallium nitride tool in the Faculty of Microsystem Electronics and Photonics. The new Showerhead reactor is destined for the University's Interuniversity Didactic-Technological Centre 'TECHNOLPOLIS' in Wroclaw."

Frank Schulte, Vice President of Aixtron Europe, adds, "The Close Coupled Showerhead (CCS) concept is recognized as a robust route to uniformity and scalability. We are very

pleased that the University of Wroclaw has chosen our system for its most advanced centre TECHNOPOLIS and are looking forward to continue our close collaboration with our customer's excellent technical team."

The centre is co-funded by the European Union from the European Regional Development Fund within the framework of the Infrastructure and Environmental Programme and Poland's national budget.

Doctoral and masters students will be trained in the centre to participate in strategic economic activities such as automatics and robotics, electronics and telecommunications, computer science and teleinformatics.

TECHNOPOLIS is an investment endeavour whose purpose is to establish fundamentals for the development of educational infrastructure enabling highest quality education, necessary for the creation of knowledge society and encouraging economic growth in the region concerned.

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## US announces CIGS roadmap

The PV Roadmap aims to identify common challenges and define the areas of technical developments needed to sustain and advance a competitive U.S. photovoltaics market

The U.S. Photovoltaic Manufacturing Consortium (PVMC), has released the first-ever U.S. CIGS PV Roadmap reports.

The PVMC is an industry-led collaboration headquartered at SUNY's College of Nanoscale Science and Engineering (CNSE) in New York that is designed to accelerate next-generation solar photovoltaic (PV) technologies,

"Photovoltaics and especially thin-film PV are again at a tipping point," says Larry Kazmerski, co-chair of the U.S. CIGS PV Roadmap. "We want PV to be a substantial part of the world's energy portfolio and our efforts with this roadmap are aimed to help make CIGS thin films a significant part of that solar success."

"In building on the innovation strategy of Governor Andrew Cuomo that is establishing New York as a hub for solar energy technologies and companies, we engaged over 75 partner firms and 100 industry experts to develop a 10-year projection in the first-ever U.S. CIGS PV roadmap," continues Pradeep Haldar, PVMC Chief Operating and Technology Officer and CNSE Vice President for Clean Energy Programs.

"This blueprint identifies the critical challenges for CIGS PV manufacturing, applications for sustainable innovation, and technical developments that will serve our members and stakeholders, and enable a competitive U.S. solar industry amid the global marketplace."

Spearheaded by SEMATECH and CNSE as part of the U.S. Department of Energy's (DOE) SunShot Initiative, PVMC is targeting a reduction in the total installed cost of solar energy systems by 75 percent over the next decade.

The CIGS PV Roadmap aims to provide a congruent plan for the national CIGS industry, including module and systems manufacturers, suppliers, and end-users, that will identify common challenges and define the areas of technical developments needed to sustain and advance a competitive U.S. photovoltaic industry.

The annual roadmap entitled "2013 U.S. CIGS PV Roadmap Reports," identifies the technology challenges to attain projected module cost and performance targets over the next 10 years. The various reports, based on the latest industry analysis, advance the effort for achieving the SunShot initiative target.

The roadmap addresses six focus areas relevant to the entire industry, including roll-to-roll, rigid glass, metrology, modules and packaging, substrates and materials, and reliability/certification/test. Each section outlines the current status and critical challenges for each technology, discusses the role of industry standards for CIGS, and potential areas of innovation for the pre-competitive domain.

As the primary sponsor of the effort, PVMC provides the resources for managing and coordinating the roadmap activities. Members of the CIGS PV Roadmap represent all areas of the PV industry, including module producers and integrators, equipment suppliers, materials and metrology tools, end-users, and the research community.

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# Power Electronics

## GaN Systems puts silicon power devices in the shade

The firm's gallium nitride "Island Technology" packs more power in a quarter of the space of silicon devices

GaN Systems develops the most complete range of GaN power switching solutions available and is focussed on the easy adoption of GaN by design and systems engineers.

The firm's proprietary Island Technology produces devices that are significantly smaller and more efficient than traditional design approaches. GaN Systems has access to fabs around the globe and the company's executives will be on-hand to discuss potential applications with attendees.

The European Conference on Power Electronics and Applications is a world forum for presentation and discussion of the latest development in power electronics, reflecting the increasing importance of this technology in fields such as clean transportation systems for both mass and individual transportation, energy production systems and industrial applications.

## Air Water to develop GaN-on-SiC-on-silicon with Aixtron reactor

The company is building on large diameter SiC on silicon technology for LEDs and power devices

Air Water of Azumino in Japan has reported the successful installation of a fully automated Aixtron AIX G5 HT planetary reactor in an 8 x 6 inch configuration for the growth of GaN epitaxial layers.



*Aixtron AIX G5 HT planetary reactor*

Aixtron says Air Water selected this MOCVD system to deliver superior material uniformity, a key factor in demonstrating the advantage of Air Water substrates for GaN epitaxy. □

Following the installation, the company has announced the release of GaN-on-SiC on silicon substrates for this year.

In order to address future market demand, Air Water is also considering upgrading the system to an Aixtron AIX G5+, which can handle up to 5 x 200 mm (8 inch) silicon substrates.

As compared to traditional silicon substrates, the additional SiC layer displays the advantage of protecting the silicon substrate in the initial GaN nucleation process. Due to its crystal structure SiC is considered as an ideal template for the GaN growth.

So, the SiC-on-silicon substrate is enabling the growth of superior crystal quality GaN layers onto large areas. This characteristic brings efficiency and cost savings to a wide range of high-power and LED applications.

Air Water is a Japanese industrial gas manufacturer and has developed SiC growth on silicon for both power device and LED applications as part of the semiconductor gas business.

The company has already succeeded in the production of high quality 3C-SiC (111) on up to 8 inch silicon substrates and has also announced the release of these products for GaN epitaxial growth required to manufacture electronic devices for LED and power electronic applications.

## Power device demand for automotives soaring

The electric vehicles fuel market is set to grow the most in the Asia-Pacific and European regions

Environmental regulations, the electrification of the powertrain, the need for efficient power management and the availability of new safety features are driving the global power semiconductor market in the automotive industry.

Two of the main compound semiconductors used in power devices are SiC and GaN.

The popularity of electric vehicles, which have a larger content for power semiconductors, is fuelling installations. On the other hand, new trends like the idling-stop system will boost the use of semiconductor content within traditional fuel-based vehicles.

A recent report by Frost & Sullivan, "Analysis of Global Power Semiconductors Market in the Automotive Industry," indicates that the market earned revenue of \$2.81 billion in 2012 and estimates this to reach \$5.28 billion in 2018.

Insulated-gate bipolar transistors (IGBT) and metal oxide semiconductor field-effect transistors (MOSFETs) are chief contributors to revenues, and are replacing traditional solutions such as bipolar junction transistors and thyristors.

And Asia-Pacific and Europe will be key regions for market growth.

Rising incomes of the middle class in countries like India, China and Brazil have ignited vehicle sales, spurring the need for power semiconductors used in these vehicles.

"Consumers are shying away from traditional gas guzzling automotives, preferring fuel-efficient vehicles due to the escalating costs of fuel," says Frost & Sullivan's Measurement and Instrumentation Program Manager Aravind Seshagiri. "This has increased the deployment of power semiconductors in existing powertrain and engine control systems, as original equipment manufacturers look to improve performance and lower fuel consumption."

Stringent emission norms and mileage regulations have opened up opportunities for power saving chips. Emphasis on reducing switching losses for IGBT and switching on power requirements for MOSFETs in automotive environments where losses are induced by high temperature and electromagnetic interference, adds to the adoption of power semiconductors.

Although, while demand has gone up, it does not remain constant, making it difficult for semiconductor manufacturers to keep up with the steep variation. What's more, it is hard to accurately forecast demand due to diverse consumer requirements. This means market needs are not completely addressed, thus lowering revenues. The lack of technical advancements in the field of power semiconductors has further slowed market expansion.

"With little technological progress in the power components sector, power semiconductor application areas are likely to be

taken over by integrated circuits, especially in electric vehicles,” adds Seshagiri. “New technologies like silicon carbide-based power electronics will also be key focus areas for innovation.”

## IXYS Introduces silicon carbide high power diodes

The SiC diode modules are suited to applications such as MHz switch mode power supplies, high frequency and resonant converters as well as rectifier circuits

IXYS Corporation’s Colorado division has introduced the SS150 and SS275 series high power SiC diodes.

Three diode configurations provide designers with flexible connection and layout options.

Packaged in low inductance, surface mount DE Series package, these products provide excellent switching performance.

The SS150 and SS275 are both available in 600V, 10A and 1200V, 5A ratings. Standard internal configurations include:

*TI – Triple Independent - no common connections*

*TA – Triple Anode - anodes are tied together*

*TC – Triple Cathode - cathodes are tied together*

The SS150 and SS275 SiC diode modules are ideal for applications such as MHz switch mode power supplies, high frequency and resonant converters as well as rectifier circuits.

The use of SiC allows extremely fast switching, high frequency operation, with zero recovery and temperature independent behaviour. Coupled with our low inductance RF package, these diodes can be utilised in any number of fast switching diode circuits or high frequency converter applications.

SS150 & SS275 Features:

- Surface Mount Package
- 600V, 10A and 1200V, 5A Available
- Zero Reverse Recovery
- Zero Forward Recovery
- High Frequency Operation
- Temperature Independent Behavior
- Low Inductance
- Positive Temperature Coefficient for Vf

“The SS150 and SS275 High Power SiC Diode Modules allow designers more flexible design options with high frequency applications,” comments Stephen Krausse, General Manager of IXYS Colorado.

The SS150 and SS275 high power SiC diode modules are available directly from IXYS Colorado.

## Silicon carbide market goes back to black

According to a new report from Reportlinker.com, black SiC has been the largest market and is expected to show the highest growth up to 2019

High demand for steel manufacturing and steel processing along with recycling has been driving the market for silicon carbide (SiC) in the past few years.

Silicon carbide is a key component of the semiconductor devices and growth in the electronics and semiconductor market is also a driving factor governing SiC market growth. The high precision required for manufacturing components and the low level of tolerances in the end-user market have been restraining the market at the same time.

A new market research report regarding developments in SiC is now available in Reportlinker.com’s catalogue. It is called, “Silicon Carbide (Black SiC, Green SiC) Market For Automotive, Aerospace, Military, Electronics, Healthcare, Steel And Energy Applications - Global Industry Analysis, Size, Share, Growth, Trends And Forecast, 2013 - 2019”.

Based on the product segments, the SiC market can be categorised into different segments such as black SiC, green SiC and others such as coated SiC, refractory SiC, metallurgical SiC, metallurgical briquettes and SiC micro grit.

Black SiC has been the largest market and is expected to show the highest growth during the forecast period.

The major end-user segments in the SiC market are steel & energy, automotives, aerospace & aviation, military & defence, electronics & semiconductors and medical & healthcare. Of these, electronics & semiconductors, automotives and steel & energy have been the major markets while medical & healthcare is expected to show the highest growth in the near future.

## POET Tech makes the next move to commercialisation

The company is aiming to take it’s gallium arsenide (GaAs) based technology to the next level

The Board of Directors at POET Technologies has endorsed the next phases of the company’s commercialisation plan put forward by the Special Strategic Committee (SSC) chaired by Executive Director Peter Copetti.

The company is the developer of proprietary planar-optoelectronic technology known as ‘POET’. This is a platform for the monolithic fabrication of integrated electronic and optical devices on a single semiconductor wafer.

The multi-pronged approach is based on discussions with potential industry partners and advisers regarding the

company's two key markets consisting of the military and commercial sector that have been identified as potential early adopters of the POET platform.

While POET's incorporation in military projects is currently proceeding well, and should provide value in several key verticals, significant value exists in adapting POET for mass production within a commercial semiconductor fab environment.

The company wants to rapidly move to the next phase of its commercialisation plan, which includes addressing feature size and scalability requirements for commercial fabs. The Board has therefore endorsed, and authorised the SSC to proceed on the following recommendations:

*Establishing a POET Development Alliance (PDA)* - The company will be establishing relationships with one or more industrial partners looking towards jointly adapting POET to commercial scale III-V implementation. Alliance partners will provide key input including intellectual assets, technical staff, manufacturing capability, and foundry resources. In addition to optimising device parameters and yields, a near-term goal will be to establish comprehensive design rules and a device parameter library for POET, which will proliferate licensed designs in a POET device ecosystem.

*Drive for Reduction of Feature Size to 100nm Range* - The company will re-prioritise its technical roadmap by introducing specific milestones associated with reducing feature size from the submicron to the 100nm range in scale, targeting Q4 2013 for that milestone. Consequently, the milestone for full optoelectronic integration on a single die will be re-scheduled to Q2 2014.

Even without this full integration milestone, the 100nm goal anticipates the cadence of commercial III-V foundry capabilities. This roadmap will focus the company's ODIS subsidiary on developmental work that will allow for scalable production within existing commercial fabs.

*Adoption of a Shareholder Rights Plan (SRP)* - The company will be structuring a special SRP to protect the potential value of the company, for all shareholders, during the period where discussions with potential partners may be taking place regarding PDA-related agreements, and as progress on the 100nm project continues.

"This move crystallises the company's strategy for unlocking the value of our intellectual property," says Copetti. "A development alliance with the right partners will definitely shorten time-to-market, and help evolve a design ecosystem for POET in the marketplace."

Further SSC actions will be endorsed by the Board depending on the status of the above initiatives. Copetti adds, "While the new feature-size milestone is a challenge given our commitment to projects in our delivery pipeline, I believe the POET team is more than capable of achieving this goal. There is no doubt that POET can demonstrate its n- and p-channel capability to be a viable and scalable complement to silicon CMOS."

By offering components with the potential for increased speed, density, reliability, and lower costs, POET offers the semiconductor industry the ability to push Moore's Law to

the next cadence level, overcoming current silicon-based bottlenecks, and potentially changing the roadmap for a broad range of applications.

The POET platform is currently the basis for a number of key projects. These include optical code division multiple access (OCDMA) devices for avionics systems, combined RF/optical phased arrays, optoelectronic directional couplers, and ultra-low-power random access memory (RAM).

With its head office in Toronto, Ontario, Canada, and operations in Storrs, CT, the company, through ODIS Inc., a U.S. company, designs III-V semiconductor devices for military, industrial and commercial applications, including infrared sensor arrays and ultralow-power random access memory.

The firm has 34 patents issued and 7 patents pending for the POET process, with potential high speed and power-efficient applications in devices such as servers, tablet computers and smartphones.

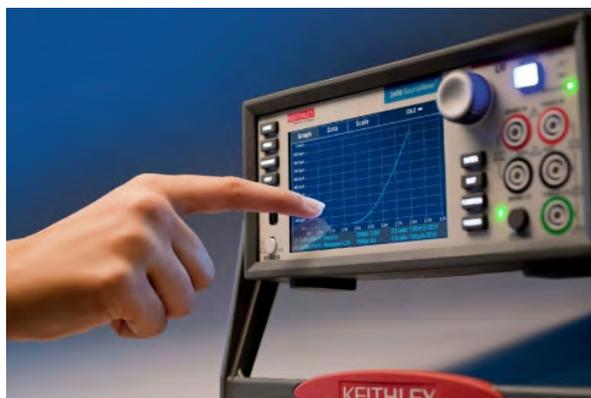
## Keithley unveils interactive touchscreen for power device analysis

The firm's offering combines capabilities of I-V systems, curve tracers, and semiconductor analysers at a fraction of their cost

Keithley Instruments has revealed a benchtop Source Measure Unit (SMU) instrument with a capacitive touchscreen graphical user interface.

The Model 2450 SourceMeter SMU Instrument combines the intuitive touchscreen and icon-based control that novice SMU users can appreciate with the versatility that experienced users need to learn faster, work smarter, and invent more easily.

The Model 2450's design, Keithley's latest generation of SMU instruments, offers a fundamentally new way for users to interact with test and measurement instruments. It is based on the company's innovative "Touch, Test, Invent" design philosophy.



Keithley Instruments Model 2450 SMU

This new design philosophy reflects recent market changes, including shrinking product design/development cycles and

fewer personnel devoted exclusively to test engineering tasks. At the same time, the profile of the typical instrument user has also evolved.

In addition to electrical engineers, it now includes a growing number of non-engineers (such as electrochemists, physicists, materials scientists, etc.) who need fast access to data but sometimes have limited training in electrical measurement.

What's more, as the previous generation of electrical engineers has retired, their younger replacements have tended to be more software oriented than hardware oriented.

To accommodate all of these market and user changes, the Model 2450 incorporates numerous ease-of-use features that ensure a faster "time-to-answer" than competitive solutions, including a context-sensitive help function, "Quickset" modes that speed instrument configuration, and on-screen graphing capabilities that quickly turn raw data into usable results.

The instrument builds on the design strengths and high precision of both the Model 2400 SourceMeter SMU instrument (an industry standard since its 1995 introduction) and the newer Series 2600B System SourceMeter SMU Instrument line.

The Model 2450 combines the functionality of a power supply, true current source, 6-1/2-digit multimeter, electronic load, and trigger controller in one tightly integrated, half-rack instrument. With all of these capabilities, the Model 2450 integrates the capabilities of I-V systems, curve tracers, and semiconductor analysers at a fraction of their cost.

#### Benchtop Application Advantages

Many of the Model 2450's features help speed and simplify lab/benchtop work as described below.

**Full-colour, 5-inch touchscreen user interface:** The full-colour display and large on-screen characters enhance legibility. A simple, icon-based menu structure allows reaching any measurement set-up panel with just a touch.

**Extended measurement ranges with superior low current performance:** The new low current (100nA, 10nA) and voltage (20mV) ranges eliminate the need to add separate low-level instruments to a benchtop system. Back-panel triax cable connections eliminate the need for expensive cable adaptors, which can degrade low-level measurement performance.

**Built-in context-sensitive help function:** Help information is provided right where it's needed through the touchscreen, minimising the need to review a manual.

**Error and event logging:** The touchscreen displays error messages and an event log to simplify diagnosing instrument errors, for higher productivity.

**KickStart start-up software:** This "no-programming" instrument control software simplifies taking and graphing data in minutes. For more complex analyses, data can be easily stored to disk, and then exported to Microsoft Excel® or another software environment.

#### System-Level Application Advantages

Several features simplify integrating the Model 2450 into automated test systems:

**Embedded Test Script Processor (TSP):** An onboard Test Script Processor embeds complete test programs into non-volatile memory within the instrument itself to provide higher test throughput by eliminating the GPIB traffic problems common to systems dependent on an external PC controller.

**TSP-Link inter-unit communication bus:** Unlike users of mainframe-based systems, Model 2450 users are not constrained by power or channel count limitations. TSP-Link connections support system expansion with multiple 2450s and other TSP instruments, including Series 2600B SMU instruments and the Model 3706A Switch/Multimeter. Up to 32 Model 2450 instruments can be linked for multi-point or multi-channel parallel test, under the direction of a master unit's TSP controller.

**Model 2400 legacy mode:** In addition to its native 2450 SCPI operating mode, the Model 2450 offers a 2400 SCPI operating mode for backward compatibility with existing 2400 SCPI programs. This preserves Model 2400 users' software investments and eliminates the re-work normally associated with upgrading a system with a new instrument.

**PC connectivity and automation:** Rear panel triax connectors, multiple instrument communication interfaces (GPIB, USB 2.0, and LXI/Ethernet), a Dsub 9-pin digital I/O port (for internal/external trigger signals and handler control), instrument interlock control, and TSP-Link® jacks simplify configuring multi-instrument test setups.

#### Pricing and Availability

The list price of the Model 2450 €4,535 or £3,810. A version without a front panel designed for integration into automated systems is available for €4,283 or £3,598. The Model 2450 is available to order now.

## Cree not a casualty in financial crisis

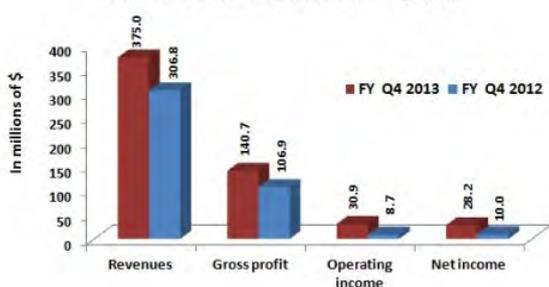
The LED and SiC power device chip manufacturer has shown robust growth over the last fiscal year

Cree announced revenue of \$375.0 million for its fourth quarter of fiscal 2013, ended June 30th, 2013.

This represents a 22 percent increase compared to revenue of \$306.8 million reported for the fourth quarter of fiscal 2012, and a 7 percent increase compared to the third quarter of fiscal 2013.

Net income for the fourth quarter was \$28.2 million, or \$0.23 per diluted share, an increase of 182 percent year-over-year compared to net income of \$10.0 million, or \$0.09 per diluted share, for the fourth quarter of fiscal 2012.

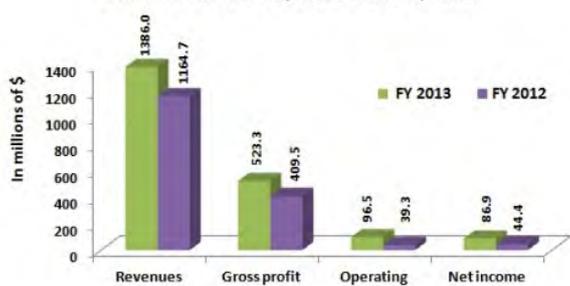
GAAP results for FY Q4 2013 and FY Q4 2012



For fiscal year 2013, Cree reported revenue of \$1.39 billion, which represents a 19 percent increase compared to revenue of \$1.16 billion for fiscal 2012. GAAP net income was \$86.9 million, or \$0.74 per diluted share, an increase of 96 percent compared to \$44.4 million, or \$0.39 per diluted share, for fiscal 2012.

The company generated \$285.2 million of operating cash flow and \$186.9 million of free cash flow (cash flow from operations less capital expenditures) during fiscal 2013.

GAAP results for FY Q4 2013 and FY Q4 2012



“Our fiscal fourth quarter was a strong finish to a great year, with record revenue and good earnings growth in line with our targets,” stated Chuck Swoboda, Cree Chairman and CEO.

“Total company backlog is ahead of this point last quarter and we are targeting solid growth in LED lighting in Q1. Our new products have opened new applications, improved payback, and fuelled growth in LED lighting. We remain focused on driving mass adoption and our goal of 100 percent upgrade to LED lighting,” adds Swoboda.

Gross margin decreased 60 basis points from Q3 of fiscal 2013 to 37.5 percent. Cash and investments increased by \$86.9 million from Q3 of fiscal 2013 to \$1.0 billion. Accounts receivable, net increased by \$10.6 million from Q3 of fiscal 2013 to \$192.5 million, with days sales outstanding of 46. Inventory increased by \$1.3 million from Q3 of fiscal 2013 to \$197.0 million and represents 76 days of inventory.

Business Outlook:

For its first quarter of fiscal 2014 ending September 29th, 2013, Cree targets revenue in a range of \$380 million to \$400 million, with gross margin targeted to be 38.5 percent. The firm’s gross margin targets include stock-based compensation expense of approximately \$2.2 million. Operating expenses are targeted to increase by approximately \$3 million sequentially.

The tax rate is targeted at 23.0 percent for the first quarter of fiscal 2014. Net income is targeted at \$28 million to \$34 million, or \$0.23 to \$0.28 per diluted share and is based on an estimated 122.4 million diluted weighted average shares.

All data quoted in this article is GAAP based.

## TriQuint endorses awards along with CAP Wireless acquisition

TriQuint’s Board of Directors approved 67,900 stock options and 46,760 RSU awards to former CAP Wireless employees

TriQuint’s Board of Directors’ Compensation Committee has approved stock options and restricted stock unit (RSU) awards in conjunction with the firm’s acquisition of California based CAP Wireless, Inc.

Terms of the acquisition were not disclosed and the impact to earnings this year is expected to be immaterial.

The directors approved 67,900 stock options and 46,760 RSU awards to former CAP Wireless employees under the ‘TriQuint 2008 Inducement Plan’.

The awards were granted August 7th, 2013. The stock options will expire on August 7th, 2023 and will vest 25 percent on August 7th, 2014 with the remaining 75 percent vesting quarterly over the next three years, and have an exercise price equal to 100 percent of the closing price of TQNT common stock on Aug 7th, 2013.

The RSUs will vest 25 percent on August 1st, 2014 with the remaining 75 percent vesting annually over the next three years.

TriQuint’s Compensation Committee, which is solely comprised of independent directors, approved the grant of the awards on August 7th, 2013 in accordance with NASDAQ Listing Standard 5635(c)(4).

## Samsung Selects Anadigics for Galaxy Mega

Anadigics provide the wireless connectivity in the new Galaxy Mega

Anadigics Inc. has announced that the Company’s AWT6751 and AWT6755 dual-band ProEfficient-Plus WCDMA power amplifiers (PAs) enable wireless connectivity in the new Galaxy Mega by Samsung Electronics. This phablet features either an expansive 6.3 or 5.8-inch display blending the functionality and form factor of both a smartphone and tablet. The Galaxy Mega offers up to a 1.7 GHz dual-core processor, 8 megapixel camera, and Android 4.2.2 Jelly Bean operating system.

“The selection of Anadigics’ AWT6751 and AWT6755 power amplifiers for the Galaxy Mega demonstrates the tremendous strength of our relationship with Samsung, and the compelling advantages enabled by ProEfficient-Plus technology,” said Jerry Miller, senior vice president of Cellular Products at ANADIGICS. “Our dual-band ProEfficient-Plus solutions not only help to extend battery life in power-hungry, large-screen mobile devices, but also deliver space-saving integration to provide greater design flexibility. We are extremely pleased to work closely with Samsung and look forward to powering the next-generation of feature-rich smartphones, phablets and tablets.”

Anadigics’ dual-band ProEfficient-Plus solutions utilize the Company’s exclusive InGaP-Plus technology and patented design architectures to deliver exceptional performance and integration. These power amplifiers deliver industry-leading efficiency in low-power mode for greater talk time and high-power mode for longer data application use. This level of performance, combined with exceptionally low quiescent currents without the use of a DC/DC converter, maximizes battery life in 3G mobile devices. ProEfficient-Plus power amplifiers are also compatible with average power tracking (APT) to further increase efficiency and reduce current consumption at medium and low operating powers. The complete family of dual-band ProEfficient-Plus solutions are offered in compact 3 mm x 4 mm x 0.9 mm packages and feature internal voltage regulation to save valuable PCB space.

ANADIGICS Dual-Band ProEfficient-Plus Family Key Facts and Highlights:

Industry-leading efficiency across all power levels and exceptionally low quiescent current to maximize battery life, including longer talk time and data use

Two independent amplification chains to provide industry-leading performance for each band

Compact 3 mm x 4 mm x 0.9 mm package with internal voltage regulation and integrated DC blocks on the RF ports to reduce PCB space requirements

Best-in-class linearity to maintain stable, high-throughput 3G connections

RF matching optimized for output power, efficiency, and linearity in a 50-Ohm system

## Latest GaN transistor developments to be presented at summit

Characterisations and performance of D-Mode GaN HEMT transistor used in a cascode configuration revealed

A team of experts on gallium nitride technologies from GaN Systems Inc, a developer of gallium nitride power switching semiconductors, is presenting a major conference paper at the 224th ECS Electrochemical Energy Summit (San Francisco, California October 27 – November 1).

“Characterisations and performance of D-Mode GaN HEMT transistor used in a cascode configuration” authored by Tom MacElwee, John Roberts, Hughes Lafontaine, I. Scott, Greg Klowak, and Lyubov Yushyna will be presented during the GaN and SiC Power Technologies symposium.

GaN Systems has developed proprietary gallium nitride high power transistors for clean technology power conversion applications, enabling superior switching efficiencies over current silicon based solutions. These devices offer substantial benefits to switching power supply designs, inverters, hybrid and electric vehicles, battery management and power factor correction.

The paper reports on D-mode HEMT device performance when configured in cascode mode, including basic parameters of the device and its integration into a PQFN package. A detailed discussion demonstrates the 500V 3.3A switching characteristics of the cascode and proves excellent switching performance with measured voltage slew rates as large as 70 V/ns.

The GaN D-mode HEMT device developed in the work covered by the paper was fabricated using a conventional RF GaN process flow on 3” 4H Si-SiC starting substrate. The SiC substrate should allow for excellent thermal performance and high voltage operation of the switching device due to the semi-insulating nature of the SiC substrate.

## How many people do you need to change a light bulb?

None - it’s an LED bulb



Gallium nitride-on-silicon is a hot topic for LEDs and power devices.

But LEDs could be the game changer - in the immediate future at least - as LED bulbs can last a lifetime. With new government regulations to make our world more environmentally friendly, and the demise of incandescent bulbs, LEDs are on the rise.

It was in the late 1800s when Thomas Edison invented the first commercially practical incandescent light that some of us are still using.

But it’s time for us to move on.

In the last ten years, there have been a cluster of companies targeting the massive lighting market. The question is who

will be the quickest to come up with the goods? We want the brightest, eco-friendliest most versatile LED bulb at the lowest cost which is also easy on the eye.

It's a tall order.

Most white to blue semiconductor LEDs incorporate the wide bandgap compound semiconductor gallium nitride (GaN). And you may be spoilt for choice with the different substrates that can be used in making the device - these include sapphire, SiC, silicon and GaN itself.

Many of these substrates are costly though. The exception is silicon, which comes in large substrate sizes such as 6" and 8".

So what are the challenges of growing GaN on silicon?

Firstly the difference in lattice parameter between the most prevalent silicon (111) and GaN is large (around 17 percent). One of the key aspects to counter this is growing a layer (often AlN) - this layer prevents chemical reactions between gallium and silicon and makes the wafer behave like a substrate having lattice parameters closer to that of GaN. Then the buffer layer (mainly AlGaIn) is grown to further reduce the mismatch.

There is also a 52 percent thermal mismatch between GaN and silicon. This means that once the wafer is cooled down after growth, the GaN will contract at a different rate to the silicon substrate.

Having said that, the plus side would work two-fold. Silicon substrates are cheap and also, growing on silicon would enable fabs to use their existing tools without having to invest in costly alternative equipment.

Current players in the GaN-on-Si market include Toshiba and Plessey. Both companies have recently launched LEDs for the lighting market. But efficiencies are still relatively low.

Using technology initiated by Colin Humphreys' group at Cambridge, Plessey and Aixtron are working together to optimise a process using a close coupled showerhead (CCS) reactor capable of growing 6 inch GaN-on-Si.

Apart from Toshiba, competitors include Lattice Power, Transphorm, Azzurro, Infineon, Philips Lumileds, Samsung and imec (and partners). Soitec, Azzurro, Kyma, Translucent and EpiGaN provide GaN-on-Si templates.

So only time and investment will tell who comes out on top.

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## Meaglow to upgrade ALD nitride deposition tool in Turkey

The hollow cathode plasma source reduces the oxygen contamination in ALD systems and increases the quality of thin III-nitride films during growth

Meaglow is to install a hollow cathode plasma source for the

group of Necmi Biyikli, a professor at the Institute of Materials Science and Nanotechnology, at Bilkent University in Turkey.

The plasma source is being used to upgrade their Atomic Layer Deposition (ALD) system by replacing an inductively coupled plasma source. This enhancement will reduce the oxygen contamination in ALD systems and increase the quality of nitride thin films grown.

The III-nitrides grown at the university with the ALD system are used for LEDs and power electronic applications. The actual materials grown using the system are AlN, GaN and InN.

Bilkent University researchers will be presenting some of their findings about suitable applications for these products at the ALD 2013 conference on Wednesday.:

«The Bilkent system was easy to retrofit and the Meaglow Plasma source was the perfect solution for their oxygen contamination problem,» says Butcher, Chief Scientist of Meaglow.



ALD system converted with a hollow cathode plasma source

Initial results show a significant reduction of oxygen content in compound nitride films grown. Results will be presented October 27th to November 1st at the 224th ECS Fall Meeting in San Francisco, California at an invited talk presented at the symposium on "Atomic Layer Deposition Applications".

Meaglow is now focused on commercialising its hollow cathode plasma technology which also has the advantage of scalability to large deposition areas. Meaglow is seeking additional ALD system owners and suppliers interested in removing the oxygen contamination in their films.

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## Kyma uses Nanotronics tool to classify defects in GaN

The newly installed inspection system will be used in the characterisation of Kyma's growing III-nitride semiconductor materials product line

In May of 2013, Nanotronics Imaging installed an nSPEC

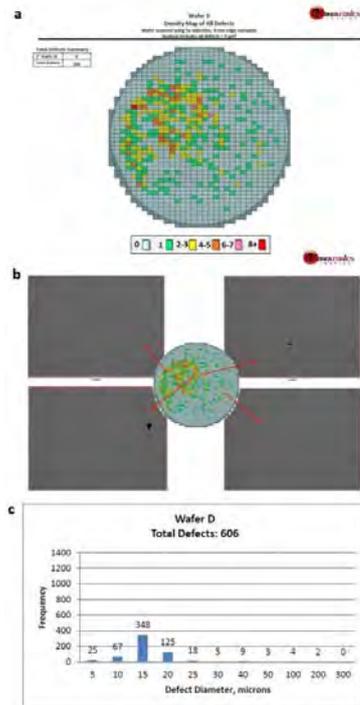
system at Kyma Technologies in Raleigh, North Carolina.



nSPEC system

Kyma and Nanotronics began discussing how the nSPEC tool might benefit Kyma’s nitride semiconductor materials production effort in early 2013. A collaborative partnership was quickly spawned which led to Kyma’s purchase of the nSPEC tool.

The nSPEC enables Kyma to inspect their wafers via powerful image analysis software. This includes the ability to store high resolution images, capture particular features and areas of interest while translating the acquired visual information into quantifiable data.



nSPEC data: a) Density map of all defects ; b) Examples of some of the defects on the map compared to microscope images ; c) Histogram showing quantities of each defect size

“Working with the Nanotronics Imaging team has been an exciting and highly productive experience,” says Keith Evans, Kyma’s president & CEO. “Our technical team, led by our Chief Scientist Jacob Leach, pushed the nSPEC tool in about a dozen different directions. The response of the Nanotronics team was superb and the result is that we can now routinely

sense several different important characteristics of our materials better than ever before.”

He adds “We are very pleased with the kinds of inspection that the nSPEC is giving us, which has already given us significant new insight into our processes here at Kyma.”

Kyma Technologies has graciously agreed to open its doors for people to observe the nSPEC in action. This is an ideal opportunity for semiconductor groups and Universities in the South Eastern region of the U.S. to learn about the powerful capabilities of nSPEC and its value to their respective applications.

“This is really a great partnership and opportunity for us, we are so thrilled that Kyma is happy with their purchase of an nSPEC and are excited to bring interested people and future partners to Kyma to see the nSPEC there,” says Matthew Putman, CEO of Nanotronics Imaging.

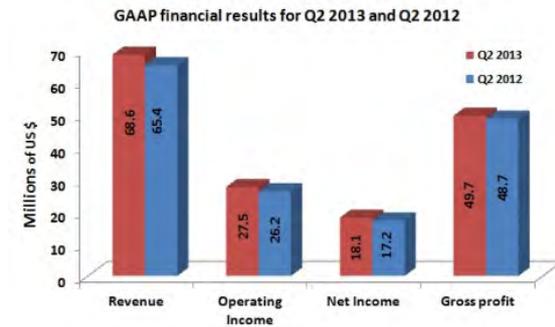
The nSPEC is an automated, optical, inspection device geared toward defect detection and characterisation of semiconductor wafers, dies and devices. It is a scanning optical microscope fully integrated with patented, image analysis processing.

It is claimed that never before has there been an automated machine that provides such crisp images and rich information about defects and features on semiconductor wafers.

## Hittite Microwave on the rise in Q2 2013

The company has shown robust financial results in revenues, profits and incomes

Hittite Microwave Corporation has reported revenues for the second quarter ended June 30th, 2013 of \$68.6 million, an increase of 4.9% compared with \$65.4 million for the second quarter of 2012.

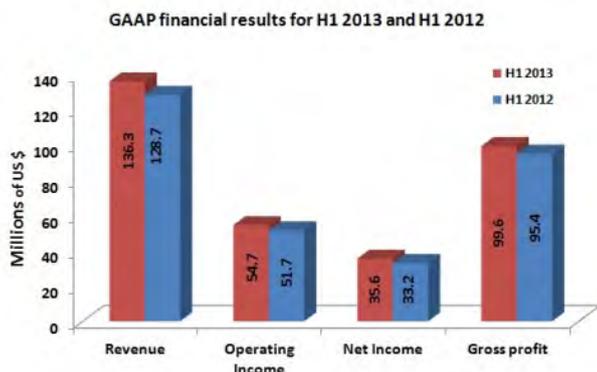


Net income for the quarter was \$18.0 million, or \$0.58 per diluted share, an increase of 5.1% compared with \$17.2 million, or \$0.56 per diluted share, for the second quarter of 2012.

For the second quarter of 2013, revenue from customers in the United States was \$30.2 million, or 44.0% of the company’s total revenue, and revenue from customers outside the United States was \$38.4 million, or 56.0% of total revenue.

Gross margin was 72.4% for the second quarter of 2013, compared with 74.5% for the second quarter of 2012 and 73.7% for the first quarter of 2013. Operating income for the second quarter of 2013 was \$27.5 million, or 40.1% of revenue, compared with \$26.2 million, or 40.1% of revenue, for the second quarter of 2012 and \$27.1 million.. Total cash and marketable securities at June 30th, 2013 was \$438.2 million, an increase of \$8.8 million for the quarter.

Results for the first half of 2013 and 2012 are depicted in the graph below.



#### Business Outlook

The company expects revenue for the third quarter ending September 30th, 2013 to be in the range of \$66.5 million to \$68.5 million and net income to be in the range of \$16.7 million to \$17.7 million, or \$0.54 to \$0.57 per diluted share.

The company hosted a conference call to discuss its financial results and a webcast replay is available by visiting the Investors page at [www.hittite.com](http://www.hittite.com).

Hittite Microwave Corporation is an innovative designer and manufacturer of high performance integrated circuits, or ICs, modules, subsystems and instrumentation for technically demanding digital, RF, microwave and millimetrewave applications covering DC to 110 GHz. The company also started marketing GaN power amplifiers earlier this month.

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

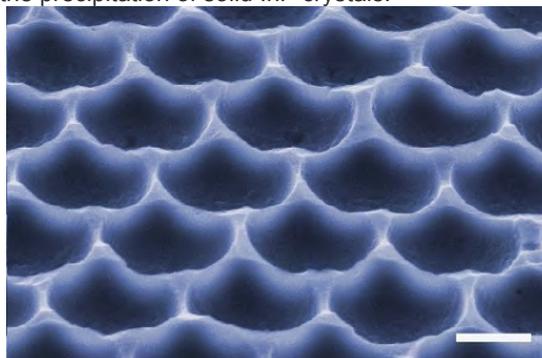
Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. "The techniques we are reporting here should be

a game-changer for III-V solar cells, as well as for LEDs." The most efficient photovoltaics are made from III-V compounds. However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3 μm thick InP thin-films on molybdenum foils with ultra-large grain size up to 100 μm. The researcher say this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500 cm<sup>2</sup>/V-s and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination,

photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only 40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*, 3, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during

H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

"Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors."

IQE expects to report its interim results around mid-September 2013

## GaN Systems appoints a new VP of Product Management

Semiconductor veteran Larry Spaziani is to head the drive for greater market share for specialist gallium nitride devices

GaN Systems, a developer of GaN power switching semiconductors, has appointed Larry Spaziani as Vice President, Product Management effective July 22nd 2013.



Larry Spaziani, VP, Product Management, GaN Systems

GaN Systems develops and manufactures GaN transistors targeted at efficient power conversion for solar, wind and smart-grid, electric and hybrid vehicles and high-efficiency power supply applications. Spaziani will head up GaN Systems' product team and be responsible for driving forward acceptance of GaN Systems' unique technology.

Comments Girvan Patterson, CEO of GaN Systems, "We are delighted to welcome Larry on board. Larry's experience in technical development and successful track record in marketing and new product launches will drive this important growth phase for our breakthrough device designs in gallium nitride high power transistors."

Spaziani joins GaN Systems from International Rectifier, where he was Executive Director, Enterprise Power Business Development, responsible for managing its new product development team and forging relationships with external business partners and technology leaders. Prior to IR, he was VP Marketing and Business Development at CHiL Semiconductor, where he managed the Applications and FAE teams and oversaw 43 new product launches in three years.

Spaziani's strong track record at executive level in the semiconductor industry also includes senior positions at Unitrode and Texas Instruments, where he was responsible for off-line and isolated power products. Spaziani has lived and worked both in the USA and Europe and holds an MSEE from Boston University.

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## Cree SiC MOSFETs halve the component count

Delta Elektronika demonstrated a 21 percent decrease in overall silicon carbide power-supply losses

Cree has announced that its newly expanded portfolio of 1200-V SiC MOSFETs are being incorporated into the latest advanced power supplies from Delta Elektronika BV.

Delta Elektronika demonstrated a 21 percent decrease in overall power-supply losses and a reduction in component count by up to 45 percent when compared to power-supply products using traditional silicon technology.

"We are delighted to use Cree's new SiC transistor in our product series, as it improves both the efficiency and power density of our products," says Job Koopmann, director of Delta Elektronika BV. "The switching behaviour is outstanding, and controlling the MOSFET is simple and straightforward. This

device is helping us to continue developing more-reliable products, which our customers expect from us."

Since 1959, Netherlands-based Delta Elektronika BV has been a leader in producing highly reliable, high-quality power supplies for a range of industrial applications, such as specialised equipment used in factories, automation and industrial power conversion.

Its power supplies typically provide high efficiency with low noise levels and are well known for their long operating lifespan. By implementing Cree's advanced second-generation SiC MOSFETs in its latest power supply series, Delta Elektronika BV is leading the industry in the deployment and delivery of highly reliable advanced technology.

"We are pleased to have Delta Elektronika BV as one of the volume adopters of our newest generation of SiC MOSFETs," comments Cengiz Balkas, general manager, Cree Power and RF. "Delta Elektronika BV has a half-century legacy of producing some of the most-reliable, efficient and compact power supplies on the market. The industrial power-supply market, which values efficiency, reliability and power density, is a key market for SiC MOSFET technology. Our new, second-generation SiC MOSFET portfolio, which now includes a 160-mOhm MOSFET for the 5 to 10kW market, is receiving strong market pull."

Introduced in March 2013, Cree's second-generation SiC MOSFETs have been well received throughout the power industry and are experiencing an increasing rate of adoption in several key applications, including a design-in in a major manufacturer's next-generation, highly efficient PV inverters.

With SiC, power-supply manufacturers are able to reduce their component count to help improve reliability while maintaining or improving the power supply's efficiency. Improving power density can also lead to reductions in the size, weight, volume and, in some cases, even the cost of power supplies. SiC has been demonstrated to achieve more than twice the power density of typical silicon technology in standard power-supply designs.

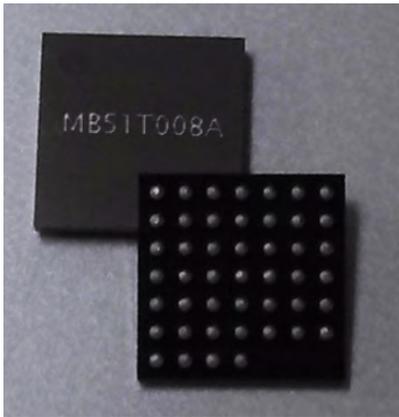
Packaged SiC MOSFETs from Cree are available from DigiKey, Farnell/Newark, Richardson and Mouser, and die are available from SemiDice.

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## Fujitsu to power ahead with GaN-on-Si chip shipments

The firm's gallium nitride device enables smaller, more efficient power supply products for use in telecommunications, industrial equipment, automotive, and other applications

Fujitsu Semiconductor Limited (Fujitsu) has released the MB51T008A, a silicon substrate-based GaN power device that has a breakdown voltage of 150 V.



MB51T008A

The new device, which enables normally-off operations, is capable of achieving roughly one half the figure of merit (FOM) of silicon-based power devices with an equivalent breakdown voltage.

With the addition of the new product to its line up, Fujitsu will be able to offer GaN devices that contribute to smaller, more efficient power supplies for a wide range of fields, from home appliances and ICT equipment to automotive applications.

Fujitsu says the MB51T008A has a number of advantages.

Firstly, the on-state resistance of 13 mΩ and total gate charge of 16 nC enables roughly half the FOM of silicon-based power devices with an equivalent breakdown voltage. Also, minimal parasitic inductance and high-frequency operations are enabled through the use of WLCSP packaging.

In addition, a proprietary gate design enables normally-off operations and the device is ideal for high-side switches and low-side switches in DC-DC converters employed in power supplies for data communications equipment, industrial products, and automobiles.

Finally, because it supports a higher switching frequency in power supply circuits, power supplies can achieve improvements in overall size and efficiency.

Fujitsu is also developing models with breakdown voltages of 600 V and 30 V to help enable enhanced power efficiency in a wide range of product areas.

These GaN power devices are based on HEMT (High Electron Mobility Transistor) technology, which Fujitsu Laboratories has been developing since the 1980s.

Building on its IP portfolio of the technology, Fujitsu hopes to rapidly bring its GaN power devices to market. The company also plans to build partnerships with customers across a wide range of industries, in order to expand its business further.

The company also plans to highlight performance improvements in its GaN power devices with 600 V breakdown voltages, as well as prototypes and test data of a 2.5 kW power supply employing a GaN power device, a high-frequency PFC, and a high-frequency DC-DC converter.

Fujitsu will begin sample shipments in July 2013, with volume

production scheduled to begin in 2014.

## Hittite markets GaN power amplifiers

This is the first time Hittite is marketing gallium nitride based PAs

Hittite Microwave Corporation has released its 2013 Product Selection Guide summarising over 1100 products including 22 new products.

New for this publication are GaN Power Amplifiers, an I/Q Downconverter and Sub-Harmonic MMIC Mixers. The Selection Guide is organised by RF & Microwave, Analogue & Mixed Signal, Clocks & Timing and LO Frequency Generation IC sections along with Modules and Instrumentation.

Hittite's 2013 Off-The-Shelf Newsletter includes 17 new product highlights & articles and company news organized by Market application. Hittite's updated Microwave Solutions Brochure features Amplification, Power Control & Power Detection; Control Devices; Frequency Conversion and LO & Clock Generation for microwave and millimetre wave applications.

## Raytheon awarded \$279 million to develop US Navy attack systems

The firm is leveraging its gallium nitride (GaN) based AESA technologies to provide warfighters with enhanced electronic attack capabilities

Raytheon Company has been awarded a \$279.4 million cost-plus-incentive-fee contract by the U.S. Navy to conduct the Technology Development phase of the Navy's Next Generation Jammer program.

"We believe the Navy's choice validates Raytheon's leadership in advanced electronic attack systems and technologies," says Rick Yuse, president of Raytheon's Space and Airborne Systems business. "Raytheon looks forward to building on our long-standing relationship with the U.S. Navy as we provide the warfighter with innovative and reliable Next Generation Jammer solutions now and for many years to come."

Raytheon leveraged knowledge and experience as a leading tactical weapon systems integrator to provide an affordable, low-risk, comprehensive NGJ solution to the U.S. Navy. Raytheon also leveraged its GaN based AESA technologies to provide warfighters with enhanced electronic attack capabilities.

"Raytheon provided the U.S. Navy with an innovative and efficient design capable of jamming current and future threats," adds Yuse. "Our technology approach met the program requirements and leveraged our industry team's extensive experience in combat-proven, high-reliability agile-beam

RF systems designed for demanding carrier-based aircraft environments.”

NGJ will replace the ALQ-99 tactical jamming system currently on the Navy's EA-18G Growler tactical airborne electronic attack aircraft.

Raytheon's Space and Airborne Systems business, based in McKinney, Texas, will lead the Technology Development phase of the NGJ program with collaboration from Raytheon facilities in El Segundo, California; Forest, Mississippi; Dallas, Texas; Fort Wayne, Indiana; Largo, Florida.; and Andover, Massachusetts.

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## New subsidiary expands wet processing division at ClassOne

The firm has expanded the division to enhance its sales and support of Semitool equipment worldwide as well as to design and manufacture new upgrades and platforms that address emerging markets such as LED and RF power devices

ClassOne Equipment has made significant investments in the growth and expansion of its Wet Processing Division in response to increased market demand. A Design and Development Centre has been opened in Kalispell, Montana, staffed with several industry veterans who represent over 200 years of cumulative industry experience, who will focus on new product design and development.

Corporate and refurbishment activities will remain at ClassOne's headquarters in Atlanta, Georgia. “We are thrilled with the strong customer response to ClassOne's industry-leading products and support. We have expanded the division to enhance our sales and support of legacy Semitool equipment worldwide as well as to design and manufacture new state-of-the-art upgrades and platforms that address emerging markets such as MEMS, Nanotech, LED and RF Power Devices,” says Byron Exarcos, ClassOne's President. Hi adds, “Semitool's acquisition left a void in the market for mature fabs and emerging technologies that use 75 to 200mm substrates.

ClassOne is meeting the growing demand for cost effective, reliable, and long-term support for popular tools such as the Spray Solvent, Spray Acid and Equinox tools. The wide-spread adoption of our lift-and-rotate and robot refurbishment programs gives testimony to that fact.” The new facility in Kalispell will be operated under the name of ClassOne Technology as a wholly owned subsidiary of ClassOne Equipment.

The executive team includes: Win Carpenter, a 33-year veteran in the semiconductor industry, VP Wet Process Division; Tim McGlenn (26 years experience, including leading the software and electronics development of Semitool's 101, 102, 202, 302, 402 and 502 controllers), VP of Operations; and Kevin Witt (25 years focused on the development and commercialisation of new wet chemical processing platforms), VP Technology; all of whom previously held leadership positions at Semitool.

Their appointment further strengthens the division, positioning it for enhanced growth and continued market leadership. ClassOne Technology's first product, the Polaris controller, is an advanced, PLC-based, field-retrofitable control system that replaces the aging 302 control system used in many Semitool legacy tools.

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## Equipment and Materials

### Nanoplus orders Oxford Instruments tool for laser etching

The Ionfab300 Plus will be used for laser bar facet coating with anti-reflective and high-reflection multilayers, and the PlasmaPro System100 RIE system will be used for GaAs and InP compound etching

Oxford Instruments Plasma Technology (OIPT) has just received an order from Nanoplus in Germany for an ion beam deposition and a plasma etch system for use on novel types of semiconductor laser production.

Nanoplus produces semiconductor lasers over several wavelength ranges (some exclusively) for many different customers with a wide range of applications.

The Ionfab300 Plus ion beam deposition is a multi-batch cassette loading tool allowing many devices to be produced for several applications and various customers in one load. The Ionfab300 Plus will be used for laser bar facet coating with anti-reflective and high-reflection multilayers, and the PlasmaPro System100 RIE system will be used for GaAs and InP compound etching.

David Pearson, OIPT's Senior Ion Beam Technologist, comments, “Our Ionfab optical coating tools are becoming the tools of choice for many types of precision optical coatings worldwide, in particular in laser applications.”

“Nanoplus is an internationally leading supplier of single mode DFB lasers for sensing, metrology, spectroscopy and telecom applications. We even have one of our sensors on NASA's Mars Curiosity Rover”, say sAlfred Forchel, founder of Nanoplus, “We chose Oxford Instruments systems for their versatility, superior process capabilities and excellent customer support.”

Frazer Anderson, Business Group Director at Oxford Instruments concludes, “Our tools offer the ideal platform for production as well as research & development in many new application areas, and Laser Bar facet coating is just one of these. Our excellent process applications team and global service support ensure that our customers are supported in every respect and can count on their Oxford Instruments

systems for maximum uptime and reliability.”

## Air Water to develop GaN-on-SiC-on-silicon with Aixtron reactor

The company is building on large diameter SiC on silicon technology for LEDs and power devices

Air Water of Azumino in Japan has reported the successful installation of a fully automated Aixtron AIX G5 HT planetary reactor in an 8 x 6 inch configuration for the growth of GaN epitaxial layers.



*Aixtron AIX G5 HT planetary reactor*

Aixtron says Air Water selected this MOCVD system to deliver superior material uniformity, a key factor in demonstrating the advantage of Air Water substrates for GaN epitaxy. □

Following the installation, the company has announced the release of GaN-on-SiC on silicon substrates for this year.

In order to address future market demand, Air Water is also considering upgrading the system to an Aixtron AIX G5+, which can handle up to 5 x 200 mm (8 inch) silicon substrates.

As compared to traditional silicon substrates, the additional SiC layer displays the advantage of protecting the silicon substrate in the initial GaN nucleation process. Due to its crystal structure SiC is considered as an ideal template for the GaN growth.

So, the SiC-on-silicon substrate is enabling the growth of superior crystal quality GaN layers onto large areas. This characteristic brings efficiency and cost savings to a wide range of high-power and LED applications.

Air Water is a Japanese industrial gas manufacturer and has developed SiC growth on silicon for both power device and LED applications as part of the semiconductor gas business.

The company has already succeeded in the production of high quality 3C-SiC (111) on up to 8 inch silicon substrates and has also announced the release of these products for GaN epitaxial growth required to manufacture electronic devices for LED and

power electronic applications.

## Shimadzu unveils compact turbo molecular vacuum pumps

The new series of pumps, which could be used in the MOCVD growth of III-V materials, should enable cost reductions



**Magnetic bearing type integrated turbo molecular pump: "TMP-X3405 series"**

On 2nd September 2013, Shimadzu Corporation will launch the company's new "TMP-X2905/X3405" series of turbo molecular pumps.

With integrated power supplies and 3000 L/s class pumping speeds for semiconductor and flat panel display manufactures, the Turbo molecular pumps (TMPs) produce a vacuum due to the high speed rotation of turbines that enables vacuum pumping at the molecular flow level.

TMPs are essential in applications where oil free, clean and high vacuums are essential.

The versatile pumps are compact and feature integrated power supplies for installation in both light and hard processes.

Shimadzu positions TMP as global strategic products in its product portfolio and will expand sales of the TMP-X series to North America, Taiwan, Korea, and China.

Following the recent fall in the price of electronics equipment incorporating semiconductor devices and flat panel displays, there are growing demands for innovative methods to reduce the costs of semiconductor and flat panel display manufacturing equipment.

Regarding turbo molecular pumps attached to manufacturing equipment, there are growing needs for a move away from pumps where power supplies are connected with separate cables, to pumps where the power supplies are integrated into the body of the TMP itself.

Such 'integrated power supply' TMP would enable a reduction in the number of parts for manufacturing equipment, and enable reductions in costs.

Shimadzu Corporation already sells the TMP-V series of pumps with integrated power supplies for pumping inert gases used in sputter systems for 'light processing'. The TMP-X series were developed for pumping corrosive gases used in etching equipment - so called 'hard processing'.

This series will offer pumping speeds from 300 L/s to 4000 L/s to address the multifaceted needs of semiconductor and flat panel display manufactures.

## According to Shimadzu, the main features of the TMP-X series are listed below.

### 1. Industry's most compact TMP with an integrated power supply.

Redesign of conventional integrated power supply TMP enabled a 15 percent reduction in the height of the new pump whilst maintaining the pumping performance. Also, the TMP-X pumps are almost the same size as the main body of conventional TMP with separate power supply cables that are used for hard processing.

Pumps in the TMP-X series do not require racks and cables - as is the case in conventional separate power supply TMP - thus this series offers a greater degree of freedom in the design of low cost, small footprint manufacturing equipment.

### 2. Cope with hard processes employing corrosive gases

The incorporation of a pump temperature control function and improvement of the motor power output has enabled the use of the TMP-X series of pumps for manufacturing processes involving high gas flow rates and reactive gases.

What's more, Shimadzu Corporation have continued to employ anti-corrosive coating and dynamic seals in the new pumps, thus preventing erosion of the TMP and ensuring high reliability even for hard processes employing highly corrosive gases.

### 3. Low power consumption

The use of a newly developed power unit and high efficiency motor has enabled a 15% reduction (under conditions of zero load) in the power consumption compared to conventional turbo molecular pumps. This series of TMP have a low load impact on the environment.

## Magnetic bearing type integrated turbo molecular pump specifications

### Prices:

**TMP-X2905 series** 5,100,000 JPY (excluding tax)

**TMP-X3405 series** 5,500,000 JPY (excluding tax)

### Sizes:

**TMP-X2905 series** (VG250) f350 ´ H458 mm 115kg

**TMP-X3405 series** (VG300) f400 ´ H395 mm 89kg

The firm plans to sell 500 units of its TMP-X2905/X3405 in the first year.

## Mega Fluid Systems appoints industry specialist as President



MMega Fluid Systems, Inc., has appointed Delton Hyatt as President. Hyatt brings 30 years experience in high purity thin film processing, semiconductor fabrication support, and process gas, slurry, and chemical delivery.

Hyatt's management experience and extensive industry knowledge, particularly in chemical and gas equipment, will provide Mega with the strong foundation necessary to continue on the path of becoming the world leader in chemical and slurry equipment," said Kevin Brady, CEO.

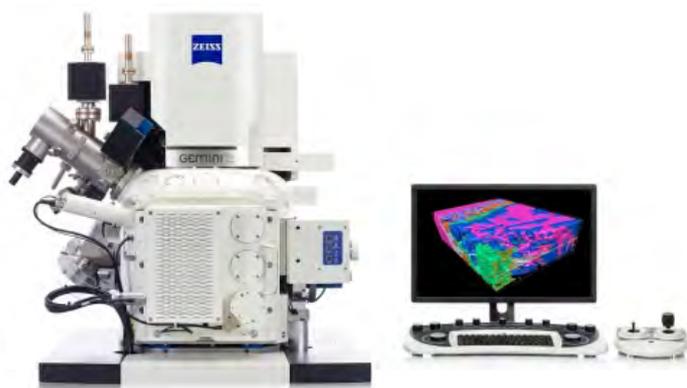
Delton began his career in business development at MKS Instruments, eventually becoming President of the Advanced Product Integration Division. He later joined the Mega Fluids (Chempure) subsidiary of Celerity (Kinetics) as the VP of Marketing, and eventually General Manager. Delton also served as the CEO of Zeihm Imaging and recently was involved in business acquisitions and integration for M+W and Total Facilities Solutions.

Mega Fluid Systems offers unsurpassed excellence in engineering, manufacturing, and testing capabilities. Mega's partners benefit from high-level customer service and support from its program management, sales, engineering, service, and executive management teams.

## Zeiss reveals 3D nanotomography and nanofabrication tool

A new system will enable fast materials processing and high resolution imaging

Zeiss will be presenting the first system of the new Crossbeam series at the MC 2013 in Regensburg, Germany.



Pictured above, its features include high speed in materials analysis and processing and its wide diversity of applications. Time intensive 3D experiments that used to run for several days can now be completed overnight.

The newly developed focused ion beam (FIB) column enables fast and precise materials processing that can be observed with the field emission scanning electron microscope in real-time. Zeiss points out high resolution over the entire voltage and current range allows users to work quickly and precisely.

The stable system is claimed to provide reproducible results even in long-term experiments. The field of application is expanded by the optionally available Massive Ablation Laser that rapidly prepares samples to access deeply buried regions of interest.

Crossbeam is suitable for use in both materials and life sciences. Materials scientists benefit from the excellent 3D analytics, the ability to image magnetic and non-conductive specimens with maximum resolution, and from the unique material contrasts.

Bioscientists can use Crossbeam, above all, for fast tomography series with high Z resolution in cell and tissue biology. The STEM detection module delivers additional structural information. The system also offers automated workflows.

At the same time, the open software offers users the possibility of integrating and automating their own applications. The modular design of Crossbeam makes it an open 3D nano workstation that can be configured and field-upgraded for a broad spectrum of today's and future applications, therefore offering the user maximum flexibility.

The microscope system is available in two versions. The GEMINI I VP (variable pressure) column of Crossbeam 340 offers optimal analysis conditions for in situ experiments with outgassing and charging specimens.

Thanks to the GEMINI II column with double condenser system, Crossbeam 540 users benefit from more information in a shorter time. The system delivers high resolution, even with low voltage and high beam current, enabling fast analytics and ease of use.

In combination with a Zeiss Xradia X-ray microscope (XRM), Crossbeam offers the possibility of complete specimen analysis across several orders of magnitude. The X-ray microscope first provides a 3D image of the specimen without destroying it before the identified areas of interest are processed with the focused ion beam and analyzed with the electron beam.

## Edwards Group to merge with Atlas Copco Group

The transaction valued at up to approximately \$1.6 billion including debt, will see Edwards' shareholders receive consideration of up to \$10.50 per share in cash

Edwards Group Limited, a developer and manufacturer of vacuum products, abatement systems and related services, and Atlas Copco Group a Sweden-based provider of industrial productivity solutions have entered into a definitive merger agreement.

Edwards' systems are used in MOCVD growth.

The transaction is valued at up to approximately \$1.6 billion, including the assumption of debt.

A subsidiary of Atlas Copco will acquire Edwards for a per-share consideration of up to \$10.50, which includes a fixed cash payment of \$9.25 at closing and an additional payment of up to \$1.25 per share post-closing, depending on Edwards' achievement of 2013 revenue within the range of £587.5 million to £650 million and achievement of a related Adjusted EBITDA target within the range of £113.9 million to £145 million. The transaction is expected to close in the first quarter of 2014.

Depending on the amount of any additional payment, the merger consideration represents a premium of approximately 11 percent to 26 percent to Edwards' 30 day average closing share price of \$8.33 up to August 16th, 2013, the last trading day prior to this announcement. Edwards priced its initial public offering on The NASDAQ Global Select Market on May 10th 2012 at \$8.00 per share.

Edwards' shareholders representing approximately 84 percent of the current shares outstanding have entered into voting agreements with Atlas Copco to vote in favour of the merger, subject to the conditions set out in the voting agreements. Further, the Board of Directors of Edwards unanimously recommends the offer to all Edwards shareholders.

Edwards and Atlas Copco have a complementary businesses

fit. Both companies share a similar strategic direction, with growth focused on technology leadership and customer service. The benefits of greater scale will help accelerate Edwards' growth strategy and provide more opportunities for Edwards' employees. Upon completion of the transaction, a new Vacuum Solutions Division will be formed within the Atlas Copco Compressor Technique business area, with headquarters in Crawley, UK.

Jim Gentilcore, Chief Executive Officer of Edwards, says, "This strategically and financially compelling transaction provides the opportunity for our stockholders to receive an attractive premium for their shares. On top of the cash payment at closing, analyst consensus for the full year and our strong start to the third quarter leads us to believe it is realistic for us to achieve the results that would deliver an additional cash payment towards the upper end of the range to our shareholders."

Gentilcore continues, "This transaction also delivers many benefits for Edwards' customers and employees. The two companies share very similar strategic goals, strong brands and leading market positions. The Edwards brand and reputation will benefit from the support, expertise and financial strength that Atlas Copco will bring."

Ronnie Leten, President and CEO of Atlas Copco, says, "We recognise the strength of Edwards' people and products as well as their excellence in technology and innovation. We are excited that this professional company will join our Group."

The merger, which has been unanimously approved by the Boards of Directors of both companies, is subject to shareholder approval, antitrust clearance, and customary closing conditions.

Barclays and Lazard acted as financial advisors to Edwards on the transaction. Legal advisors to Edwards are Davis Polk & Wardwell London LLP, Weil Gotshal & Manges LLP and Maples & Calder.

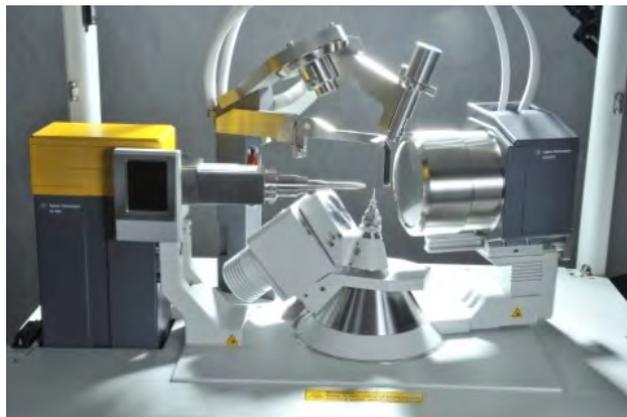
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## X-ray Agilent detectors offer smarter sensitivity

A new strategy puts previous detectors in the dark

Agilent Technologies has launched a range of X-ray Diffraction CCD detectors with smart sensitivity control.

The Eos S2, Atlas S2 and Titan S2 CCD detectors offer active areas of 92 mm, 135 mm and 165 mm, respectively, and automatically adapt their sensitivity based on the strength of the diffraction from the sample being studied.



Agilent GV1000 X-ray Diffractometer with the Atlas S2 CCD Detector.

"Smart Sensitivity Control is very similar to adjusting the ISO setting in digital photography," says Leigh Rees, Agilent's XRD general manager. "SSC is part of our Intelligent Measurement System, which also includes the ability to instantly switch hardware-binning modes."

He adds, "This allows the detectors to automatically adjust both sensitivity and dynamic range based on how strong or weak the diffraction is. This unique approach means we're measuring diffraction data invisible to previous detectors, in faster experiment times and with higher overall data quality."

Single-crystal X-ray diffraction systems are used for routine analytical chemistry and challenging small-molecule and protein-diffraction studies.

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## Major LED manufacturer finds ALSI's dicing system cutting edge

The tool will be used in the manufacture of GaN and GaP LEDs

Advanced Laser Separation International (ALSI) N.V. introduced its new laser dicing system, the ICA 1204 for GaN and GaP devices, at one of the world's largest major LED manufacturers with great success.



ICA 1204 laser dicing system

The ICA1204 system is equipped with a specific UV laser and ALSI's unique multi-beam laser splitting technology.

The overall process is based on a high speed full cut laser dicing process for wafers in the range of 150-200µm thick. Due to the specific nature of the applied coating, additional special coating process units were integrated into the system.

As a result, this new system outperformed ALSI's previous models and a competitors system with significant results. The total cycle time including the specific coating process, multi-beam dicing and wafer cleaning, which are completely integrated in the system, was reduced by almost a factor two.

Since all the process steps are integrated inside the system, the operator cost and handling cost are reduced as well. ALSI says this combination of faster cycle time, reduced handling time, and fast dicing process, also reduced the overall cost per wafer by a factor 2.

The multi-beam process is based on 10-14 beams which achieves a very high dicing speed and a fast process time, while creating an extremely narrow kerf giving superior dicing quality.

This new process and system has been tested by customers resulting in firm orders and is used in full production.

## Zygo reveals flexible 3D imaging and surface metrology tool

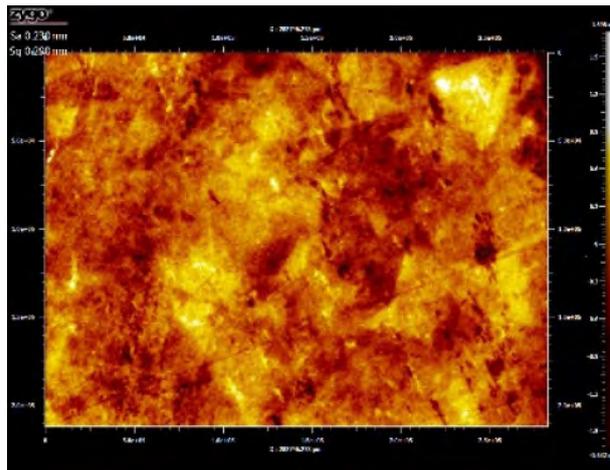
The Nexview profiler has 3D imaging and measurement system for rapid, precise, quantitative, and interactive surface metrology suited to semiconductor analysis

Zygo's new 3D profiler metrology tool is suited for both the production and scientific research markets and the company says this it is its all-new flagship product.



*Zygo Nexview 3D profiler*

The Nexview profiler is optimised for non-contact surface metrology of an extensive variety of samples and surfaces from the very smooth to the very rough. With sub-nanometre vertical resolution at all magnifications, metrologists need not sacrifice precision for changes in field of view.



*SiC mirror showing crystal grains*

Using non-contact 3D technology, the system will safely measure fragile and transparent materials without altering the test surface. Its high speed performance, even on steep slopes up to 85 degrees, lets the Nexview profiler save time compared to magnification dependent technologies.

Zygo says the Nexview profiler and its Mx software package produce extremely high fidelity surface topography maps for measuring roughness, flatness, angles, films, steps, and more.

This new software platform acts as a simple to use and learn single interface for system control and data analysis, providing rich interactive 3D maps, quantitative topography information, and intuitive measurement navigation.

Recipe changes are quick and easy with new recipes typically taking only minutes to configure.

What's more, specialised software modules for measurement in the presence of transparent films and 2D vision analysis are available for expanded functionality.

"As a new concept in surface mapping, the Nexview profiler is a significant leap forward in data collection and interactive surface analysis. These are in high demand for our customers with challenging and high precision requirements. It enables a wide variety of topography applications previously not addressed, and expands our market opportunities," comments Don Battistoni, Executive Director of Worldwide Sales, Marketing, and Service for Zygo Corporation.

## NASDAQ slams Veeco for late quarterly filing

The main reason for a delay in filing was down to the company reviewing the timing of the recognition of revenue and related expenses on the sale of some of its products

Veeco Instruments Inc. received a letter from the NASDAQ Stock Market LLC on August 14th, 2013.

It said that Veeco was not in compliance with NASDAQ Listing Rule 5250(c)(1) because its Quarterly Report on Form 10-Q

for the quarter ended June 30th, 2013 (Form 10-Q) was not filed on a timely basis with the Securities and Exchange Commission (SEC). NASDAQ Listing Rule 5250(c)(1) requires the company to timely file all required periodic financial reports with the SEC.

Veeco says Form 10-Q and its annual report on Form 10-K for the year ended December 31st, 2012 and quarterly reports on Form 10-Q for the quarters ended September 30th, 2012 and March 31st, 2013, could not be filed timely because the company was reviewing the timing of the recognition of revenue and related expenses on the sale of certain of its products. The accounting review was announced on November 15th 2012.

Veeco had previously announced that the NASDAQ Listing Qualifications Panel informed Veeco that its request for continued listing on The NASDAQ Stock Market until November 4th, 2013 was granted.

On or prior to November 4th, 2013, Veeco must regain compliance with all applicable requirements for continued listing on The NASDAQ Stock Market including filing its outstanding annual and periodic reports with the SEC.

The company continues to conduct the review and intends to file its Forms 10-Q and 10-K as soon as reasonably practicable after these accounting matters have been resolved.

Veeco's process equipment solutions enable the manufacture of LEDs, power electronics, hard drives, MEMS and wireless chips. The firm provides MOCVD, MBE, Ion Beam and other advanced thin film systems.

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## Veeco to reveal compact MBE tool

The company says its latest molecular beam epitaxy reactor is the industry's first integrated MBE System for the compound semiconductor R&D market

Veeco Instruments has introduced the GENxplor Molecular Beam Epitaxy (MBE) deposition system.

The GENxplor can create high quality epitaxial layers on substrates up to 3" in diameter and is ideal for cutting edge research on a wide variety of materials including GaAs, nitrides, and oxides.



Latest GENxplor R&D MBE System

"The compound semiconductor R&D community asked for

a more affordable, flexible, and easy-to-use MBE system and Veeco has delivered with the GENxplor," says Jim Northup, Veeco's Vice President and General Manager. "We have repackaged Veeco's industry-leading MBE technology into a novel 'all-in-one' design that combines the reactor and electronics on a single frame. It will change the way researchers use MBE."

The GENxplor uses Veeco's GEN10 growth chamber design and features process flexibility, ideal for materials research on emerging technologies such as UV LEDs, high-efficiency solar cells, and high-temperature superconductors.

Its efficient single frame design combines all vacuum hardware with on-board electronics to make it up to 40 percent smaller than other MBE systems, saving valuable lab space. And as the manual system is integrated on a single frame, installation time is reduced.

Veeco says the open architecture design of the GENxplor also improves ease-of-use and provides convenient access to effusion cells. And it also allows easier serviceability when compared to other MBE systems. When coupled with Veeco's recently introduced retractable sources, the system is ideally suited to oxide materials research.

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## Keithley unveils interactive touchscreen for power device analysis

The firm's offering combines capabilities of I-V systems, curve tracers, and semiconductor analysers at a fraction of their cost

Keithley Instruments has revealed a benchtop Source Measure Unit (SMU) instrument with a capacitive touchscreen graphical user interface.

The Model 2450 SourceMeter SMU Instrument combines the intuitive touchscreen and icon-based control that novice SMU users can appreciate with the versatility that experienced users need to learn faster, work smarter, and invent more easily.

The Model 2450's design, Keithley's latest generation of SMU instruments, offers a fundamentally new way for users to interact with test and measurement instruments. It is based on the company's innovative "Touch, Test, Invent" design philosophy.



Keithley Instruments Model 2450 SMU

This new design philosophy reflects recent market changes, including shrinking product design/development cycles and fewer personnel devoted exclusively to test engineering tasks. At the same time, the profile of the typical instrument user has also evolved.

In addition to electrical engineers, it now includes a growing number of non-engineers (such as electrochemists, physicists, materials scientists, etc.) who need fast access to data but sometimes have limited training in electrical measurement.

What's more, as the previous generation of electrical engineers has retired, their younger replacements have tended to be more software oriented than hardware oriented.

To accommodate all of these market and user changes, the Model 2450 incorporates numerous ease-of-use features that ensure a faster "time-to-answer" than competitive solutions, including a context-sensitive help function, "Quickset" modes that speed instrument configuration, and on-screen graphing capabilities that quickly turn raw data into usable results.

The instrument builds on the design strengths and high precision of both the Model 2400 SourceMeter SMU instrument (an industry standard since its 1995 introduction) and the newer Series 2600B System SourceMeter SMU Instrument line.

The Model 2450 combines the functionality of a power supply, true current source, 6-1/2-digit multimeter, electronic load, and trigger controller in one tightly integrated, half-rack instrument. With all of these capabilities, the Model 2450 integrates the capabilities of I-V systems, curve tracers, and semiconductor analysers at a fraction of their cost.

#### Benchtop Application Advantages

Many of the Model 2450's features help speed and simplify lab/benchtop work as described below.

**Full-colour, 5-inch touchscreen user interface:** The full-colour display and large on-screen characters enhance legibility. A simple, icon-based menu structure allows reaching any measurement set-up panel with just a touch.

**Extended measurement ranges with superior low current performance:** The new low current (100nA, 10nA) and voltage (20mV) ranges eliminate the need to add separate low-level instruments to a benchtop system. Back-panel triax cable connections eliminate the need for expensive cable adaptors, which can degrade low-level measurement performance.

**Built-in context-sensitive help function:** Help information is provided right where it's needed through the touchscreen, minimising the need to review a manual.

**Error and event logging:** The touchscreen displays error messages and an event log to simplify diagnosing instrument errors, for higher productivity.

**KickStart start-up software:** This "no-programming" instrument control software simplifies taking and graphing data in minutes. For more complex analyses, data can be easily stored to disk, and then exported to Microsoft Excel® or another software environment.

#### System-Level Application Advantages

Several features simplify integrating the Model 2450 into automated test systems:

**Embedded Test Script Processor (TSP):** An onboard Test Script Processor embeds complete test programs into non-volatile memory within the instrument itself to provide higher test throughput by eliminating the GPIB traffic problems common to systems dependent on an external PC controller.

**TSP-Link inter-unit communication bus:** Unlike users of mainframe-based systems, Model 2450 users are not constrained by power or channel count limitations. TSP-Link connections support system expansion with multiple 2450s and other TSP instruments, including Series 2600B SMU instruments and the Model 3706A Switch/Multimeter. Up to 32 Model 2450 instruments can be linked for multi-point or multi-channel parallel test, under the direction of a master unit's TSP controller.

**Model 2400 legacy mode:** In addition to its native 2450 SCPI operating mode, the Model 2450 offers a 2400 SCPI operating mode for backward compatibility with existing 2400 SCPI programs. This preserves Model 2400 users' software investments and eliminates the re-work normally associated with upgrading a system with a new instrument.

**PC connectivity and automation:** Rear panel triax connectors, multiple instrument communication interfaces (GPIB, USB 2.0, and LXI/Ethernet), a Dsub 9-pin digital I/O port (for internal/external trigger signals and handler control), instrument interlock control, and TSP-Link® jacks simplify configuring multi-instrument test setups.

#### Pricing and Availability

The list price of the Model 2450 €4,535 or £3,810. A version without a front panel designed for integration into automated systems is available for €4,283 or £3,598. The Model 2450 is available to order now.

## Oxford Instruments branches out in China

The firm has appointed a new president to lead its operations in China to develop and accelerate growth strategies for both industrial and research markets in the region

Oxford Instruments, a provider of tools and systems for semiconductor industry and research, appointed Gu Ran as President of Oxford Instruments China on 22nd July 2013.

Gu Ran will be based in the factory in Shanghai, but will also be managing the regional offices in Shanghai, Beijing, Guangzhou, and Chengdu. His key objectives will be to develop and implement accelerated growth strategies for China in both industrial and research markets.



Gu Ran, President of Oxford Instruments China

David Scott, Director of Emerging Markets comments, "China continues to be a very important market for Oxford Instruments. We have a highly skilled workforce dedicated to growing our business and Gu Ran's experience of business development and leadership across a range of international technology companies will help us improve on the success we have achieved so far."

Oxford Instruments opened its first office in China in November 1999 with a team of six. Now the Group employs over 150 people and turnover has more than quadrupled over the last 14 years.

Oxford Instruments provides solutions needed to advance fundamental physics research and its transfer into commercial nanotechnology applications. Its strategy is to effect the successful commercialisation of these ideas by bringing them to market in a timely and customer-focused fashion.

This involves the combination of core technologies in areas such as low temperature, high magnetic field and ultra high vacuum environments, Nuclear Magnetic Resonance, X-ray, electron and optical based metrology, and advanced growth, deposition and etching.

## SAES Pure Gas reaches agreement to support Johnson Matthey customers

SAES Pure Gas will provide support to customers who own Johnson Matthey gas purifiers.

SAES Pure Gas Inc. has reached an agreement with Johnson Matthey Gas Purification Technology where SAES Pure Gas will provide support to customers who own Johnson Matthey gas purifiers.

With the recent closure of the Johnson Matthey Gas Purification Technology business, customers will now be able to contact SAES Pure Gas for on going support.

"Following Johnson Matthey's announcement of the closure of their Gas Purification Technology business, we were

approached by many customers asking for our support" comments Tim Johnson CEO of SAES Pure Gas.

"Johnson Matthey offered a full line of Palladium membrane hydrogen purifiers, and we recognize this as a critical technology for manufacturing High Brightness LEDs and other high purity applications. As the worldwide leader in ultra high purity gas purification, we understand the importance of providing on going support for customers using this technology. This agreement builds on our recent acquisition of the palladium hydrogen purifier business from Power + Energy and establishes SAES Pure Gas as the leading supplier of palladium purifiers."

SAES Pure Gas is now the authorized supplier of both warranty and non-warranty support or replacement for Johnson Matthey HP series, V-purge, HTG, GPT and PSH Series palladium membrane hydrogen purifiers.

## FB-CVD Tool for particle and small structure coatings announced

Structured Materials Industries, Inc. has announced the delivery of a manual research and development tool for Fluidized Bed -Chemical Vapor Deposition (FB-CVD) of functionalized thin films on particles.



In FBCVD simple or complex shapes are coated by passing precursors over their hot (or cooled) surfaces as they are suspended in a fluidized bed of either sand or an equivalent powdered material. Heating is used when decomposing precursors and cooling is used when condensing materials such as polymers on the particles.

Coatings can be performed sequentially or as a complex multicomponent material in order to build up single, multiple, or functional layer coatings. The structures can be grown using a variety of chemistries in a variety of atmospheres and can be passivated in place for packaging. This vertical tube system is designed for researchers who desire to coat powders and small complex structures.

The system features gas inlets, a switching manifold, heating zone - a 25mm x 100mm deposition zone (alternative sizes are available), height adjustable heating for controlling readouts, easy loading, a mobile enclosed housing, and a user friendly operation. The self-contained system occupies a ~2' by 4' footprint.

## How many people do you need to change a light bulb?

None - it's an LED bulb



Gallium nitride-on-silicon is a hot topic for LEDs and power devices.

But LEDs could be the game changer - in the immediate future at least - as LED bulbs can last a lifetime. With new government regulations to make our world more environmentally friendly, and the demise of incandescent bulbs, LEDs are on the rise.

It was in the late 1800s when Thomas Edison invented the first commercially practical incandescent light that some of us are still using.

But it's time for us to move on.

In the last ten years, there have been a cluster of companies targeting the massive lighting market. The question is who will be the quickest to come up with the goods? We want the brightest, eco-friendliest most versatile LED bulb at the lowest cost which is also easy on the eye.

It's a tall order.

Most white to blue semiconductor LEDs incorporate the wide bandgap compound semiconductor gallium nitride (GaN). And you may be spoilt for choice with the different substrates that can be used in making the device - these include sapphire, SiC, silicon and GaN itself.

Many of these substrates are costly though. The exception is silicon, which comes in large substrate sizes such as 6" and 8".

So what are the challenges of growing GaN on silicon?

Firstly the difference in lattice parameter between the most prevalent silicon (111) and GaN is large (around 17 percent). One of the key aspects to counter this is growing a layer (often AlN) - this layer prevents chemical reactions between gallium and silicon and makes the wafer behave like a substrate having lattice parameters closer to that of GaN. Then the buffer layer (mainly AlGaN) is grown to further reduce the mismatch.

There is also a 52 percent thermal mismatch between GaN and silicon. This means that once the wafer is cooled down after growth, the GaN will contract at a different rate to the silicon substrate.

Having said that, the plus side would work two-fold. Silicon substrates are cheap and also, growing on silicon would enable fabs to use their existing tools without having to invest in costly alternative equipment.

Current players in the GaN-on-Si market include Toshiba and Plessey. Both companies have recently launched LEDs for the lighting market. But efficiencies are still relatively low.

Using technology initiated by Colin Humphreys' group at Cambridge, Plessey and Aixtron are working together to optimise a process using a close coupled showerhead (CCS) reactor capable of growing 6 inch GaN-on-Si.

Apart from Toshiba, competitors include Lattice Power, Transphorm, Azzurro, Infineon, Philips Lumileds, Samsung and imec (and partners). Soitec, Azzurro, Kyma, Translucent and EpiGaN provide GaN-on-Si templates.

So only time and investment will tell who comes out on top.

## Ultratech/Cambridge NanoTech branches out in Massachusetts

A new state-of-the-art facility will expand operations for next-generation ALD equipment development and enable leading-edge scientific research

Ultratech, a supplier of lithography, laser-processing and inspection systems used to manufacture semiconductor devices and high-brightness LEDs (HB-LEDs), has moved Ultratech/Cambridge NanoTech to Waltham, Massachusetts.

After acquiring the assets of Cambridge NanoTech last December, Ultratech invested in a new facility to enhance atomic layer deposition (ALD) development. With this new facility, Ultratech/Cambridge NanoTech has now greatly enhanced its capability to develop innovative process technology for ALD applications.



*Ultratech/Cambridge NanoTech cleanroom*

ALD is an enabling technology which provides coatings and material features with significant advantages compared to other existing techniques for depositing precise nanometre-thin films.

This technology is expected to be in high demand in volume manufacturing environments for integrated optics, micro-electro-mechanical systems (MEMS), implantable devices in the biomedical sector and batteries and fuel cells in the energy market.

Ultratech Chairman and Chief Executive Officer Arthur W. Zafiropoulo states, "By creating a new state-of-the-art facility and leveraging the valuable Cambridge NanoTech intellectual property, we have further enhanced our ability to advance the development of next-generation ALD solutions. In addition, we have retained the same team that Cambridge NanoTech customers have worked with in the past."

Zafiropoulo concludes, "The completion of the new facility marks our successful integration of the Cambridge NanoTech assets into Ultratech's nanotechnology product group. By investing in the expansion of these operations, we expect to generate increased revenue in new and existing markets. Ultratech, and our ALD unit, Ultratech/Cambridge NanoTech, will continue to focus on technology solutions that support our global customers' advanced product and technology roadmaps."

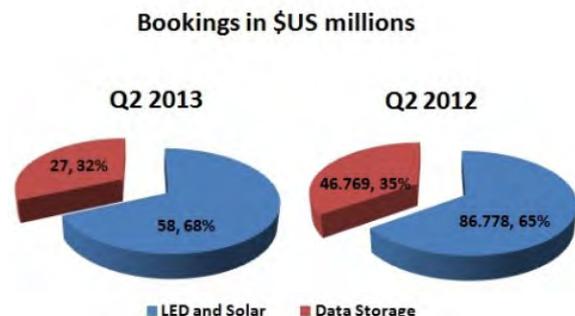
## Pricing pressure takes its toll on Veeco's financials

With few MOCVD deals available, Veeco continues to experience significant competitive pricing pressure which is having an adverse impact on the company's margins and breakeven level

Veeco Instruments is providing select financial metrics and business highlights for the quarter ended June 30th, 2013.

Due to the accounting review announced on November 15th, 2012, the company is unable to report revenue and earnings information.

Second quarter 2013 bookings were \$85 million, up 21% sequentially, including: LED & Solar \$58 million (MOCVD \$52 million and MBE \$6 million), and Data Storage \$27 million.



The company's unaudited cash balance at June 30th, 2013 was \$585 million, down slightly from the \$588 million reported at the end of the March quarter.

Second quarter shipments were up sequentially in MOCVD and were flat in MBE and Data Storage.

John R. Peeler, Veeco's Chairman and Chief Executive Officer, commented, "MOCVD orders improved about 42 percent sequentially to \$52 million as we won some important deals with top customers in Korea, Taiwan and China. Data Storage and MBE business conditions remain muted as customers continue to tightly manage their capital expenditures, so second quarter orders were flat on a sequential basis."

"Market signals in MOCVD remain mixed. On the positive side, utilisation rates in Asia are high and stable, and customers express optimism for their LED business profitability and growth. Customers report strong demand for mid-power LEDs for indoor replacement bulbs and high-power LEDs for outdoor lighting."

Yet, they remain extremely cautious about capacity expansion. As a result, while quoting activity has increased from earlier in the year, the conversion process from quotation to purchase order is slow. We expect MOCVD order patterns to remain choppy as the timing of large multi-unit deals can have a significant impact on our quarterly bookings levels."

"While our Data Storage customers remain cautious on capacity additions, the decline in areal density growth and resulting increase in drive component count (i.e. heads and media per drive) could pressure manufacturing capacity later in the year. In the meantime, we remain focused on collaborating with our customers on development of next-generation solutions that are aligned with their roadmaps."

Peeler concluded, "We are pleased that Veeco continues to weather this business downturn with a strong cash position. We are making significant progress on our accounting review and have achieved several key milestones. It is a top priority for Veeco to conclude this review as soon as possible, be able to report complete financial results, and get up-to-date on our delayed filings."

## Veeco big in China with multiple MOCVD order from Sanan

The largest LED manufacturer in China will use the reactor to grow LEDs for applications including backlighting and general illumination

Sanan Optoelectronics placed a multi-tool order for Veeco's TurboDisc MaxBright M MOCVD systems in the third quarter of 2013.

The multi-reactor systems will be used to ramp production of LEDs in its Xiamen, China fab for applications including backlighting and general illumination.



Zhiqiang Lin, Chief Executive Officer of Sanan, says, "Veeco has been and remains our MOCVD supplier of choice. As we were selecting equipment for our new phase of expansion, it was evident that the MaxBright M would give us the best footprint efficiency to maximise space and productivity in our Xiamen fab. Veeco has been a great partner for us since as we have solidified our position as the top LED manufacturer in China and as we have increased our business outside of China as well."

William J. Miller, Veeco's Executive Vice President, comments, "We are pleased to continue our partnership with Sanan and look forward to supporting their expansion plans. According to IHS - IMS Research, a leading LED industry research firm, China remains the largest region in LED chip production with the most potential for adoption across all lighting applications. We believe Sanan is well positioned to capitalize on that growth."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System is one of the industry's highest footprint efficiency MOCVD systems designed to manufacture high quality, high brightness light emitting diodes. The MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers flexible layout configurations compared to the original MaxBright.

Sanan Optoelectronics is engaged in the design, development, manufacture and distribution of full colour ultra-high brightness LEDs, epitaxial wafers, photo-diode detectors and compound solar cells. The company is headquartered in Xiamen, PRC.

## KaiStar selects Veeco to support LED manufacturing ramp

The joint venture will use Veeco's MOCVD reactor to increase its indium gallium nitride (InGaN) LED production

KaiStar Lighting ordered multiple Veeco TurboDisc MaxBright M MOCVD Systems in the second quarter of 2013.



KaiStar, a joint venture between Epistar Corporation and Shenzhen Kaifa Technology Co., Ltd., is based in Xiamen, China. The systems will be added to KaiStar's current installed base of Veeco MOCVD systems as part of their 2013 capacity expansion plan.

MJ Jou, President of Epistar Corporation, comments, "This latest capacity expansion is based on our customers' growing demand for LEDs for backlighting and general illumination applications. We have been delighted with the performance of Veeco's production-proven MOCVD systems, which provide high productivity and low cost of ownership. Combined with their excellent service and support, it was an easy decision for us to again turn to Veeco for our manufacturing ramp."

William J. Miller, Veeco's Executive Vice President, adds, "We are gratified that KaiStar has again chosen Veeco as their MOCVD supplier of choice as they ramp production. As always, we are committed to help them achieve their manufacturing goals."

Veeco's TurboDisc MaxBright M GaN MOCVD Multi-Reactor System is one of the industry's highest footprint efficiency MOCVD systems designed to manufacture high quality, high brightness LEDs. The MaxBright M provides up to 15 percent improved footprint efficiency, easier serviceability and offers flexible layout configurations compared to the original MaxBright.

KaiStar has registered capital of \$120 million. The company plans to focus on the lighting market through the production of InGaN LEDs for lighting and backlighting applications, lamps and automotive products.

## Meaglow to upgrade ALD nitride deposition tool in Turkey

The hollow cathode plasma source reduces the oxygen contamination in ALD systems and increases the quality of thin III-nitride films during growth

Meaglow is to install a hollow cathode plasma source for the group of Necmi Biyikli, a professor at the Institute of Materials Science and Nanotechnology, at Bilkent University in Turkey.

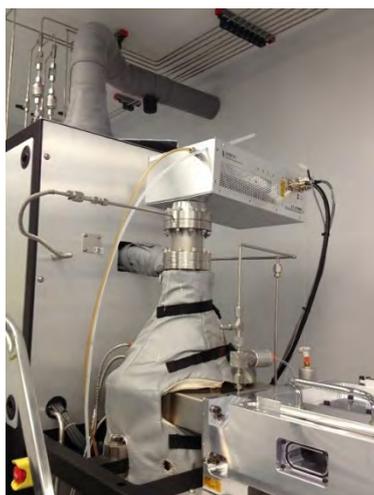
The plasma source is being used to upgrade their Atomic Layer Deposition (ALD) system by replacing an inductively coupled plasma source. This enhancement will reduce the oxygen contamination in ALD systems and increase the quality of nitride thin films grown.

The III-nitrides grown at the university with the ALD system are used for LEDs and power electronic applications. The actual materials grown using the system are AlN, GaN and InN.

Bilkent University researchers will be presenting some of their findings about suitable applications for these products at the ALD 2013 conference on Wednesday.

The presentation will take place from 9:00 - 9:15am and is entitled, "Characterization and Electronic Device Applications of III-nitride Thin Films Deposited by Plasma-enhanced ALD," and will be presented by student finalist C. Ozgit-Akgun from Bilkent.

"The Bilkent system was easy to retrofit and the Meaglow Plasma source was the perfect solution for their oxygen contamination problem," says Butcher, Chief Scientist of Meaglow.



ALD system converted with a hollow cathode plasma source

Initial results show a significant reduction of oxygen content in compound nitride films grown. Results will be presented October 27th to November 1st at the 224th ECS Fall Meeting in San Francisco, California at an invited talk presented at the symposium on "Atomic Layer Deposition Applications".

Meaglow is now focused on commercialising its hollow cathode plasma technology which also has the advantage of scalability to large deposition areas. Meaglow is seeking additional ALD system owners and suppliers interested in removing the oxygen contamination in their films.

## Park's automated AFM classifies defects on III-V wafers

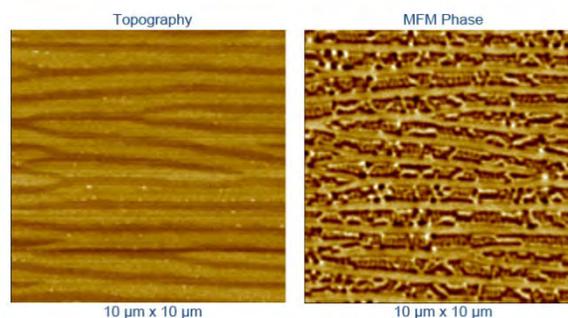
The fully automated system speeds up surface analysis by up to ten times when compared to using a manual method

Park Systems has launched the Park NX-HDM.



Park NX-HDM

This is a fully automated automatic defect review and sub-angstrom surface roughness atomic force microscopy (AFM) system and can be used to analyse the surface roughness of III-V wafers. Surface topography is of grave importance in compound semiconductor structures and can massively impact device performance.



Images courtesy of Dr. Hesjedahl, PDI Berlin

*Magnetic Force Microscopy (MFM) image of epitaxially grown MnAs films on GaAs (001)*

The company says this is the first metrology tool capable of providing this level of accuracy and automation. The NX-HDM system sets a new standard for the industry in automatic defect review AFM technology by increasing throughput by up to 1000 percent and offers a 30 percent higher success rate than the prior system. It analyses and identifies defects in all wafer sizes up to 150mm.

“For researchers working with hard disk media and other flat substrates, the process of identifying nanoscale defects is time consuming with conventional tools, hindering throughput. The Automatic Defect Review (ADR) speeds up and improves the way it identifies, scans and analyses defects in substrates and media,” comments Sang-il Park, CEO and Chairman.

“Beta test runs with Park NX-HDM demonstrate a 10x increase in throughput for defect review in an automated process when compared with more traditional manual methods of defect review. Moreover, we perfected the remapping and defect identification algorithm, and the success rate of the new NX-HDM is 30 percent higher than its previous generation, XE-HDM.”

Park NX-HDM for LED, solar, and general semiconductor device industries, speeds up the automatic defect review for media and wafers. The survey scan, zoom-in scan, and analysis of imaged defect types are automated with a wide range of automated optical inspection (AOI) tools.

What’s more, ‘True Non-Contact Mode’, combined with one of the industry’s lowest noise floors, provides accurate and reliable measurements for the sub-angstrom surface roughness of diverse media and wafers.

The unique Park dual servo system with two symmetric, low-noise position sensors are incorporated on each axis of the XY scanner to retain a high scan orthogonality for widescan ranges and sample sizes. The secondary sensor corrects and compensates for non-linear and non-planar positional errors caused by a single sensor.

“There has never been a metrology tool capable of providing accurate and reliable measurements for the sub-Angstrom roughness of the substrate surfaces,” says Ryan Yoo, Vice President of Global Sales and Marketing. “By delivering the industry’s lowest noise floor of less than 0.5 Å, Park NX-HDM can acquire accurate, repeatable, and reproducible sub-angstrom roughness measurements for the flattest substrates and media.”

Suppliers to various industries are developing ultra-flat substrates to address the ever-increasing need for shrinking device dimensions. However, there has never been a metrology tool capable of providing accurate and reliable measurements for the sub-Angstrom roughness of this substrate surfaces.

Park NX-HDM combines the industry’s lowest noise floor of less than 0.5 Å with Park’s proprietary ‘True Non-Contact’ technology to create repeatable and reproducible sub-Angstrom roughness measurements without tip degradation. Scan size and scan speed are adjustable to match the user’s needs in throughput and quality control.

## Kyma uses Nanotronics tool to classify defects in GaN

The newly installed inspection system will be used in the characterisation of Kyma’s growing III-nitride semiconductor

materials product line

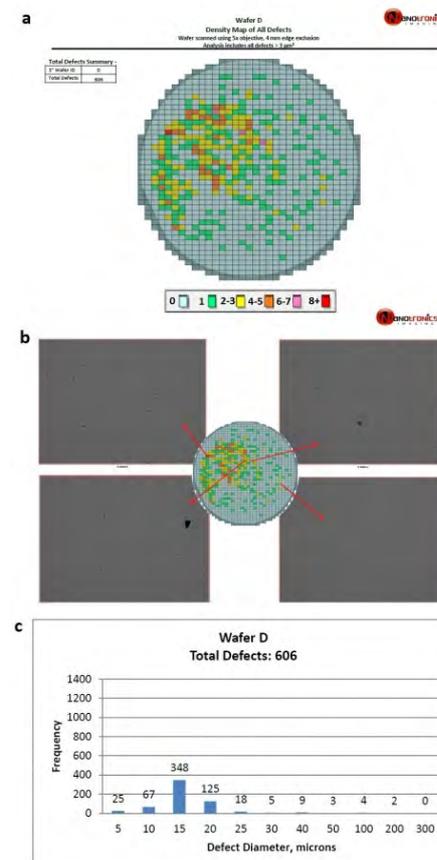
In May of 2013, Nanotronics Imaging installed an nSPEC system at Kyma Technologies in Raleigh, North Carolina.



nSPEC system

Kyma and Nanotronics began discussing how the nSPEC tool might benefit Kyma’s nitride semiconductor materials production effort in early 2013. A collaborative partnership was quickly spawned which led to Kyma’s purchase of the nSPEC tool.

The nSPEC enables Kyma to inspect their wafers via powerful image analysis software. This includes the ability to store high resolution images, capture particular features and areas of interest while translating the acquired visual information into quantifiable data.



*nSPEC data: a) Density map of all defects ; b) Examples of some of the defects on the map compared to microscope images ; c) Histogram showing quantities of each defect size*

“Working with the Nanotronics Imaging team has been an exciting and highly productive experience,” says Keith Evans, Kyma’s president & CEO. “Our technical team, led by our Chief Scientist Jacob Leach, pushed the nSPEC tool in about a dozen different directions. The response of the Nanotronics team was superb and the result is that we can now routinely sense several different important characteristics of our materials better than ever before.”

He adds “We are very pleased with the kinds of inspection that the nSPEC is giving us, which has already given us significant new insight into our processes here at Kyma.”

Kyma Technologies has graciously agreed to open its doors for people to observe the nSPEC in action. This is an ideal opportunity for semiconductor groups and Universities in the South Eastern region of the U.S. to learn about the powerful capabilities of nSPEC and its value to their respective applications.

“This is really a great partnership and opportunity for us, we are so thrilled that Kyma is happy with their purchase of an nSPEC and are excited to bring interested people and future partners to Kyma to see the nSPEC there,” says Matthew Putman, CEO of Nanotronics Imaging.

The nSPEC is an automated, optical, inspection device geared toward defect detection and characterisation of semiconductor wafers, dies and devices. It is a scanning optical microscope fully integrated with patented, image analysis processing.

It is claimed that never before has there been an automated machine that provides such crisp images and rich information about defects and features on semiconductor wafers.

## Teledyne LeCroy’s oscilloscope first to achieve 100 GHz

The firm has also released the first in a series of indium phosphide (InP) chips planned for future generations of high speed oscilloscopes

Teledyne LeCroy, Inc., a subsidiary of Teledyne Technologies Inc. says it has demonstrated the world’s first 100 GHz real-time oscilloscope by successfully acquiring and displaying live signals at 100 GHz bandwidth.

The performance demonstrated dramatically exceeds currently available capabilities. High speed oscilloscopes are vital tools in the development of high-speed digital networks, the critical backbone of the rapidly expanding cloud-based computing paradigm that characterises our digital age.

“Reaching 100 GHz real-time oscilloscope performance is one of many industry milestones achieved by Teledyne

LeCroy,” says Tom Reslewic, chief executive officer, Teledyne environmental and electronic measurement instrumentation. “It reveals new phenomena, opens channels for new discoveries and paves the way for vast improvements in the field of high speed measurement.”

The demonstration was conducted at the research facilities of Teledyne Scientific Company in Thousand Oaks, California.

Teledyne LeCroy and Teledyne Scientific also announced that they have completed the design of a jointly developed next-generation InP chip and have released the design for fabrication at Teledyne Scientific’s InP foundry.

The jointly developed chip is the first device in an expansive chip set planned for future generations of high speed oscilloscopes. Teledyne acquired LeCroy Corporation in August 2012 and has pursued synergies related to the development of ultra high speed oscilloscopes.

“We are pleased to see the 100 GHz real-time oscilloscope milestone reached less than one year after the acquisition of Teledyne LeCroy,” comments Robert Mehrabian, chairman, president and chief executive officer of Teledyne. “Releasing the new InP chip in collaboration with Teledyne Scientific on the very same day illustrates the breadth of our technology expertise, and our commitment to taking high performance oscilloscopes to the next level.”

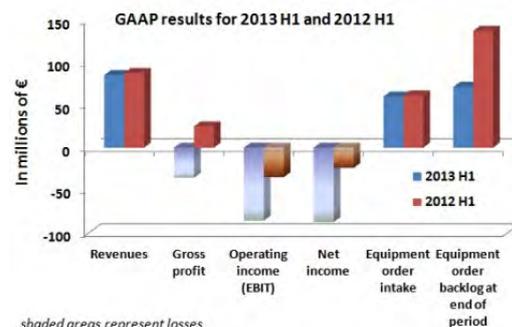
InP promises higher speed devices than can be designed in other known processes. Teledyne is a specialist in next generation InP technology, with advanced design and production capabilities currently in place.

## Aixtron gross profits and incomes dive in H1 2013

Although the company has made progress in efficiency and cost reduction programs, customers remain hesitant to invest

Aixtron SE, a provider of deposition equipment to the semiconductor industry, has announced its financial results for the second quarter of 2013 and the first half of 2013 (2013 H1).

H1 2012 financials were much better than for the first half of 2013, as incomes and profits plummeted as shown below.



The firm made revenues of EUR (€) 45.3 million for the second

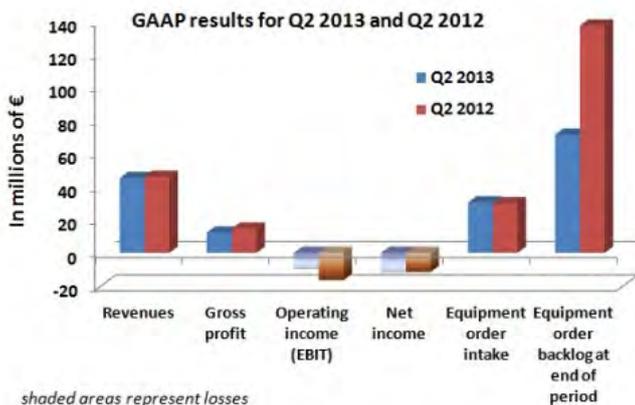
quarter of 2013. This represents a quarterly sequential increase of 13 percent compared to € 40.2 million in Q1 2013. Aixtron also recorded improvements in its gross profit and operating result (EBIT).

This development reflects first positive impacts from the 5-Point-Program, which was started in Q1 2013. Efficiency improvements and cost cutting measures resulted in reductions in both cost of sales and operating expenses.

#### Key Financials

Investment demand from LED manufacturers remained subdued despite a continued reduction of production overcapacities in the market. This was also reflected in the development of order intake (Q2 2013: € 30.5 million; Q1 2013: € 29.9 million).

Gross profit in Q2 2013 amounted to € 12.3 million and thus came in significantly better than the previous quarter which had been affected by inventory write-downs (Q1 2013: € 47.7million; Q2 2012: € 14.7 million; H1 2013: € 35.4 million; H1 2012: € 25.0 million). The Q2 2013 gross profit also benefitted from a favourable product mix.



The Q2 2013 EBIT of € -9.8 million improved against both the previous year's and the last quarter's results (Q2 2012: € -16.5 million; Q1 2013: € -76.3 million; H1 2013: € -86.1 million; H1 2012: € -34.7 million). As mentioned above, this sequential development also reflects the initial success of the 5-Point-Program which began in Q1 2013.

The net result for Q2 2013 amounted to € -11.8 million, representing a significant improvement over the € -76.0 million in Q1 2013 (Q2 2012: -11.6 million; H1 2013: € -87.8 million; H1 2012: € -23.9 million).

Free cash flow in the first half of 2013 amounted to € 5.6 million, despite a net cash outflow of € -3.7 million in Q2 2013. As of June 30th, 2013, Aixtron recorded cash and cash equivalents, including bank deposits with a maturity of more than three months, of € 215.9 million (€ 219.9 million as of March 31st, 2013; € 209.5 million as of December 31st, 2012).

H1 2012 financials, however were much better than for the first half of 2013, as incomes and profits plummeted as shown below.

#### 5-Point-Program

This program, presented by the CEO in May 2013, consists of a number of targeted individual projects, which are all designed to address the following five topics: 1) focus on customer benefits; 2) utilisation of technology and product portfolio; 3) processes; 4) attention to financial targets; 5) strengthening of Aixtron's corporate culture.

The program consists of a series of different projects. After planning and implementing an improved product development process, a specific initiative for the optimization of the Aixtron supply chain has been started. The aim is to increase efficiency on a global scale in procurement, logistics and inventory-management. In addition, Aixtron continues customer-specific measures, e.g. to increase output and yield of the installed base. Another major objective of the Company program is to reduce operating expenses by 20 percent.

#### Management Review

Martin Goetzler, President & Chief Executive Officer at Aixtron SE since March 1st, 2013, firmly believes in the success of the transformation measures. He said, "With our 5-Point-Program we are on track to regain sustainable profitability. Our main focus is on innovative technology solutions, increasing the production efficiency of our customers as well as the efficiency of our own core process flows. This is valid for all of our targeted growth markets, including applications beyond LED, such as next generation memory chips. Our Q2 figures show first positive results of the successful implementation of our 5-point-program."

The rising rates of capacity utilisation at leading LED manufacturers give reason to believe that the overcapacity in the market for MOCVD equipment for the production of LEDs continues to diminish. However, it remains difficult to predict, when and to what extent this will translate into significant new equipment orders. Due to this continuing low visibility, Management remains unable to give precise guidance on the company's revenues and EBIT margin for the current financial year.

## BluGlass in the money with \$3 million grant

The company now hopes to increase efforts into gallium nitride (GaN) on silicon substrates R&D for LEDs

Australian firm BluGlass Ltd. has received a major vote of confidence in its technology by being awarded a (AUS)\$3 million (US\$2.75 million) grant.



The award comes under the Australian Federal Government's 'Clean Technology Innovation Program'.

The funding was specifically allocated to the company's 'Versatile prototype deposition machine for higher efficiency, energy saving, lower cost LEDs on various substrates including silicon' project. This project aims to reduce the amount of greenhouse gas emissions generated in the production of these energy saving LED devices.

BluGlass has invented a new process using Remote Plasma Chemical Vapour Deposition (RPCVD) to grow semiconductor materials such as GaN and InGaN.

This could prove crucial to the production of high efficiency devices such as next generation lighting technology LEDs with advanced low cost potential.

The company will now be able to expedite research and development into GaN on silicon substrates.

Of interest to potential manufactures, BluGlass' unique low temperature RPCVD technology offers significant performance and cost advantages, and it is estimated that for each RPCVD tool put into production there could be a reduction in greenhouse gas emissions of more than 39,000 t CO<sub>2</sub> equivalent per RPCVD unit (based on 3.5 million LED lamps per annum).

## Taking III-V growth into the next dimension

A new process enables the relatively inexpensive growth of III-Vs. The VLS process is claimed to enable similar optoelectronic properties to those obtained by III-Vs grown using MOCVD

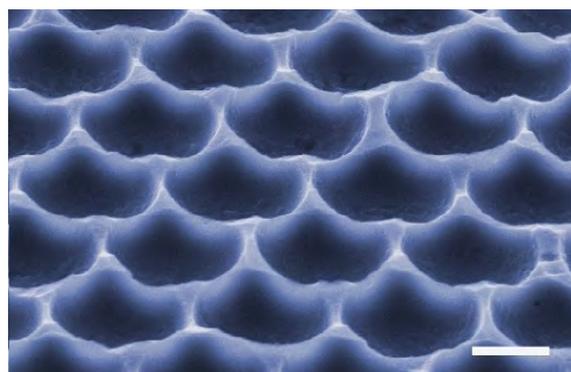
Engineers at the University of California, Berkeley, have developed an inexpensive new way to grow thin films of InP. This achievement could bring high-end solar cells within reach of consumer pocketbooks. The work, led by Ali Javey, UC Berkeley associate professor of electrical engineering and computer sciences, is described in a paper published in *Scientific Reports*, *Nature's* peer-reviewed open access journal. "Performance is everything in the solar cell industry, but performance at a reasonable cost is key," says Javey, who is also a faculty scientist at the Lawrence Berkeley National Laboratory. "The techniques we are reporting here should be a game-changer for III-V solar cells, as well as for LEDs." The most efficient photovoltaics are made from III-V compounds.

However, the complex manufacturing requirements for III-V materials make them up to ten times more expensive than silicon. This limits their use in military applications and NASA satellites.



UC Berkeley engineers could help make high-end solar cells, currently used in satellites and other space and military applications, affordable for consumer markets. (iStockPhoto)

The conventional growth of III-Vs requires expensive epitaxial growth substrates, low precursor utilisation rates, long growth times, and large equipment investments. Addressing this issue, UC Berkeley researchers decided to explore cheaper ways to grow the III-V material indium phosphide (InP). They demonstrated that InP can be grown on thin sheets of metal foil in a process that is faster and cheaper than traditional methods, yet still comparable in optoelectronic characteristics. The researchers used a process they call Vapour Liquid Solid (VLS) growth. In this research, the scientists deposited indium films onto electropolished molybdenum foils by either electron-beam (e-beam) evaporation or electroplating, followed by e-beam evaporation of a 50 nm silicon oxide (SiO<sub>x</sub>) cap. The Mo/In/SiO<sub>x</sub> stack was then heated in hydrogen to a growth temperature above the melting point of indium (~157°C). After temperature stabilisation, phosphorous vapour was introduced into the chamber. The diffusion of phosphorous vapour through the capping layer and dissolution in the liquid indium resulted in the precipitation of solid InP crystals.



Scanning electron micrograph of the InP (Credit: Ali Javey, Rehan Kapadia and Zhibin Yu)

Using this technique they demonstrated high quality 1 - 3 μm thick InP thin-films on molybdenum foils with ultra-large grain size up to 100 μm. The researcher say this is about 100 times larger than those obtained by conventional growth processes such as MOCVD. The films exhibited electron mobilities as high as 500 cm<sup>2</sup>/V-s and minority carrier lifetimes as long as 2.5 ns. What's more, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicated that an open circuit voltage of up to 930 mV can be achieved, only

40 mV lower than measured on a single crystal reference wafer. This work is described in detail in the paper, "A direct thin-film path towards low-cost large-area III-V photovoltaics," by Kapadia *et al* in *Scientific Reports*, 3, Article number 2275. doi:10.1038/srep02275 The full paper can be accessed via the link <http://www.nature.com/srep/2013/130724/srep02275/full/srep02275.html> The U.S. Department of Energy helped fund this research.

## IQE revenues balloon by 80 percent

The development of products including gallium nitride materials and compound semiconductors on silicon projects are progressing well

IQE plc, a global supplier of advanced semiconductor wafer products and wafer services to the semiconductor industry, provides a trading update for the six months ended 30th June 2013.

The Board expects first-half performance to be ahead of market expectations, with first-half revenues approaching £63 million, EBITDA in excess of £10 million and net debt below £39 million. This represents revenue growth of over 80 percent, and EBITDA growth of over 150 percent compared with the first half of 2012. Sales growth was primarily driven by the wireless division, which included contributions from the RFMD and Kopin acquisitions.

The wireless market has continued to grow in line with expectations, driven by the increasing adoption of more sophisticated communication devices including 4G and LTE smartphones and tablets, and newly launched dual band wifi (802.11ac). These advanced products demand the highest levels of RF performance which can only be delivered by compound semiconductor enabled front end solutions.

The integration of the RFMD and Kopin acquisitions has been successfully completed as planned. IQE says work to realise the projected synergies is progressing well. The Board will provide a full update on this progress with the Group's half year results.

The photonics business is also making good progress with several applications in transition from research and development into production. Notably, these include a number of advanced laser (VCSEL) products for consumer, industrial and medical applications such as: optical communications devices for short range optical links; data centres and broadband delivery; optical devices for gesture recognition; gaming and cosmetic applications; and lasers for projection, medical and defence applications.

Advanced CPV solar technology acquired through the investment in Solar Junction and the exclusive seven year license agreement, is now in the final stages of qualification. The Group remains on track for this business to achieve end customer qualification and move into volume production during H2 2013.

The development of advanced products including GaN materials and the Group's compound semiconductors on silicon projects are progressing well. They are building a platform for further diversified growth in the rapidly growing markets for energy efficient devices, such as LEDs and power semiconductors over the next few years.

The Board is confident that the Group remains on track to achieve market expectations for the full year.

Drew Nelson, Chief Executive of IQE, said, "Our key markets have continued to demonstrate robust growth, driven predominantly by high levels of demand for 4G and LTE enabled smartphone and tablet products, along with accelerating requirements for photonic products and advanced sensor applications. Additionally, requirements for energy-efficient third-generation CPV solar products, Solid State Lighting (SSL) and power efficient GaN devices, continue to increase strongly."

"Our transactions with Solar Junction, RF Micro Devices and Kopin, over the last 18 months, represent significant milestones in the execution of our overall strategy and have significantly enhanced both our short and long term growth potential," continues Nelson.

"They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high growth CPV market," he adds.

"Compound semiconductors are widely acknowledged as the key enabling materials that will drive a wide range of next generation technologies from high performance data transmission and management, to highly energy efficient products, including solar energy, SSL and power semiconductors."

IQE expects to report its interim results around mid-September 2013.

## NASDAQ approves Veeco's request for continued listing

On or prior to November 4th, 2013, the company must regain compliance with all applicable requirements for continued listing on the NASDAQ Stock Market including filing its outstanding annual and periodic reports with the SEC

Veeco Instruments Inc. announced that on July 17th, 2013, the NASDAQ Listing Qualifications Panel informed the company that its request for continued listing on the NASDAQ Stock Market until November 4th, 2013 was granted.

Veeco is a supplier of many tools including MBE and MOCVD growth reactors used in both compound semiconductor and silicon wafer manufacturing.

On or prior to November 4th, 2013, the company must regain compliance with all applicable requirements for continued listing on the NASDAQ Stock Market including filing its outstanding

annual and periodic reports with the Securities and Exchange Commission (SEC).

Veeco and its auditors are working to sort out its SEC reports earlier than the November date.

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## Zeiss acquires X-ray microscopy expert Xradia

Xradia's non destructive X-ray microscopy solutions close the gap between light and electron microscopy

Zeiss, a specialist in optics and optoelectronics has announced that the acquisition of U.S.- based Xradia, Inc. has been completed.

The closing took place on July 12th, 2013 after all formal conditions, as set in the acquisition agreement, were fulfilled.

Xradia, Inc. is now operating under the new name of Carl Zeiss X-ray Microscopy, Inc.

This acquisition strengthens the position of the Zeiss Microscopy business group, a manufacturer of light, electron and X-ray microscopes, with solutions for research and routine inspection in materials and life sciences application fields.

X-ray microscopes show unique capabilities in materials research, allowing for 3D imaging of the internal structure of materials. Spatial resolution down to 50 nanometres can be achieved on a lab-based system.

The non-destructive nature of X-ray imaging enables the observation and quantification of microstructural evolution in the same region of a single sample over time, or under changing environmental conditions.

Several examples of in situ and 4D (three-dimensional imaging over time) experiments are proving beneficial for research and industry. Just some of these include crack propagation in ceramics and metals, failure analysis of structural materials and the evolution of defects in operating lithium ion batteries and fuel cells.

X-ray microscopes close the resolution gap between light and electron microscopy and offer scientists multiple new imaging modalities to complement their research.

The optical design allows the Zeiss Xradia Ultra and Versa series to cover a large resolution range, enabling the user to easily find the region of interest by zooming into larger samples (Scout-and-Zoom).

Zeiss is working towards integrated workflow solutions for life sciences and materials research.

In materials science, this is typically achieved by using X-ray microscopes to perform non-destructive 4D microstructural evolution experiments prior to destructive sectioning and then using electron microscope techniques for additional resolution and contrast. In life sciences,

X-ray microscopes are being used to provide a navigational map of the subsurface after tissue samples have been stained for electron microscope investigation. By incorporating 3D X-ray microscopes into this workflow, the emerging 3D electron microscope techniques are expected to gain a significant boost in efficiency.

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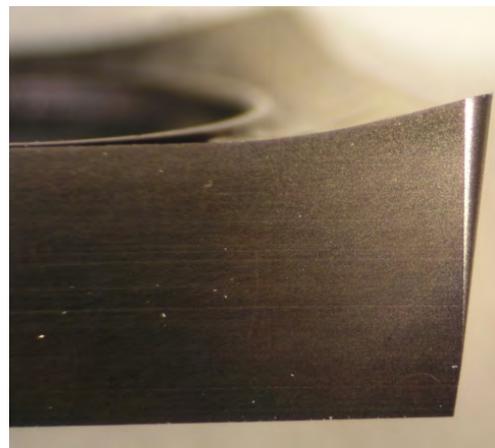
## Picodeon's diamond-like coatings shine

The company's US PLD technology delivers improved reliability in applications where through-thickness defects may cause delamination of thin films and serious damage to components

Finnish coating technology specialist Picodeon has developed a technique for depositing diamond-like films onto a wide range of substrates using its patented ultra-short pulsed laser deposition (US PLD) technology.

This technology can be used in the manufacturing of compound semiconductor devices.

Diamond-like coatings create superhard surfaces (greater than 40 Gpa) with a low coefficient of friction and excellent coating adhesion.



*Picodeon's cutting tool coating*

The US PLD deposition process uses a high laser pulse repetition rate and fan-shaped plasma bloom which enables high production rates and makes feasible the industrial coating of large surfaces at film thicknesses down to the nanoscale.

Applications for diamond-like coatings range from machine tooling components through to wear components for medical, optical and sensor applications.

"Any components that need to have the highest possible hardness or wear-resistance can achieve improved lifecycles, greater heat and pressure resistance and/or improved performance with diamond-like coatings," says Picodeon CEO Marko Mylläri. "Our US PLD deposition process can deliver the exact surface defined by our customers' engineers because of the high level of tuning enabled by our process."

Picodeon's US PLD deposition is a cold ablation technology

which works across a vast range of coating materials and substrates. By adjusting processing parameters, the structure and properties of the coating can be tailored to the requirements of the application, even for nanostructure-scale surface coatings.

The US PLD technology delivers very high coating integrity without pinholes, giving improved reliability in applications where through-thickness defects may cause delamination of thin films and serious damage to components.

In addition to diamond-like coatings, US PLD technology, under the tradename Coldab, enables the deposition of carbon nitrides, carbon nitride composites containing PTFE or boron nitride (BN) as well as a wide range of other borides, oxides and precious metal thin films.

Picodeon says its Coldab US PLD technology enables high production rates and coating qualities and opens new possibilities and applications for pulsed laser deposition coatings.

In selected areas it may even enable the development of exclusive coating methods.

## Sensirion launches flexible flow sensor

The sensor has no moving parts and is claimed to have the highest sensitivity down to the lowest flow rates

Sensirion's new SLQ-QT500 features a flow range up to 120 ml/min for water-based liquids as well as hydrocarbon based liquids.



SLQ-QT500

It is suited for the integration into demanding coating systems in the semiconductor industry.

Applications include high-end semiconductor process control, industrial automation and fast dosing operations .

Based on Sensirion's thermal microsensor technology, the wetted parts are the PFA fittings and the quartz glass tube. The whole fluidic path is straight and there are no obstacles or moving parts in the sensor.

Sensirion says its SLQ-QT500 is ideally suited for liquids with virtually any viscosity as well as liquids which contain small

particles as long as they are not abrasive in the quartz glass tube.

A smart digital interface and RS485 communication is offered for long distance and bus capabilities. The firm believes the sensitivity and measuring speed offer new possibilities for the monitoring or control of fast dosing operations.

The instantaneous flow rate of the fluid is available as well the output of a total dosed volume with automatic dosing detection. The sensor is available with calibration for H<sub>2</sub>O and isopropanol (IPA).

### Features

*For flow rates up to 120 ml/min (hydrocarbons and water based liquids)*

*Fast response time down to 30 ms*

*For high and low viscosity liquids*

*For liquids with small particles*

*RS485 digital interface*

*Straight flow path, no moving parts*

*Assured purity*

*Highest sensitivity down to the lowest flow rates*

*Superb chemical resistance, inert materials*

*Wetted materials: PFA and quartz glass only*

*Maximum working pressure 10 bar*

## EV Group on a roll partly thanks to III-Vs

The demand for flexible, high-volume manufacturing solutions in 3<sup>rd</sup> power device and compound semiconductor markets are partly driving growth at the company

EV Group (EVG), a supplier of wafer bonding and lithography equipment for the semiconductor markets, has achieved strong revenue growth and expanded its headcount for the first half of 2013.

The company attributes this success to continuing demand for its flexible process solutions designed to address high-volume manufacturing (HVM) needs across multiple markets - including compound semiconductors, power devices, 3D-ICs and MEMS.

EVG's latest technology innovations that address these and other markets will be showcased this week at SEMICON West 2013 at the Moscone Convention Centre in San Francisco. In addition to unveiling a series of new solutions, EVG also says it continues to expand its wafer processing services and process development consultation capabilities worldwide as part of the company's long-term growth strategy.

"2013 has been a strong year for EV Group as we continue to invest in new technologies and capabilities to support our customers' ability to ramp next-generation devices to volume production quickly and cost-effectively at high yields," says Dave Kirsch, vice president and general manager of EV Group North America.

"This requires not only leading-edge process equipment but also world-class global support and process development

services. EVG's local teams work hand in hand with our corporate headquarters to provide increased flexibility and capability for our customers. That includes our ability to offer small-scale and pilot-production services at our global applications labs, which is a key differentiator for us and a key value proposition for customers," he continues to explain.

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## Expanding sales growth and global customer support operations

During the first half of 2013, EVG achieved approximately 10 percent growth in sales and more than 10 percent increase in employees. To support its customers' roadmaps, EVG continues to invest aggressively in research and development - approximately 20 percent of sales - in several key efforts.

Among these efforts, EVG has invested in new state-of-the-art cleanrooms and application labs with in-house process demo capability on fully automated systems at its corporate headquarters in Austria, as well as its regional headquarters in Japan and North America.

EVG's dedication to customer service and support was acknowledged when the company was again recognised in VLSIresearch's annual Customer Satisfaction Survey - this year as one of the 10 BEST Focused Suppliers of Chip Making Equipment.

### Wafer bonding

Already a supplier of HVM wafer bonding solutions, EVG recently unveiled several new platform developments in both fusion bonding and temporary bonding/debonding applications.

The firm unveiled the latest version of its EVG40NT automated measurement system, which features improved specifications to achieve the highest wafer-to-wafer alignment accuracies needed for the production of next-generation 3D integrated image sensors.

The EVG40NT is seamlessly integrated with EVG's GEMINI FB automated production fusion bonding system to enable a closed-loop control system that facilitates customers' ramp to volume production across multiple markets and applications.

Last week, EVG also introduced its LowTemp debonding platform, which features three high-volume-production room-temperature debonding process types and is supported by a supply chain of seven qualified adhesive suppliers to enable greater manufacturing flexibility.

### Lithography and resist processing

Building upon the company's expertise in lithography, EVG also recently unveiled the EVG120 automated resist processing system, which integrates spin/spray coating and wet processing to provide a highly flexible system that maximises productivity and cost of ownership.

The EVG120 is ideally suited for a wide variety of markets and applications, including passivation, dielectrics and thick-film processing for compound semiconductor devices.

Rounding out EVG's latest developments in wafer surface preparation, the company also recently announced the CoatsClean wafer cleaning solution, which combines process, equipment and formulation technology to deliver an innovative, low-cost-of-ownership approach to single-wafer photoresist and residue removal.

Co-developed with DYNALOX, CoatsClean is designed to address thick films and difficult-to-remove material layers for many markets including compound semiconductors.

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## Veeco wins R&D 100 award

The firm has been awarded for its SPECTOR-HT system which is used to create precision thin film coatings for laser machining, telecoms, laser diode manufacturing and laser guidance systems

Veeco Instruments has been honoured with an R&D 100 Award for its SPECTOR-HT Ion Beam Deposition (IBD) System.



Initiated in 1962 and called the "Oscars of Innovation," the R&D Awards, issued by R&D Magazine, recognise and celebrate the top 100 technology products of the year.

The SPECTOR-HT is used to create precision thin film coatings for the optical market for applications such as laser machining, telecommunications, manufacturing of laser diodes, heads up displays and laser guidance systems.

"Veeco is honoured to receive this R&D 100 Award that recognises excellence and innovation in technology, and celebrates achievement," says William J. Miller, Veeco's Executive Vice President.

"The SPECTOR-HT provides manufacturers the advantages of ion beam sputtering technology - stable deposition rates, high purity, high density and low roughness films; combining for stable low optical loss films - in a robust package that significantly boosts throughput and lowers cost of ownership," adds Miller.



Launched in 2012, the SPECTOR-HT Ion Beam Deposition System provides up to 400 percent increase in throughput, 300 percent increase in target utilisation and 50 percent improvement in material uniformity compared to previous generations of ion beam sputtering equipment. It also offers exceptional film quality, and a cost-effective manufacturing platform.

Veeco says it is the industry's first fully automated ion beam deposition system to achieve accelerated deposition rates at speeds comparable to competing optical deposition technologies, such as physical vapour deposition (PVD), evaporative coatings or ion assisted deposition, while maintaining high quality, optimal films.

## Robot automated transportation for cleanrooms revealed

The robot is cleanroom suitable up to ISO class 3 / US FED class 1 and has more than 5,000 km of autonomous navigation in clean rooms

Roth & Rau - Ortner, a factory automation specialist, and its partner MetraLabs Automation, a provider of freely navigating autonomous mobile robots, have introduced their jointly-developed mobile robot, SCOUT at SEMICON West.

SCOUT has been specially developed for the flexible and automated transportation of materials in semiconductor fabs and other clean production environments.

SCOUT navigates autonomously, without any kind of guidance system and communicates via WiFi and operator GUI to issue new transport jobs and show important status information like its current position. The robot is cleanroom suitable up to ISO class 3 / US FED class 1 and has more than 5,000 km of autonomous navigation in clean rooms, which proves its reliability.



*SCOUT can be used safely in areas where people and machines work closely together*

"Thanks to its compact size and reliable sensor technology, SCOUT can be used safely in areas where people and machines work closely together," explains Matthias Merten, CEO of MetraLabs Automation, Inc. "This makes SCOUT an ideal alternative in cases where a permanently installed transport system such as a rail or a conveyor system cannot be implemented or would be too expensive.

SCOUT is capable of transporting various materials and products between any point in the fab, taking measurements, providing tools and auxiliaries. Various attachments like mechanical manipulators (e.g. robot arms or linear axis) and transportation trays (e.g. for the transportation of four SMIF Pods or HA200 storage boxes) enable SCOUT to be adjusted to different conditions according to the desired use.

"SCOUT is an integral part of our "Missing Link" concept, which covers custom-tailored automation solutions for existing semiconductor fabs. These solutions are primarily directed at semi-automated production lines with high requirements for personnel because they can cut costs dramatically by minimising downtime and freeing up manpower," adds Karli Hantzschmann, Division Manager Automation of Roth & Rau - Ortner.

Older wafer fabrication businesses often called for cassettes to be handled manually between the production processes. This tied up valuable assets, such as staff; required high investments in time and cost and was prone to error.

Ortner's solution replaces formerly manual links between two work steps, improving the process for transportation, tool loading, storage and identification.



*SCOUT at work in a semiconductor cleanroom*

Roth & Rau - Ortner and MetraLabs will demonstrate SCOUT's reticle transportation application at SEMICON West in booth # 1831, South Hall.

## New subsidiary expands wet processing division at ClassOne

The firm has expanded the division to enhance its sales and support of Semitool equipment worldwide as well as to design and manufacture new upgrades and platforms that address emerging markets such as LED and RF power devices

ClassOne Equipment has made significant investments in the growth and expansion of its Wet Processing Division in response to increased market demand. A Design and Development Centre has been opened in Kalispell, Montana, staffed with several industry veterans who represent over 200 years of cumulative industry experience, who will focus on new product design and development. Corporate and refurbishment activities will remain at ClassOne's headquarters in Atlanta, Georgia.

"We are thrilled with the strong customer response to ClassOne's industry-leading products and support. We have expanded the division to enhance our sales and support of legacy Semitool equipment worldwide as well as to design and manufacture new state-of-the-art upgrades and platforms that address emerging markets such as MEMS, Nanotech, LED and RF Power Devices," says Byron Exarcos, ClassOne's President.

Hi adds, "Semitool's acquisition left a void in the market for mature fabs and emerging technologies that use 75 to 200mm substrates. ClassOne is meeting the growing demand for cost effective, reliable, and long-term support for popular tools such as the Spray Solvent, Spray Acid and Equinox tools. The widespread adoption of our lift-and-rotate and robot refurbishment programs gives testimony to that fact."

The new facility in Kalispell will be operated under the name of ClassOne Technology as a wholly owned subsidiary of ClassOne Equipment. The executive team includes: Win Carpenter, a 33-year veteran in the semiconductor industry, VP Wet Process Division; Tim McGlenn (26 years experience, including leading the software and electronics development of Semitool's 101, 102, 202, 302, 402 and 502 controllers), VP of Operations; and Kevin Witt (25 years focused on the development and commercialisation of new wet chemical processing platforms), VP Technology; all of whom previously held leadership positions at Semitool. Their appointment further strengthens the division, positioning it for enhanced growth and continued market leadership.

ClassOne Technology's first product, the Polaris controller, is an advanced, PLC-based, field-retrofittable control system that replaces the aging 302 control system used in many Semitool legacy tools.

## 5N Plus to acquire all outstanding shares of AM&M

The producer of metal and chemical products used in the MOCVD growth of III-V materials has broadened its portfolio. With the acquisition, the firm will have access to metallic powders which can be used in a variety of electronic markets

5N Plus, has signed an exclusive option to acquire all of the issued and outstanding shares in the capital of AM&M Advanced Machine and Materials Inc. (AM&M).

AM&M is a Kanata, Ontario based corporation specialised in the manufacturing of micron size metallic powders which can be used in a variety of electronic markets. These include solder powders for increasingly demanding applications, silver-based powders for high thermal conductivity interfaces, and CIGS powders for thin film solar panels.

The intellectual property and processing capabilities developed by AM&M allows for the cost-effective and high-yield production of spherical, low oxygen content powders with uniform particle size.

"Upon completion of the acquisition of AM&M, we will immediately add new products to our existing offering as well as benefit from the expertise of AM&M's executives. Combining AM&M's technology with our family of high purity metals and alloys, we will be able to offer our customers a large array of custom-made powders optimised for their specific needs. This investment is in line with our growth strategy which includes developing opportunities to promote our specialty metals further along the value stream," says Nicholas Audet, Vice President Business Unit - Electronic Materials of 5N Plus.

5N Plus will immediately start the promotion and distribution of AM&M's products via its global sales force. Closing of the transaction is subject to due diligence and other standard conditions customary to a transaction of this nature.

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## Polish University orders another Aixtron tool for III-V solar research

Technological centre TECHNOPOLIS is to develop high-efficiency multi-junction gallium arsenide based solar cells

The University of Wroclaw in Poland has successfully started-up a 3 x 2-inch Aixtron Close Coupled Showerhead (CCS) MOCVD reactor to create optoelectronic devices.

The tool will be mainly used to create high efficiency multi-junction solar cells, based on GaAs related materials.

Marek Tlaczala comments, "We decided to purchase the Aixtron system based on our good experience with the performance of our existing CCS 3 x 2-inch gallium nitride tool in the Faculty of Microsystem Electronics and Photonics. The new Showerhead reactor is destined for the University's

Interuniversity Didactic-Technological Centre 'TECHNOPOLIS' in Wroclaw."

Frank Schulte, Vice President of Aixtron Europe, adds, "The Close Coupled Showerhead (CCS) concept is recognized as a robust route to uniformity and scalability. We are very pleased that the University of Wroclaw has chosen our system for its most advanced centre TECHNOPOLIS and are looking forward to continue our close collaboration with our customer's excellent technical team."

The centre is co-funded by the European Union from the European Regional Development Fund within the framework of the Infrastructure and Environmental Programme and Poland's national budget.

Doctoral and masters students will be trained in the centre to participate in strategic economic activities such as automatics and robotics, electronics and telecommunications, computer science and teleinformatics.

TECHNOPOLIS is an investment endeavour whose purpose is to establish fundamentals for the development of educational infrastructure enabling highest quality education, necessary for the creation of knowledge society and encouraging economic growth in the region concerned.

## Pall to unveil latest filtration and purification technologies

The firm's new products will help semiconductor device and wafer manufacturers detect certain key contamination levels, and clean and maintain control of their fluids to enhance yields

The new technologies include:

**The Gaskleen High-Bright purifier:** This will help ensure consistent, cost-effective delivery of the pure ammonia needed to make LEDs with the highest luminosity. The purifier is a highly efficient product designed to remove molecular contaminants from ammonia used in the manufacture of HB LEDs.

Featuring twice the service life of other commercially available technologies, the new purifiers will help ensure consistent, cost-effective delivery of pure ammonia needed to make LEDs with the highest luminosity.

The Gaskleen purifier assemblies combine Pall's proprietary purification materials and Ultramet-L stainless steel filter media. They remove moisture and other oxygenated compounds from ammonia to sub ppb levels, while providing 3 nm or 0.4 micron filtration. What's more, they do not release metal ions into the process stream, further increasing luminosity.



*Gaskleen High-Bright purifier*

**Advanced 12 nm Filtration Membrane for Wet Chemical Processing:** This is a key addition to Pall's chemical filter lineup is the new 12 nm XpressKleen filter and all PFA disposable assemblies. This filter uses an advanced molecular surface tailoring (MST) process to remain wet in critical aqueous chemicals like SC1 and SC2.

It also features an improved patent-pending PTFE membrane that easily stands up to the conditions of new, higher temperature processes. This new filter maintains critical fluid purity with guaranteed claims for ultra-low metal ion extractables (< 3 ppb), particle rinse-up and organics. Advanced manufacturing, incorporating statistical process controls, assures repeatable and reliable performance.

**Gaskleen Pico1000 Analyser for Moisture in Nitrogen:** This measures trace moisture in nitrogen process gas streams, with a limit of detection of 1 part per billion (ppb). It is ideally suited for qualifying and certifying ultra-high purity (UHP) process gas lines, as well as for detecting end-of-life when deployed downstream of our Gaskleen purifiers. The robust, compact design of the analyser is readily portable, allowing users to easily move it around the fab for quick checks of process gas quality at many points. In addition, the Pico1000 consumes up to 70 percent less process gas, compared to competitive analysers, and for a cost saving of 30 percent over traditional 1 ppb moisture analysers.

**100 nm Filtration Medium for Point-of-Use Chemical Mechanical Planarisation:** Pall will feature its new CMP StarKleen™ Nano filter capsule specifically designed for the classification of ceria and low solids, colloidal silica CMP slurries.

The CMP StarKleen 100 nm filter performs 30 percent better in terms of defectivity reduction than its predecessor for both shallow trench isolation (STI) and barrier copper processes. The product utilises Pall's most advanced melt blown technology and is manufactured using a proprietary process that enables greater control of pore sizes and gradient. The capsule is available in multiple lengths thus allowing for usage over a wide range of flow rates.

The Pall Microelectronics team supports customers in the semiconductor, data storage, fibre optic, display, LED and solar energy materials industries with innovative detection, filtration, and purification products, and deep applications expertise, for chemical, gas, water, chemical mechanical polishing and

photolithography processes.

## SSEC unveils single wafer wet processing solutions for III-Vs

Unique configurations improve process control, lower CoO, and bring higher throughput

Solid State Equipment LLC (SSEC) has introduced its WaferEtch and WaferStorm product lines.

These platforms are specifically configured to meet the process needs of applications in compound semiconductor, advanced packaging and MEMS manufacturing. These tools aim to improve process control and reduce chemistry consumption, translating to higher throughput and lower cost of ownership (CoO).

One key CoO reduction driver was enabled by an engineering break-through that makes the chambers more compact and stackable. This results in 50 percent more process chambers within the same small footprint of the legacy products.

The WaferEtch platform is configured for aqueous-based etch processes such as through-silicon via (TSV) reveal. The WaferStorm platform is configured for solvent-based processes such as resist strip, metal lift-off, and TSV cleaning.

“Superior performance, improved yields, and increased throughput at a lower CoO are the cornerstones of SSEC’s single wafer wet processing approach,” says Laura Rothman Mauer, Chief Technical Officer of Solid State Equipment LLC.

She adds, “We have worked closely with our customers to develop practical solutions to some of the industry’s toughest manufacturing challenges in 2.5D and 3D ICs, MEMS, and compound semiconductors. The launch of these preconfigured product lines is the culmination of this work, and we are excited to bring these innovations to market.”

### WaferEtch

The WaferEtch platform is an aqueous-based, customisable platform uniquely configured to meet the needs of specific etch applications for compound semiconductor, 3D ICs and MEMS processes. These systems use a wet etch process chemistry that demonstrates optimal etch rate and in situ cleaning.



*WaferEtch TSV REVEALER*

The flagship of the WaferEtch platform, the TSV REVEALER, is specifically configured to address the requirements of TSV reveal, which is the process where the backside of the wafer is thinned to reveal the copper interconnects. It has become a target area in the manufacture of 2.5D and 3D IC packaging for process control and cost reduction.

The TSV REVEALER replaces three tools required for the dry etch approach: plasma etch, silicon thickness measurement, and clean. An optical end point detection system with advanced algorithms determines when vias are revealed. Integration of a wafer thickness measurement sensor in the etch system provides closed-loop control of the etching process. The TSV REVEALER achieves a significant reduction in CoO making 3D TSVs more economically feasible.

### WaferStorm

The WaferStorm platform is a solvent-based platform, initially available in three unique configurations: TSV CLEANER, METAL LIFTER, and DRY FILM REMOVER. All WaferStorm systems are based on SSEC’s unique soak and spray technology, which provides improved performance at lower CoO than conventional wet bench-only or spray-only approaches.

The process combines equal soak time in the wet buffer tank for each wafer, followed by spray, and then a final step depending on the process being performed. This unique combination minimizes both spray time and chemistry use, and adds a significant level of process control. The reduction in spray time results in increased throughput.



*WaferStorm TSV CLEANER*

TSV clean is a critical process step that is essential to reliability. The deep reactive ion etch (DRIE) process leaves behind a polymer residue which can lead to defects and voids in the barrier, seed, and fill steps that follow. SSEC's WaferStorm TSV CLEANER is proven to remove residues in high-aspect-ratio holes that wet bench-only or spray-only tools leave behind. The tool features equal-time soak software for process control.



*WaferStorm DRY FILM REMOVER*

Removal of dry film resists used in advanced microbumping processes for 3D ICs and wafer level packaging (WLP) applications is a challenge due to the film thickness and composition. The SSEC WaferStorm DRY FILM REMOVER combines heated chemistries and proprietary soak and spray at high pressure for rapid and complete removal of stubborn dry film residue.

The soak step uses heated solvents throughout the buffer cycle time. After being softened by the soak, the wafers are transferred to the single-wafer spray station where they are exposed to high-pressure fan sprays with heated solvents for rapid removal of dry film residue. This combination ensures thorough removal and increased throughput.



*WaferStorm METAL LIFTER*

Metal lift-off consists of the sequential steps of photolithography, metal deposition, and solvent lift-off of both metal and non-metal substances in MEMS and compound semiconductor applications. The SSEC WaferStorm METAL LIFTER is configured specifically to perform the sequential soak and spray combinations unique to the process.

The immersion station operates in a low-oxygen atmosphere, which maintains the bath longer. Following a soak in the immersion tank, lift-off takes place in a spray station using a high-pressure chemical spray, which translates to increased throughput. The tool features a lift-off material filtration station and strainers for separating metal films, which results in the complete removal of the metal.

## SEMATECH & Air Products unite to advance III-Vs

Air Products will collaborate with SEMATECH's engineers to better understand the underlying principles responsible for the deposition of III-V structures

Air Products, a global provider of industrial gases, used in MOCVD growth, has joined SEMATECH's Front End Processes (FEP) program.

Air Products will work with SEMATECH to assess advanced materials and technologies for the development of sub-10 nm node III-V devices.

Continued scaling will require the use of new materials and chemistries to keep pace with the International Technology Roadmap for Semiconductors (ITRS). For example, III-V channels offer significant power and performance benefits, such as higher mobility, enhanced drive current and supply voltage scaling which enable continued device scaling and performance improvement.

As a member of this program, located at SUNY's College of Nanoscale Science and Engineering (CNSE), Air Products will

closely collaborate with SEMATECH's engineers and leverage SEMATECH's activities in advanced materials to enable better understanding of the underlying principles responsible for the deposition of III-V structures. The goal of this team will be to help guide the development of new chemical products that address a wide variety of needs for next generation semiconductor devices.

"Air Products will be cooperating with SEMATECH to accelerate the introduction of innovative products to the marketplace," says John Langan, the Global Director of Electronics Technology for Air Products. "By leveraging the capabilities of SEMATECH, we are accelerating new product development to fulfil the requests we are receiving for electronics materials from our industry partners."

"SEMATECH is pleased to welcome Air Products as a partner," adds Paul Kirsch, director of SEMATECH's FEP program. "Air Products long standing and deep expertise in specialty materials will complement our own device and process expertise. We will work together to develop practical and promising manufacturable solutions to address the emerging needs of the advanced transistor markets."

The goal of SEMATECH's FEP program is to provide novel leading-edge materials, processes, structural modules and electrical and physical characterisation methods to support the continued scaling of logic and memory applications.

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## Novel Devices

### Opto Diodes' AlGaAs 850nm LED boosts optical output

A new gallium aluminium arsenide night vision device may improve illumination tasks

Suited for night vision illumination tasks, Opto Diodes', OD-669-850 infrared LED illuminator produces uniform optical beam and has optical output from 800 to 1,250 mW (typ) and a peak emission wavelength of 850nm.

Spectral bandwidth at 50 percent is typically 40nm, and half-intensity beam angle is 120°. All surfaces on standard 2-lead, TO-66 electrically-isolated package are gold plate. Operating and storage ranges are - 40 to +100°C.

Opto Diode, a division of ITW, and a member of the ITW Photonics Group, has launched the OD-669-850 high-power AlGaAs infrared IRLED illuminator.

Ideal for night vision illumination tasks, the infrared illuminator features ultra-high optical output, from 800 (minimum) to 1250 mW (typical) and a peak emission wavelength of 850nm.

Opto Diode's new device provides a uniform optical beam. The spectral bandwidth at 50 percent is typically 40 nm, and the half-intensity beam angle is 120 degrees. All surfaces on the standard 2-lead, TO-66 electrically-isolated package are gold

plate.

The OD-669-850 IRLED illuminator's operating and storage temperatures range from - 40 degrees C to +100 degrees C with a maximum junction temperature of 100 degrees C.

Power dissipation (under absolute maximum ratings at 25 degrees C) is 6 W, with a continuous forward current of 370 mA, a peak forward current of 1A and reverse voltage at 5 V. The lead soldering temperature (at 1/16 in. from case for 10 seconds) is 260°C.

Opto Diode Corporation, is a member of the ITW Photonics Group and delivers standard and custom photodetectors, and reliable, high quality, standard and custom infrared and visible LEDs.

The company, with the recent acquisition of International Radiation Detectors, also designs and manufactures semiconductor radiation devices that detect photons in the UV range, X-rays, and other high energy particles. The domestic U. S. manufacturing plant includes a wafer fab and ensures delivery of volume quantities at competitive prices with short lead times.

Opto Diodes works in a variety of industries, including test & measurement, biotechnology, medical, entertainment, military and defence, industrial, aerospace, automotive and R&D sectors.

The ITW Photonics Group was created to bring together and build on the technical expertise of three individual companies that specialise in photonics technology and span a spectrum of wavelengths.

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### Silicon carbide market goes back to black

According to a new report from Reportlinker.com, black SiC has been the largest market and is expected to show the highest growth up to 2019

High demand for steel manufacturing and steel processing along with recycling has been driving the market for silicon carbide (SiC) in the past few years.

Silicon carbide is a key component of the semiconductor devices and growth in the electronics and semiconductor market is also a driving factor governing SiC market growth. The high precision required for manufacturing components and the low level of tolerances in the end-user market have been restraining the market at the same time.

A new market research report regarding developments in SiC is now available in Reportlinker.com's catalogue. It is called, "Silicon Carbide (Black SiC, Green SiC) Market For Automotive, Aerospace, Military, Electronics, Healthcare, Steel And Energy Applications - Global Industry Analysis, Size, Share, Growth, Trends And Forecast, 2013 - 2019".

Based on the product segments, the SiC market can be

categorised into different segments such as black SiC, green SiC and others such as coated SiC, refractory SiC, metallurgical SiC, metallurgical briquettes and SiC micro grit.

Black SiC has been the largest market and is expected to show the highest growth during the forecast period.

The major end-user segments in the SiC market are steel & energy, automotives, aerospace & aviation, military & defence, electronics & semiconductors and medical & healthcare. Of these, electronics & semiconductors, automotives and steel & energy have been the major markets while medical & healthcare is expected to show the highest growth in the near future.

## Asymmetric topological insulators accelerate computers

Researchers have progressed in their understanding of topological insulators such as the tellurides of mercury, bismuth and antimony. These materials have the potential to be the building blocks of a quantum computer



New research shows that a class of materials being eyed for the next generation of computers behaves asymmetrically at the sub-atomic level.

This could be a key step towards understanding topological insulators that may have the potential to be the building blocks of a super-fast quantum computer running on almost no electricity.

A topological insulator is a material that behaves like an insulator in its interior but whose surface contains conducting states.

The study performed by scientists from the Energy Department's National Renewable Energy Laboratory (NREL) used calculations based on first principles and co-authored the paper which appears in the current issue of *Nature Physics*.

In the paper, researchers explain how the materials act differently above and below the Dirac point and how the orbital and spin texture of topological insulator states switched exactly at the Dirac point.

The Dirac point refers to the place where two conical forms - one representing energy, the other momentum - come together at a point.

In the case of topological insulators, the orbital and spin textures of the sub-atomic particles switch precisely at the Dirac

point. The phenomenon occurs because of the relationship between electrons and their holes in a semiconductor.

This research is a key step toward understanding topological insulators like bismuth selenide (Bi<sub>2</sub>Se<sub>3</sub>), bismuth telluride (Bi<sub>2</sub>Te<sub>3</sub>), antimony telluride (Sb<sub>2</sub>Te<sub>3</sub>), and mercury telluride (HgTe) that may have the potential to be the building blocks of a quantum computer, a machine with the potential of loading the information from a data centre into the space of a laptop and processing data much faster than today's best supercomputers.

"The energy efficiency should be much better," notes NREL Scientist Jun-Wei Luo, one of the co-authors. Instead of being confined to the on-and-off switches of the binary code, a quantum computer will act more like the human brain, seeing something but imagining much more, he said. "This is entirely different technology."

Topological Insulators are of great interest currently for their potential to use their exotic properties to transmit information on electron spins with virtually no expenditure of electricity, said Luo. NREL's Xiuwen Zhang is another co-author as are scientists from University of Colorado, Rutgers University, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, and the Colorado School of Mines.

Luo and Zhang work in NREL's Centre for Inverse Design, one of 46 Energy Frontier Research Centres established around the nation by the Energy Department's Office of Science in 2009 to accelerate basic research on energy.

The finding of orbital texture switch at Dirac point implies the novel backwards spin texture - right-handed instead of left-handed, in the short-hand of physicists - comes from the coupling of spin texture to the orbital texture for the conserved quantity is total angular momentum of the wave function, not spin. The new findings, supported partly by observations taken at the Advanced Light Source at Lawrence Berkeley National Laboratory, were surprising and bolster the potential of the topological insulators.

"In this paper, we computed and measured the profile of the topological states and found that the orbital texture of topological states switches from tangential to radial across the Dirac point," Zhang says. Equally surprising, they found that phenomenon wasn't a function of a unique material, but was common to all topological insulators.

The topological insulators probably won't be practical for solar cells, because at the surface they contain no band gap. In other words, there is no gap from the material being in a conducting state and an inert state. A bandgap is essential for solar cells to free photons and have them turn into energy carrying electrons.

But these topological insulators could be very useful for other kinds of electronics-spintronics. The electrons of topological insulators will self-polarise at opposite device edges. "We usually drive the electron in a particular direction to spatially separate the spin-up and spin-down electrons, but this exotic property suggests that electrons as a group don't have to move," Luo says.

He adds, "The initial idea is we don't need any current to polarize the electron spins. We may be able to develop a spin

quantum computer and spin quantum computations.”

In theory, an entire data centre could operate with virtually no electricity. “That’s probably more in theory than reality,” Luo continues, noting that other components of the centre likely would still need electricity. “But it would be far more energy efficient.” And the steep drop in electricity would also mean a steep drop in the number of coolers and fans needed to cool things down.

Luo cautions that this is still basic science. The findings may have limited application to renewable energy, but he points out that another of NREL’s key missions is energy efficiency.

The researchers’ work is described in detail in the article, “Mapping the orbital wavefunction of the surface states in three-dimensional topological insulators,” by Yue Cao *et al* in *Nature Physics* 9, 499 - 504, (2013). DOI:10.1038/nphys2685

## LED device for capturing your signature in lights

A new sensor incorporating GaN (gallium nitride) could provide an artificial sense of touch and be used in biological imaging and MEMS systems

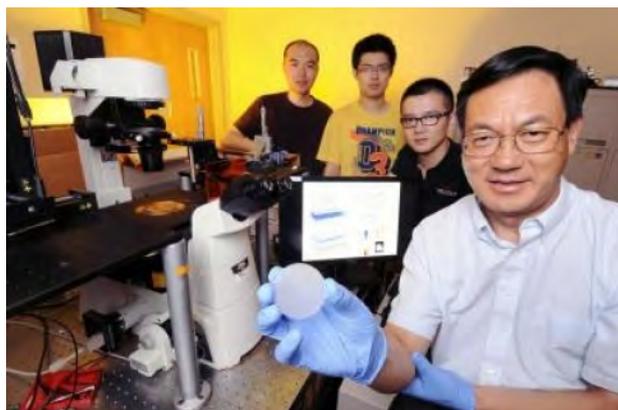
Researchers at the Georgia Institute of Technology have developed a sensor that converts mechanical pressure - from a signature or a fingerprint - directly into light signals that can be captured and processed optically.

The scientists used thousands of zinc oxide (ZnO) nanometre-scale wires to accomplish this,

The sensor device could provide an artificial sense of touch, offering sensitivity comparable to that of the human skin. Beyond collecting signatures and fingerprints, the technique could also be used in biological imaging and micro-electromechanical (MEMS) systems.

And ultimately, it could provide a new approach for human-machine interfaces.

“You can write with your pen and the sensor will optically detect what you write at high resolution and with a very fast response rate,” says Zhong Lin Wang, Regents’ professor and Hightower Chair in the School of Materials Science and Engineering at Georgia Tech. “This is a new principle for imaging force that uses parallel detection and avoids many of the complications of existing pressure sensors.”



*Zhong Lin Wang holding the sensor device along with his research team in the background*

Individual ZnO nanowires that are part of the device operate as tiny LEDs when placed under strain from the mechanical pressure. They allow the device to provide detailed information about the amount of pressure being applied.

Known as piezo-phototronics, the technology - described by Wang in 2009 - provides a new way to capture information about pressure applied at very high resolution: up to 6,300 dots per inch.

Piezoelectric materials generate a charge polarisation when they are placed under strain. The piezo-phototronic devices rely on that physical principle to tune and control the charge transport and recombination by the polarisation charges present at the ends of individual nanowires.

Grown on top of a GaN film, the nanowires create pixelled light emitters whose output varies with the pressure, creating an electroluminescent signal that can be integrated with on-chip photonics for data transmission, processing and recording.

“When you have a zinc oxide nanowire under strain, you create a piezoelectric charge at both ends which forms a piezoelectric potential,” Wang explains. “The presence of the potential distorts the band structure in the wire, causing electrons to remain in the *p-n* junction longer and enhancing the efficiency of the LED.”

The efficiency increase in the LED is proportional to the strain created.

Differences in the amount of strain applied translate to differences in light emitted from the root where the nanowires contact the GaN film.

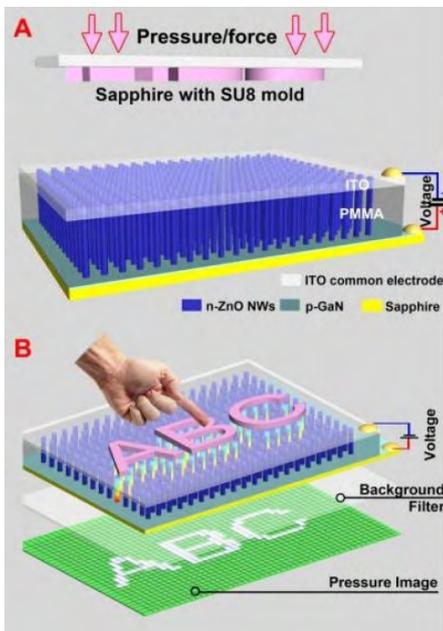
To fabricate the devices, a low-temperature chemical growth technique is used to create a patterned array of ZnO nanowires on a GaN thin film substrate with the *c*-axis pointing upward.

The interfaces between the nanowires and the GaN film form the bottom surfaces of the nanowires. After infiltrating the space between nanowires with a PMMA thermoplastic, oxygen plasma is used to etch away the PMMA enough to expose the tops of the zinc oxide nanowires.

A nickel-gold electrode is then used to form ohmic contact with the bottom gallium-nitride film, and a transparent indium-tin

oxide (ITO) film is deposited on the top of the array to serve as a common electrode.

When pressure is applied to the device through handwriting, nanowires are compressed along their axial directions, creating a negative piezo-potential, while uncompressed nanowires have no potential.



*Schematic showing a device for imaging pressure distribution by the piezo-phototronic effect. The illustration shows a nanowire-LED based pressure sensor array before (a) and after (b) applying a compressive strain. A convex character pattern, such as “ABC,” molded on a sapphire substrate, is used to apply the pressure pattern on the top of the indium-tin oxide (ITO) electrode.*

The researchers have pressed letters into the top of the device, which produces a corresponding light output from the bottom of the device. This output - which can all be read at the same time - can be processed and transmitted.

The ability to see all of the emitters simultaneously allows the device to provide a quick response. “The response time is fast, and you can read a million pixels in a microsecond,” says Wang. “When the light emission is created, it can be detected immediately with the optical fibre.”

The nanowires stop emitting light when the pressure is relieved. Switching from one mode to the other takes 90 milliseconds or less, Wang says.

The researchers studied the stability and reproducibility of the sensor array by examining the light emitting intensity of the individual pixels under strain for 25 repetitive on-off cycles. They found that the output fluctuation was approximately 5 percent, much smaller than the overall level of the signal. The robustness of more than 20,000 pixels was studied.

A spatial resolution of 2.7  $\mu\text{m}$  was recorded from the device samples tested so far. Wang believes the resolution could be improved by reducing the diameter of the nanowires - allowing more nanowires to be grown - and by using a high-temperature fabrication process.

The researchers’ study is described in detail in the paper, “High-resolution electroluminescent imaging of pressure distribution using a piezoelectric nanowire LED array,” by Caofeng Pan *et al* in *Nature Photonics* (2013), published online on 11th August 2013. [DOI:10.1038/nphoton.2013.191](https://doi.org/10.1038/nphoton.2013.191)

This research was sponsored by the U.S. Department of Energy’s Office of Basic Energy Sciences, the National Science Foundation, and the Knowledge Innovation Program of the Chinese Academy of Sciences.

## Latest GaN transistor developments to be presented at summit

Characterisations and performance of D-Mode GaN HEMT transistor used in a cascode configuration revealed

A team of experts on gallium nitride technologies from GaN Systems Inc, a developer of gallium nitride power switching semiconductors, is presenting a major conference paper at the 224th ECS Electrochemical Energy Summit (San Francisco, California October 27 – November 1).

“Characterisations and performance of D-Mode GaN HEMT transistor used in a cascode configuration” authored by Tom MacElwee, John Roberts, Hughes Lafontaine, I. Scott, Greg Klowak, and Lyubov Yushyna will be presented during the GaN and SiC Power Technologies symposium.

GaN Systems has developed proprietary gallium nitride high power transistors for clean technology power conversion applications, enabling superior switching efficiencies over current silicon based solutions. These devices offer substantial benefits to switching power supply designs, inverters, hybrid and electric vehicles, battery management and power factor correction.

The paper reports on D-mode HEMT device performance when configured in cascode mode, including basic parameters of the device and its integration into a PQFN package. A detailed discussion demonstrates the 500V 3.3A switching characteristics of the cascode and proves excellent switching performance with measured voltage slew rates as large as 70 V/ns.

The GaN D-mode HEMT device developed in the work covered by the paper was fabricated using a conventional RF GaN process flow on 3” 4H Si-SiC starting substrate. The SiC substrate should allow for excellent thermal performance and high voltage operation of the switching device due to the semi-insulating nature of the SiC substrate.

## Measuring light amplification with polymers for next generation lasers

Using picosecond laser pulses diminishes thermal degradation to get a more accurate measurement of a material's optical gain; this is vital for laser development

Researchers from North Carolina State University have developed more accurate measurements of how efficiently a polymer called MEH-PPV amplifies light.

This should advance efforts to develop a new generation of lasers and photonic devices.

"By improving our understanding of this material, we get closer to the longstanding industry goal of using MEH-PPV to create cheaper, more flexible photonic technologies," says Lewis Reynolds, a teaching associate professor of materials science and engineering at NC State and senior author of a paper describing the research.

MEH-PPV is a low-cost polymer that can be integrated with silicon chips, and researchers have long sought to use the material to convert electricity into laser light for use in photonic devices such as optical amplifiers and chemical sensors.

At issue is MEH-PPV's 'optical gain,' which is a way of measuring how effectively a material can amplify light. Understanding a material's optical gain is essential to laser development.

Researchers determine the optical gain of MEH-PPV by pulsing laser light into the material and measuring the light that the MEH-PPV then produces in response.

The NC State team used extremely short laser pulses – 10 laser pulses per second, with each pulse lasting only 25 picoseconds (25 trillionths of a second).

Previous efforts to determine MEH-PPV's optical gain produced inaccurate results because they used laser pulses that lasted one thousand times longer.

"The longer pulses caused thermal degradation in the MEH-PPV, meaning they led to structural and molecular changes in the material," says Zach Lampert, a former Ph.D. student at NC State and lead author of the paper. "Essentially, the longer laser pulses were heating the polymer. We were able to minimise these thermal degradation effects, and get a more accurate measurement, by using the picosecond pulses."

"Our new approach is fairly straightforward and can be easily implemented elsewhere," Reynolds says.

This work is described in detail in the paper, "Intrinsic optical gain in thin films of a conjugated polymer under picosecond excitation," by Zach E. Lampert *et al* in *Applied Physics Letters*, 103, 033303 (2013). DOI: 10.1063/1.4816040

## Graded InGaN enlightens us on molecular interactions

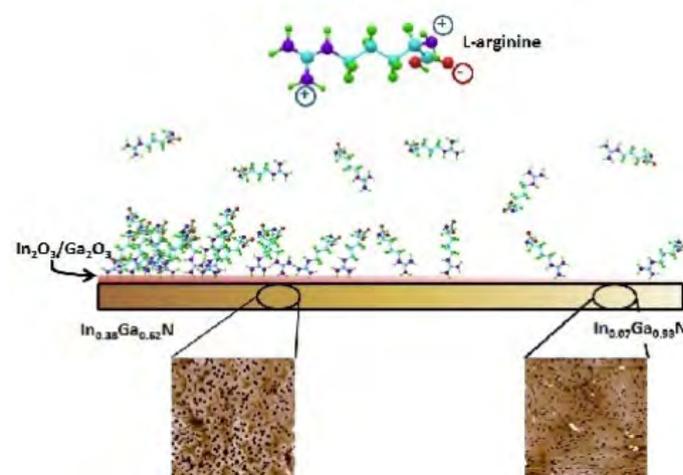
By varying the compositional ratio of indium to gallium in InGaN, the band gap of the material can be tuned, allowing for device optimisation in the study of biological interactions

Scientists use 'gradients' to understand how molecules interact in biological systems.

A gradient is a material that has a specific molecule on its surface, with the concentration of the molecule sloping from a high concentration on one end to a low concentration at the other end. The gradient is used not only to determine whether other molecules interact with the molecules on the gradient, but to determine the threshold level at which any interactions take place.

Now, researchers from North Carolina State University (NC State) have developed a new technique for creating biomolecular gradients that is both simpler than existing techniques and that creates additional surface characteristics that allow scientists to monitor other aspects of molecular behaviour.

And the gradient material they have used to investigate this is indium gallium nitride (InGaN).



The new technique begins with a substrate made of InGaN. Negatively-charged oxides form on the surface, which then bind to the amino acid L-arginine. (Image credit: Lauren Bain)

The new technique begins by creating an InGaN substrate. The substrate itself is a gradient, sloping from an indium-rich end to a gallium-rich end. The indium-rich end is more conducive to the formation of oxides. When exposed to humidity, negatively charged indium and gallium oxides form on the surface of the substrate.

The researchers then put the substrate into a solution that contains an amino acid called L-arginine, which is positively charged at biologically relevant pH levels, such as those found in the human body.

"The L-arginine binds to the negatively charged oxides on the surface of the substrate," says Lauren Bain, a Ph.D. student at

NC State who is lead author of a paper on the work. "Because there is more oxide accumulation at the indium-rich end, there is a higher concentration of L-arginine at that end, and the concentration gradually declines along the surface of the substrate as you move toward the gallium-rich end."

"We studied L-arginine because it is small, but relevant. Because it is small, we could easily assess what was happening during our study," Bain says. "But because it is a building block for proteins, we can build on this work to study full peptides and proteins, such as ligands that bind to cell receptors."

"This technique also creates changes in the topography of the InGaN's surface, based on the different crystalline structures within the material as it shifts from being indium-rich to being gallium-rich," explains Albena Ivanisevic, an associate professor at NC State and senior author of the paper. "This allows us to assess topographical differences in molecular adhesion, which is important, given the variety of topographies found in biological systems."

A paper describing this work "Biomolecular Gradients via Semiconductor Gradients: Characterization of Amino Acid Adsorption to In<sub>x</sub>Ga<sub>1-x</sub>N Surfaces." by Lauren E. Bain *et al* was published online in July 2013, *ACS Applied Materials and Interfaces*. DOI: 10.1021/am4015555

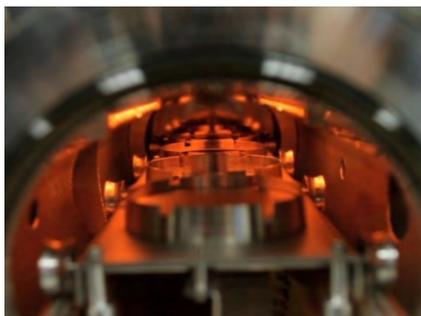
The substrate development for this project was proposed by Tania Paskova, a professor of electrical and computer engineering at NC State. The actual substrate was prepared in the lab of NC State professor Salah Bedair.

## MicroPower to use Texas State MBE reactor

The firm will use the reactor to manufacture lead telluride IV-VI compound semiconductor chips

Last week, Texas State University and MicroPower Global established an agreement granting the company exclusive use of a Molecular Beam Epitaxy (MBE) system.

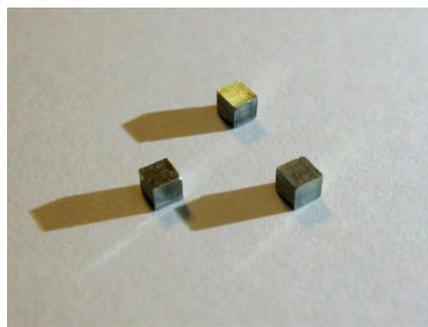
Use of the MBE reactor will enable the company to commence production of its advanced semiconductor chips, which convert heat directly to electricity three times more efficiently than ever before.



MBE reactor

The MBE tool, a V100 system which has two operating chambers, will continue to be owned by Texas State, with MicroPower paying a monthly fee once operational. Total production capacity using both chambers would be approximately 1.3 million cm<sup>2</sup> worth of MicroPower chips annually, double the initial capacity that the company had projected.

The chips are based on lead telluride, a IV-VI compound semiconductor.



MicroPower single chips

"We are pleased to continue our relationship with MicroPower as the company enters an exciting new phase," says Bill Covington, chief research officer for Texas State. "The level of commercial experience on offer to students is important to us, and several of our graduates have already become full-time MicroPower employees - as the company grows we very much hope this trend continues."

The MBE system will be moved by the end of the summer, from its present location on campus to the company's facility at Texas State's Science, Technology and Advanced Research (STAR) Park. Texas State professors Tom Myers and Ravi Droopad will oversee the relocation.

MicroPower has also agreed terms with the university for the operation of a new research chamber, due to be installed this month on the development MBE system in the Roy F. Mitte science building on campus. Currently used for the growth of "barriers" on MicroPower chips, this will accelerate development capabilities.

"These agreements provide us with a great opportunity to accelerate our development, and in the near future to move seamlessly into production with much less capital expenditure than is typically associated with the transition to manufacturing," says Max Lewinsohn, MicroPower's chairman.

"There is significant demand for our energy conversion technology. Our key challenge at this stage is to secure the necessary funding to enable us to ramp up our operations and be able to cater for the high level of interest we are experiencing," explains Lewinsohn.

As well as pursuing traditional forms of financing, MicroPower has also launched a crowd funding campaign on Kickstarter, to give members of the public, who are interested in energy savings and reducing emissions, the opportunity to support the venture. The project launched on July 15th, can be viewed at <http://www.kickstarter.com/projects/1005823715/micropower-chips-energy-savings-and-energy-efficie>

MicroPower Global is a private company which is developing the next generation of thermoelectric devices for use in the areas of energy conservation, energy harvesting and refrigeration. The new MicroPower semiconductor chips can efficiently and cost-effectively convert heat, including waste heat, directly into electricity, leading to significant energy savings in a number of industrial and consumer applications.

The ability to harvest heat at temperatures ranging from 200°C to 600°C will make MicroPower chips the new thermoelectric standard for waste heat recovery. The current thermoelectric market is relatively small at approximately \$300 million annually but MicroPower will be able to open up already identified new global markets worth many billions annually. Its technology has been patented internationally and independently verified.

Texas State University's STAR Park



The Science, Technology and Advanced Research (STAR) Park is a 38 acre site which hosts Texas State's first building, STAR One, dedicated to the university's research and commercialisation efforts. STAR One, a 20,000-square-foot facility, serves as a technology accelerator for start-up and early-stage businesses, and provides tenants access to secure wet labs, clean space, conference room, and office space.

The Incubator Program is designed to foster the development of new commercial ventures related to Texas State technologies in applied research. This building houses 'spin-offs' from research conducted and intellectual property generated by university faculty, and 'spin-ins' from companies that want to strategically work with the university.

The overall goal of the Incubator Program is to provide space and infrastructure to expedite research and commercial development of promising technologies in the context of viable, well managed, start-up companies.

By bringing together a critical mass of university and private sector specialists, the Incubator Program becomes a magnet for scientific expertise, novel problem solving, and successful commercial ventures.

The Incubator Program is particularly interested in supporting companies which have established research relationships with Texas State, or which have an interest in, and potential for, initiating such relationships.

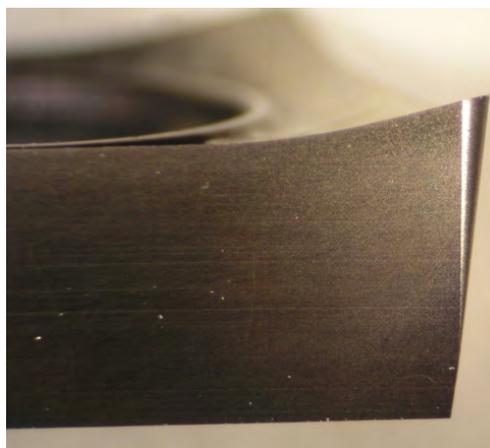
## Picodeon's diamond-like coatings shine

The company's US PLD technology delivers improved reliability in applications where through-thickness defects may cause delamination of thin films and serious damage to components

Finnish coating technology specialist Picodeon has developed a technique for depositing diamond-like films onto a wide range of substrates using its patented ultra-short pulsed laser deposition (US PLD) technology.

This technology can be used in the manufacturing of compound semiconductor devices.

Diamond-like coatings create superhard surfaces (greater than 40 Gpa) with a low coefficient of friction and excellent coating adhesion.



Picodeon's cutting tool coating

The US PLD deposition process uses a high laser pulse repetition rate and fan-shaped plasma bloom which enables high production rates and makes feasible the industrial coating of large surfaces at film thicknesses down to the nanoscale.

Applications for diamond-like coatings range from machine tooling components through to wear components for medical, optical and sensor applications.

"Any components that need to have the highest possible hardness or wear-resistance can achieve improved lifecycles, greater heat and pressure resistance and/or improved performance with diamond-like coatings," says Picodeon CEO Marko Mylläri. "Our US PLD deposition process can deliver the exact surface defined by our customers' engineers because of the high level of tuning enabled by our process."

Picodeon's US PLD deposition is a cold ablation technology which works across a vast range of coating materials and substrates. By adjusting processing parameters, the structure and properties of the coating can be tailored to the requirements of the application, even for nanostructure-scale surface coatings.

The US PLD technology delivers very high coating integrity

without pinholes, giving improved reliability in applications where through-thickness defects may cause delamination of thin films and serious damage to components.

In addition to diamond-like coatings, US PLD technology, under the tradename Coldab, enables the deposition of carbon nitrides, carbon nitride composites containing PTFE or boron nitride (BN) as well as a wide range of other borides, oxides and precious metal thin films.

Picodeon says its Coldab US PLD technology enables high production rates and coating qualities and opens new possibilities and applications for pulsed laser deposition coatings.

In selected areas it may even enable the development of exclusive coating methods.

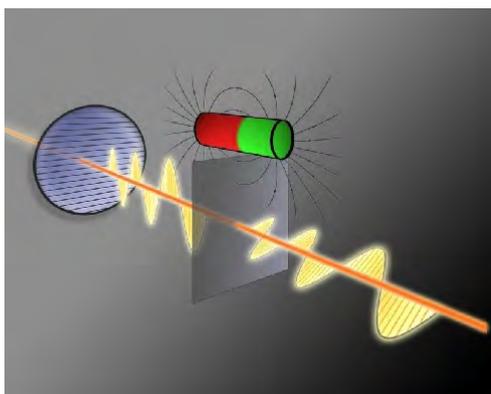
## Light can power transistors

Passing light through platelets of a special material incorporating cadmium telluride and silicon nitride and applying a magnetic field can rotate the polarisation direction of light

Researchers at TU Vienna have managed to turn the oscillation direction of beams of light.

They applied an electrical current to a special material, which comprises CdTe, HgTe, Si<sub>3</sub>N<sub>4</sub> and RuO<sub>2</sub>. Using this structure, a transistor was built that functions with light instead of electrical current.

Light can oscillate in different directions, as we can see in the 3D cinema: Each lens of the glasses only allows light of a particular oscillation direction to pass through. However, changing the polarisation direction of light without a large part of it being lost is difficult.



*The oscillation direction of a light wave is changed as it passes through a thin layer of mercury telluride*

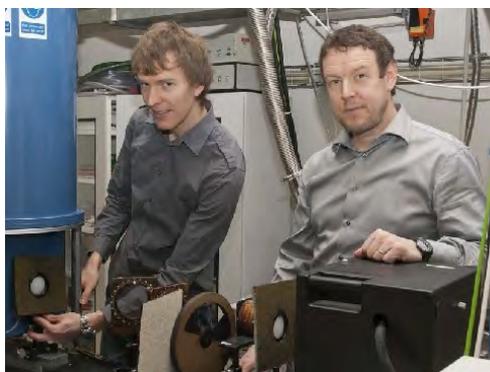
TU Vienna has now managed this feat, using a type of light - terahertz radiation - that is of particular technological importance. An electrical field applied to an ultra-thin layer of material can turn the polarisation of the beam as required. This produces an efficient optical transistor for light that can be miniaturised and used to build optical computers.

Rotated light - the Faraday effect

Certain materials can rotate the polarisation direction of light if a magnetic field is applied to them. This is known as the Faraday effect. However, normally, this effect is minutely small.

Two years ago, Andrei Pimenov and his team at the Institute of Solid State Physics of TU Vienna, together with a research group from the University of Würzburg, managed to achieve a massive Faraday effect as they passed light through special mercury telluride platelets and applied a magnetic field.

At that time, the effect could only be controlled by an external magnetic coil, which has severe technological disadvantages. "If electro-magnets are used to control the effect, very large currents are required", explains Andrei Pimenov. Now, the turning of terahertz radiation simply by the application of an electrical potential of less than one volt has been achieved. This makes the system much simpler and faster.



*Alexey Shuvaev and Andrei Pimenov*

It is still a magnetic field that is responsible for the fact that the polarisation is rotated, however, it is no longer the strength of the magnetic field that determines the strength of the effect, but the amount of electrons involved in the process, and this amount can be regulated simply by electrical potential. Hence only a permanent magnet and a voltage source suffice, which is technically comparatively easy to manage.

Terahertz radiation

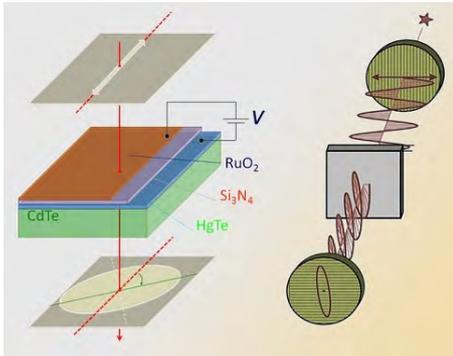
The light used for the experiments is not visible: it is terahertz radiation with a wavelength of the order of one millimetre. "The frequency of this radiation equates to the clock frequency that the next but one generation of computers may perhaps achieve", explains Pimenov.

"The components of today's computers, in which information is passed only in the form of electrical currents, cannot be fundamentally improved. To replace these currents with light would open up a range of new opportunities." It is not only in hypothetical new computers that it's important to be able to control beams of radiation precisely with the newly developed light turning mechanism: terahertz radiation is used today for many purposes, for example for imaging methods in airport security technology.

Optical transistors

If light is passed through a polarisation filter, dependent on the polarisation direction, it is either allowed to pass through or is blocked. The rotation of the beam of light (and thus the electrical potential applied) therefore determines whether a

light signal is sent or blocked. “This is the very principle of a transistor”, explains Pimenov.



*Left: The light beam (from above) is sent through a special material to which an electromagnetic potential is applied. That way, the polarisation direction can be rotated*

“The application of an external voltage determines whether current flows or not, and in our case, the voltage determines whether the light arrives or not.”

The new invention is therefore the optical equivalent of an electrical transistor.