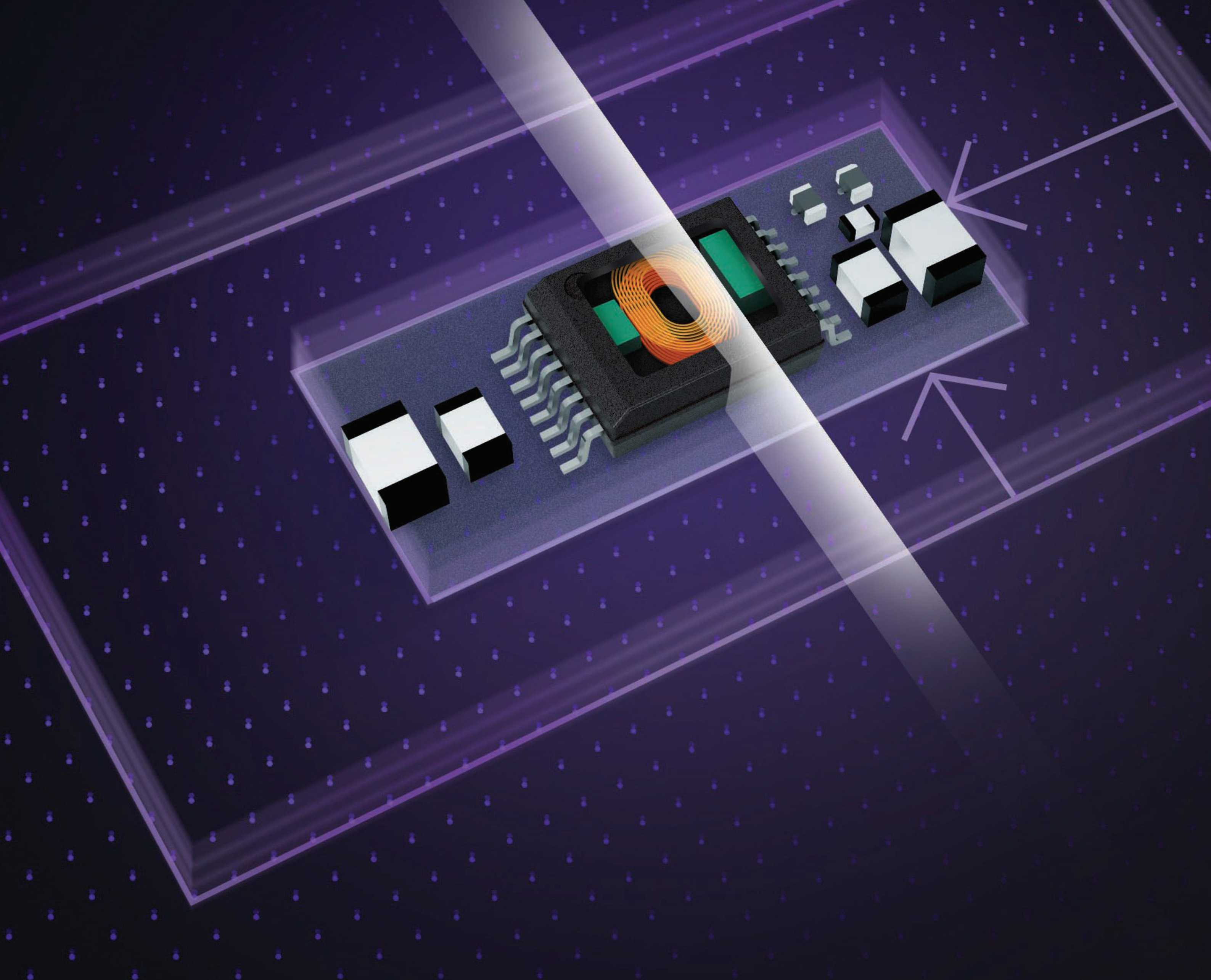
PE POWER ELECTRONICS

ISSUE II 2026

AN ANGEL BUSINESS COMMUNICATIONS PUBLICATION

POWERELECTRONICSMAGAZINE.NET

ISOSHIELD TECHNOLOGY HELPS CUT SOLUTION SIZE



VIEWPOINT

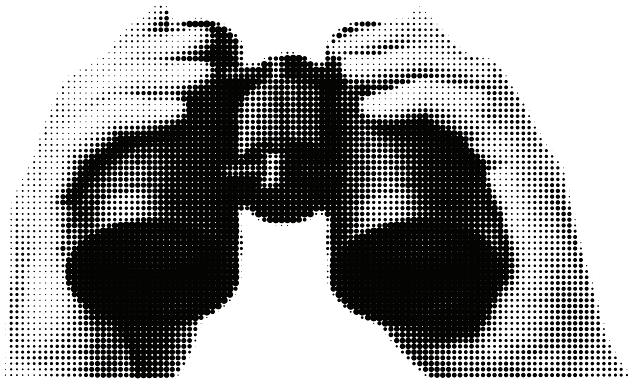
BY PHIL ALSOP
EDITOR

Fighting fuels the renewables debate

Who would have guessed it – a war in the Middle East that seems to be without an obvious ending? If only there was someone who had read their history books to understand just how intractable are conflicts in this region of the world. Neither the ‘might’ of the British Empire, nor the modern day might of the Soviet Union was able to declare a long-term military success, and that’s before we get to gulf wars, one more Afghanistan invasion...and now much of the world is held to ransom when it comes to the price of oil thanks to the latest military action with who knows what objective(s).

As a student of history, I am less than surprised at the ongoing fallout from the current Israel/US campaign. However, just in case anyone thinks I am in danger of outgrowing the size of my boots, I can honestly say that, until I was talking to the folks from TechInsights for one of our video interviews, it had not occurred to me that, as the price of oil and gas heads into the stratosphere, the futures of both renewable energy and electric vehicles become correspondingly positive. Yes, there’s the folks who seem to think that drilling for more oil and gas will somehow solve the problem, but the reality is that many countries are now realising, just as they did when Russia invaded Ukraine, that energy self-sufficiency is a pretty big deal right now. And if you don’t have (easy and inexpensive) access to reliable, plentiful supplies of oil and gas, then some combination of renewables and nuclear energy, is the way forward.

I’ll resist dwelling on the irony of the ‘drill baby drill’ lobby having created the circumstances that have led to fossil fuel availability and prices becoming dangerously volatile at the present time and instead concentrate on the huge shot



in the arm this has given to the renewables sector and the electric vehicle market. No guarantee that this boost will last, of course, but it does seem that both individual citizens and the nations to which they belong are beginning to understand that, if oil and gas have been struck of the ‘death and taxes’ certainty list, then it’s time to invest in wind, solar, tidal, green hydrogen, nuclear and electric vehicles.

Add in the fact that the booming data centre market is waking up to the opportunity/necessity of microgrids, on-site energy generation, battery storage and district heating powered by rejected heat from their facilities and it could just be that the power electronics sector is about to enjoy some serious growth over the coming months and years (and we musn’t forget the current defence and aerospace investment increase, of course!).

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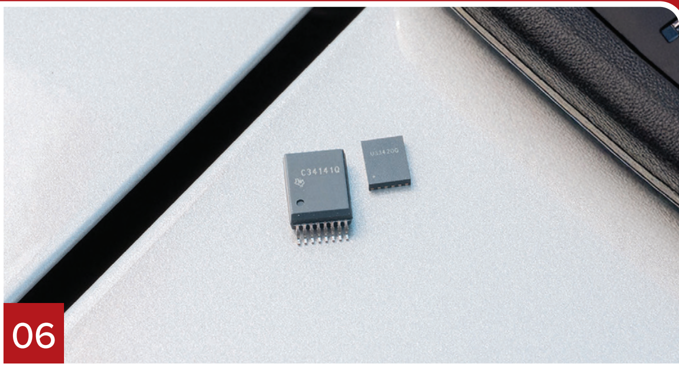

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Power Electronics International Magazine is published six times a year on a controlled circulation basis. Non-qualifying individuals can subscribe at: £105.00/e158 pa (UK & Europe), £138.00 pa (air mail), $198 pa (USA). Cover price £4.50. All information herein is believed to be correct at time of going to press. The publisher does not accept responsibility for any errors and omissions. The views expressed in this publication are not necessarily those of the publisher.

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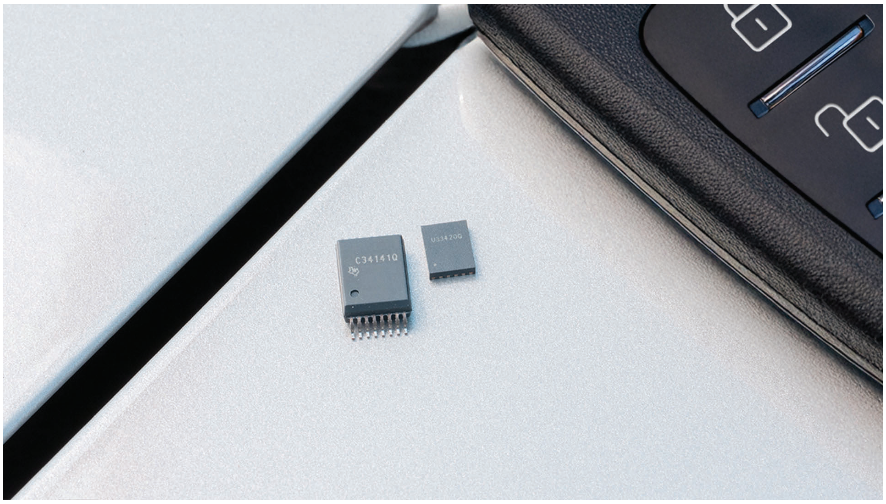
Angel BUSINESS COMMUNICATIONS

TI unveils high-performance isolated power modules

New power modules with proprietary IsoShield™ technology deliver industry-leading power density.

Texas Instruments (TI) has unveiled new isolated power modules, helping enable increased power density, efficiency and safety in applications ranging from data centers to electric vehicles (EVs). The UCC34141-Q1 and UCC33420 isolated power modules leverage TI's IsoShield technology, a proprietary multichip packaging solution that achieves up to three times higher power density than discrete solutions in isolated power designs. TI is showcasing these innovations at the 2026 Applied Power Electronics Conference (APEC), March 23-26 in San Antonio, Texas.



"Packaging innovation is revolutionizing the power industry, with power modules at the forefront of this transformation," said Kannan Soundarapandian, vice president and general manager, High Voltage Products at TI. "TI's new IsoShield technology delivers what power engineers need most: smaller solutions with improved efficiency and reliability and a faster time to market. It is the latest example of TI's continued commitment to advance power semiconductor technology to help solve today's engineering challenges."

Redefining power density with TI's packaging technology

Historically, power designers have turned to power modules to conserve valuable board space and simplify the design process. As chip sizes reach their physical limits and miniaturization increases in importance, advancements in packaging technology are enabling further performance and efficiency gains.

TI's new IsoShield technology copackages a high-performance planar transformer and an isolated power stage, offering functional, basic and reinforced isolation capabilities. It enables a distributed power architecture, helping manufacturers meet functional safety requirements by avoiding single-point failures. The result is a packaging advancement that shrinks solution size by as much as 70% while delivering up to 2W of power, enabling compact, high-performance and reliable designs for automotive, industrial and data center applications that require reinforced isolation.

Advancing data center and EV performance through power innovations

Power density innovations are nowhere more critical than in today's evolving data center and automotive designs. Meeting design requirements in those applications starts with advanced analog semiconductors – the components that enable smarter, more efficient operations. As global data centers continue to scale to meet exponentially growing demand, high-performance power modules must pack more power in smaller spaces. With TI's IsoShield packaging technology, designers can achieve higher power density in compact form factors, ensuring reliable and safe operation of the world's digital infrastructure.

Similarly, the increased power density enabled by IsoShield technology helps engineers design lighter and more efficient EVs that significantly extend range and enhance performance.

TI's new IsoShield technology copackages a high-performance planar transformer and an isolated power stage, offering functional, basic and reinforced isolation capabilities. It enables a distributed power architecture, helping manufacturers meet functional safety requirements by avoiding single-point failures.

Renesas unveils bidirectional 650V GaN switch

New power modules with proprietary IsoShield™ technology deliver industry-leading power density.

Switch using d-mode GaN technology is capable of blocking both positive and negative currents in a single device

Renesas Electronics has introduced what is claims is the industry's first bidirectional switch using depletion-mode (d-mode) GaN technology, capable of blocking both positive and negative currents in a single device with DC blocking.

Targeting single-stage solar microinverters, AI data centres and onboard electric vehicle chargers, the high-voltage TP65B110HRU is claimed to dramatically simplifies power converter designs and replaces conventional back-to-back FET switches with a single low-loss, fast-switching, easy-to-drive device.

Today's high-power conversion designs use unidirectional silicon or SiC switches, which block current in only one direction when in the off state. As a result, power conversion must be divided into stages with multiple switched bridge circuits. For example, a typical solar microinverter uses a four-switch full bridge to convert from DC to DC for the first stage, followed by a second stage to produce the final AC output to the grid.

Even as the electronics industry moves toward more efficient single-stage converters, engineers must work around inherent switching limitations. Many of today's single-stage designs use conventional unidirectional switches back-to-back, resulting in a four-fold increase in switch count and reduced efficiency.

Bidirectional GaN changes this landscape. By integrating bidirectional blocking functionality on a single GaN product, power conversion can be achieved in a single stage using fewer switching devices. Renesas says that a typical solar microinverter, for example, will require only two high-voltage Renesas SuperGaN bidirectional devices, eliminating the intermediary DC-link capacitors and cutting the switch count by half. In addition, GaN products switch fast, with low stored charge, enabling higher switching frequencies and higher power density. In a real-world single-stage solar microinverter implementation, the company's new GaN architecture demonstrated higher than 97.5 percent power efficiency with the elimination of back-to-back connections and slow silicon switches.

Renesas 650V SuperGaN devices are based on a proprietary normally-off technology described as simple to drive and highly robust. The TP65B110HRU combines a high-voltage bidirectional d-mode GaN chip co-packaged with two low-voltage silicon MOSFETs with high threshold voltage (3V) high gate margin (±20V) and built-in body diodes for efficient reverse conduction.

Compared with enhancement mode (e-mode) bidirectional GaN devices, the Renesas bidirectional GaN switch offers compatibility with standard gate drivers that require no negative gate bias. This is said to translate to a simpler, lower-cost gate loop design and fast, stable switching in both soft and hard switching operation without a performance penalty. Power conversion topologies that require hard switching, such as the Vienna-style rectifier, can benefit from its high dv/dt capability of >100 V/ns, with minimum ringing and short delays during on/off transitions. The Renesas GaN device enables true bidirectional switching with high robustness, high performance and ease of use.

"Extending our SuperGaN technology to the bidirectional GaN platform marks a major shift in power conversion design norms," said Rohan Samsi, VP, GaN Business Division at Renesas. "Customers can now achieve higher efficiency with fewer switching components, smaller PCB area and lower system cost. At the same time, they can accelerate design by leveraging Renesas' system-level integration with gate drivers, controllers and power management ICs."

Diamond power switch shatters performance records

Illinois researchers demo switch that can handle 17.1A of current at 1kV

The breakthrough, 'Ultrafast Vertical Photoconductive Intrinsic Diamond Switch with High Current (17.1 A at 1 kV)', published in Applied Physics Letters, marks a critical milestone in developing the ultrafast, high-efficiency components needed for a resilient global power grid and the next generation of electric vehicles.

Researchers at the University of Illinois Urbana-Champaign in the US have demonstrated a diamond-based power switch that shatters previous performance records, capable of handling 17.1A of current at 1kV.

The breakthrough, 'Ultrafast Vertical Photoconductive Intrinsic Diamond Switch with High Current (17.1 A at 1 kV)', published in Applied Physics Letters, marks a critical milestone in developing the ultrafast, high-efficiency components needed for a resilient global power grid and the next generation of electric vehicles.

Diamond has long been considered the ultimate semiconductor because it can withstand extreme electrical stress, move electricity at unmatched speeds, and dissipate heat far better than any other material. However, actually building a practical diamond switch has been a decades-long challenge.

"Diamond is an incredible material, but it is notoriously difficult to control using traditional methods," says Can Bayram, who led the research at the Nick Holonyak Jr. Micro and Nanotechnology Laboratory. "Most electronics rely on doping—adding impurities to a crystal to make it conduct. In diamond, that process is so difficult it often compromises the material's best qualities."

The Illinois team took a different, more elegant path: they used light.

Instead of relying on chemical impurities, the team developed a photoconductive switch that remains an insulator until it is struck by a specific wavelength of deep-ultraviolet light. When illuminated, the diamond instantly becomes a high-performance conductor.

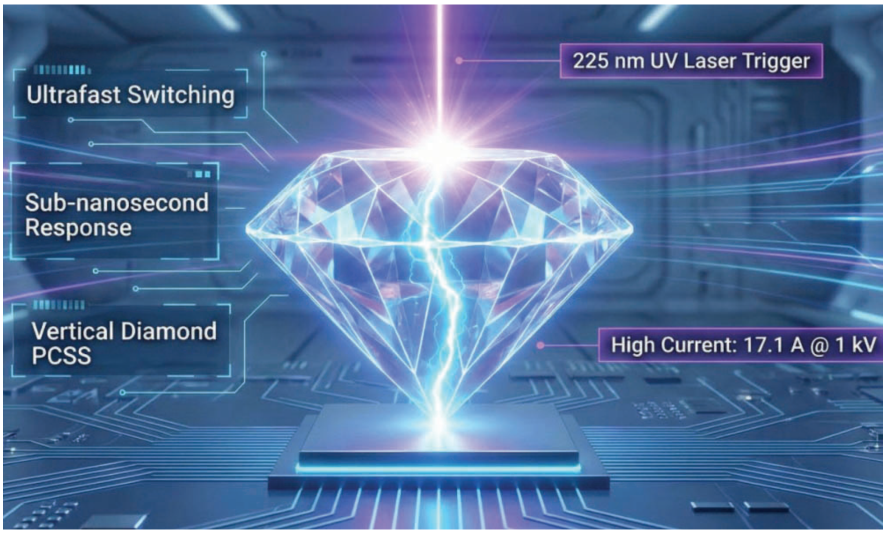
Crucially, while previous diamond switches struggled with designs that carried electricity mainly along the surface—where the material is most likely to fail—the Illinois researchers created a 'vertical' architecture. This design drives current through the protected interior, or bulk of the diamond crystal.

"By using a specific ultraviolet wavelength — the 'matched-absorption' window — we can trigger the entire volume of the diamond simultaneously," Bayram explains. "This allowed us to achieve the lowest on-resistance ever recorded for a high-voltage diamond switch, making it significantly more efficient than previous designs."

The switch's speed is equally impressive, capable of turning off in just 25 nanoseconds (billionths of a second). This speed is vital for protecting modern power grids from sudden surges and short circuits, particularly in high-voltage direct-current (HVDC) networks used to transport wind and solar power over long distances.

"This isn't just a lab record; it's a proof of concept for the infrastructure of the future," says Bayram. "We are building the fundamental building blocks for a resilient, low-carbon energy economy."

This research was supported by the Advanced Research Projects Agency-Energy (ARPA-E)



Nagoya Uni team grows Ga_2O_3 on silicon

Japanese researchera to announce six advances to bringing Ga_2O_3 devices closer to manufacturing

Researchers at Nagoya University in Japan, in collaboration with university spinout NU-Rei, are presenting six advances in the growth of Ga_2O_3.

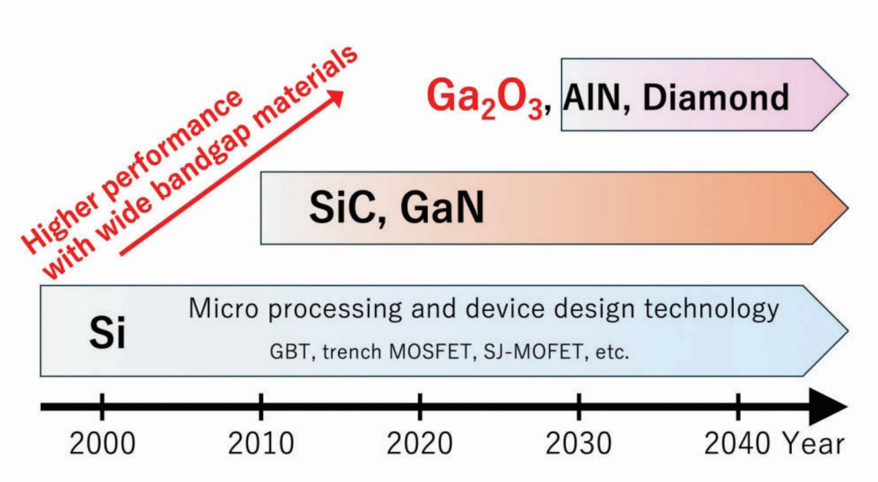
The results are being presented at the spring meeting of the Japan Society of Applied Physics (March 15-18, 2026) by a research group from Nagoya University's Centre for Low-temperature Plasma Sciences.

Together, the six results advance the full process stack needed to bring Ga_2O_3 devices closer to manufacturing, and include a world-first heteroepitaxial growth—growing a crystalline layer of Ga_2O_3 on a structurally different substrate — on silicon wafers, a step that could significantly reduce device cost and improve heat dissipation, accorrding to the team.

These results build on a related advance in Ga_2O_3 p-type control reported by Nagoya University in September 2025, and are being commercialised through the company NU-Rei, with the goal of supporting industrial adoption of Ga_2O_3 growth processes for high-voltage, high-frequency, and silicon-integrated device applications.

Central to the work is a newly developed High-Density Oxygen Radical Source (HD-ORS), which doubles the density of atomic oxygen available during thin-film growth compared to conventional sources.

The higher oxygen density strongly promotes the chemical reaction needed to convert gallium suboxide into the desired Ga_2O_3, while suppressing the volatile by-product that would otherwise escape the surface and limit how fast the film can grow. The source is compatible with both MBE and PVD.



Advances across the full process stack

HD-ORS development The new oxygen source uses an ozone-oxygen mixed gas to double atomic oxygen density, making it compatible with both MBE and PVD and establishing a high-efficiency foundation for all subsequent growth work.

High-speed MBE homoepitaxial growth Using HD-ORS, the team achieves homoepitaxial growth of β-Ga_2O_3 on tin-doped Ga_2O_3 substrates at 300°C and a rate of 1µm per hour. Growth on the (001) plane was confirmed using X-ray diffraction (XRD) and reflection high energy diffraction (RHEED). The low growth temperature reduces thermal stress and broadens compatibility with other device components.

High-speed PVD homoepitaxial growth Applying HD-ORS to PVD achieves stable (001)-oriented homoepitaxial films at rates exceeding 1 µm per hour, approaching ten times the rate of conventional MBE and pointing toward industrial-scale production.

Silicon substrate preitreatment For growth on silicon, the team establishes a pretreatment combining wet chemical cleaning with controlled adsorption of a single atomic layer of gallium onto the silicon surface. This prevents re-oxidation during heating and proves essential for subsequent heteroepitaxial growth.

World-first heteroepitaxial growth on silicon The team achieves heteroepitaxial growth of Ga_2O_3 on two-inch Si(100) wafers, with heat treatment confirming single-crystal formation. Silicon substrates are far less expensive than native Ga_2O_3 substrates, and silicon's superior thermal conductivity addresses one of gallium oxide's known material limitations.

p-type formation via NiO diffusion layers Gallium-based semiconductors are difficult to dope into p-type form, which is required to build the pn junctions at the heart of power devices. Using nickel ion implantation followed by annealing, the team forms a graded nickel oxide (NiO) diffusion layer with p-type characteristics, confirming pn-junction behaviour on both Ga_2O_3 and GaN substrates, with twice the current density of a standard nickel Schottky diode.

Isolated power modules with IsoShield technology cut solution size by as much as 70%

Integrated transformer modules deliver three times the power density for space-constrained applications such as electric vehicle (EV) traction inverters and data center power-supply units (PSUs). Advanced isolation provides 250V/ns common-mode transient immunity for harsh environments.

BY COLE NESWOLD - PRODUCT MARKETING ENGINEER AT TEXAS INSTRUMENTS

Expectations of EV performance continue to evolve, requiring engineers to support high battery voltages and faster-switching FETs while reducing vehicle weight, improving efficiency, and providing galvanic isolation to protect systems from transients and noise in harsh environments with extreme temperatures, vibration, and electromagnetic interference (EMI).

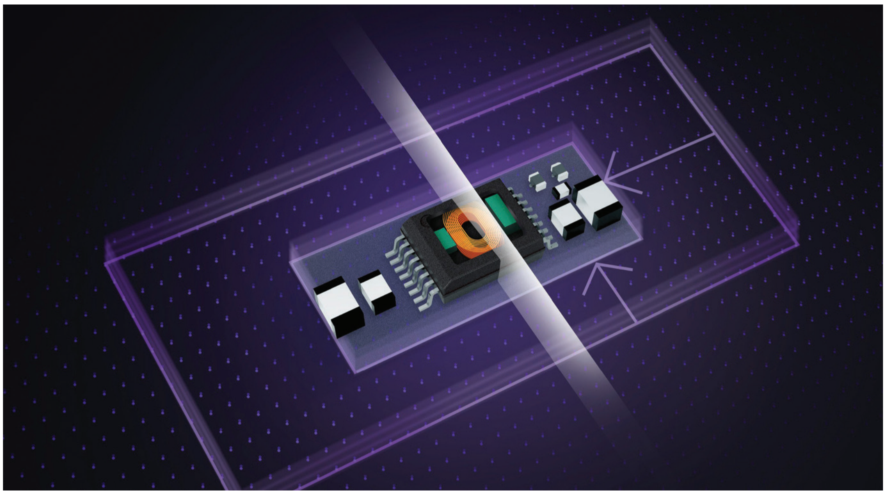
Meanwhile, AI computing demands require greater power density in data centers, with designers tasked to pack more power into smaller spaces while facing similar isolation challenges in multi-kilowatt PSUs, backup battery units (BBUs), and server racks. Traditional inductor-inductor-capacitor resonant converter and flyback designs require transformers that consume precious board space and height. Discrete transformer-based designs also add unwanted electrical effects that reduce noise immunity and increase design complexity.

Isolated power modules using TI's proprietary IsoShield™ packaging technology address these constraints by integrating transformers, switching devices and passive components to meet isolation requirements while reducing size by as much as 70% compared to existing solutions. Figure 1 shows the power module with this proprietary integrated transformer technology.

How increased power density reduces solution size

Traditional isolated power designs make choosing between power delivery and board space difficult.

Transformers must fit in compact spaces, while providing isolation between 800V battery systems and 12V or 3V control circuits. EV designers and data center engineers need to maximize power density while minimizing weight and space requirements.



➤ Figure 1. The UCC34141-Q1 with IsoShield technology in a 5.85mm-by-7.50mm-by-2.65mm package

Power modules with IsoShield packaging technology integrate the transformer, typically the largest component on a printed circuit board (PCB). While other devices can achieve similar levels of performance with a significant amount of external circuitry, IsoShield technology enables extremely small packages while still providing sufficient power. For example, the mid-voltage UCC34141-Q1 and low-voltage UCC33420-Q1 DC/DC modules provide 1.5W of isolated output power in 5.85mm-by-7.50mm-by-2.65mm and 4mm-by-5mm-by-1mm packages, respectively.

The UCC34141-Q1 reduces bias-supply solution area 70% compared to discrete flyback solutions and >35% compared to existing integrated transformer solutions. These reductions deliver 333% and 150% higher power density, respectively.

Figure 2 visualizes the solution area reduction associated with moving from flyback on the left to a fully integrated solution, the UCC34141-Q1, on the right.

Solution height is equally important. Integrating the transformer eliminates the tallest component on the board, enabling a solution that is less than one-fourth the height. The UCC34141-Q1 measures 2.65mm high, and the UCC33420-Q1 is 1mm high.

Integration and small size typically raise concerns about thermal performance and EMI, but DC/DC modules with

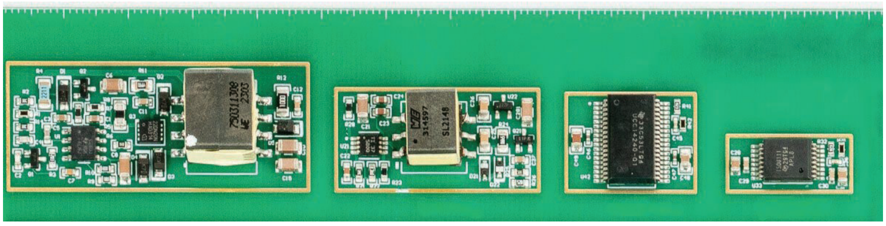


Figure 2. (above) Top view of the evolution of isolated bias-supply solutions

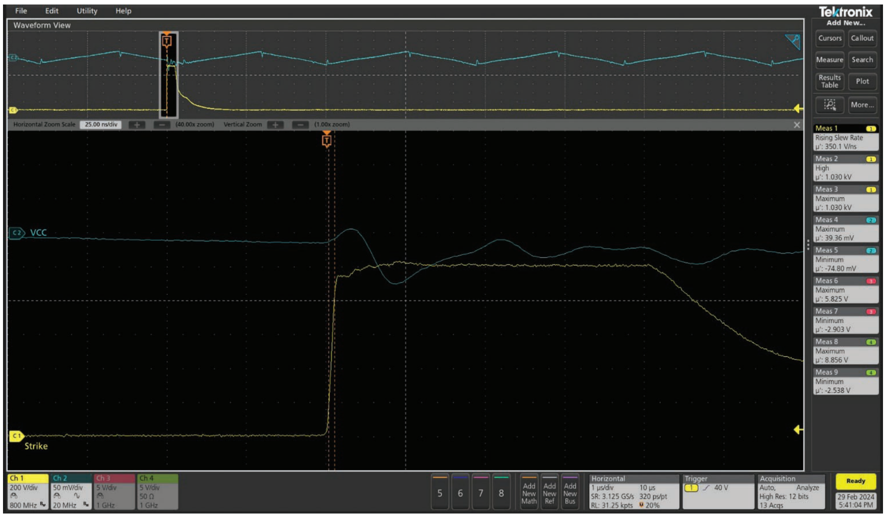


Figure 3. UCC33421-Q1 output waveform during a >250V/ns voltage strike

IsoShield technology dispel these worries. These devices improve thermal performance by as much as 30% compared to previous modules – and in 54% smaller packages. These modules only need small, inexpensive EMI filtering to pass Comité International Spécial des Perturbations Radioélectriques (CISPR) 32 Class B and CISPR 25 Class 5 requirements.

Enhanced system durability and reliability

Power-supply reliability and high performance in noisy and harsh environments are important to ensure safe system operation. Devices with IsoShield technology are designed to provide reliable performance through four types of immunity:

- **Common-mode transient immunity (CMTI):** The modules feature <3pF of parasitic capacitance across the primary and secondary windings of the integrated transformer, enabling a CMTI of 250V/ns for the UCC34141-Q1 and UCC33421-Q1. Figure 3 is an output waveform of the UCC33421-Q1 under a >250V/ns voltage strike.
- **Radiated immunity:** An injected electromagnetic noise test with a transverse electromagnetic cell on the UCC34141-Q1 shows continuous operation at a >100V/m noise level through a frequency range from 10MHz to 1GHz. The UCC34141-Q1 meets the CISPR 25 standard and exceeds the International Electrotechnical Commission 61000-4-3 standard without needing to add metal exposure or an EMI filter.
- **Magnetic immunity:** The UCC34141-Q1 operates reliably near strong magnetic fields. In applications, these fields may generate from the busbar in a traction inverter or magnetics in medical equipment such as an MRI or X-ray machine. Power modules with IsoShield technology can operate with >100mT of field strength.
- **Vibration immunity:** Strong and frequent vibrations are typical in EV applications. Thanks to their small size and low profile, devices with IsoShield technology can reduce the torque and stress on solder joints and PCB pads >90% compared to discrete transformers, which reduces the possibility of transformer failures caused by vibration. Figure 4 illustrates the solution height reduction of the devices, which contributes directly to vibration immunity.

Accelerated design cycles

Transformers are among the most difficult to select, source and design, requiring trade-offs between catalog and custom designs. Custom designs require significant specifications for windings (how many, how to route, how much loss); core (size, shape, material, loss); inductance (leakage, coupling, parasitics); and packaging.

Bias-supply modules that integrate the transformer, switching FETs and other passive components eliminate these issues, reducing the amount of component selections and design considerations. This is extremely valuable in data center applications given the rapid design and deployment of PSUs, BBUs and server racks to meet rising market demands.

Conclusion

Devices with IsoShield technology help eliminate the typical trade-offs associated with engineering higher power, higher performance and higher reliability. The ability to repurpose 70% of your previous bias-supply solution gives you the opportunity to add extra features or sensors to the system, increase redundancy, or design a higher-power-density solution.

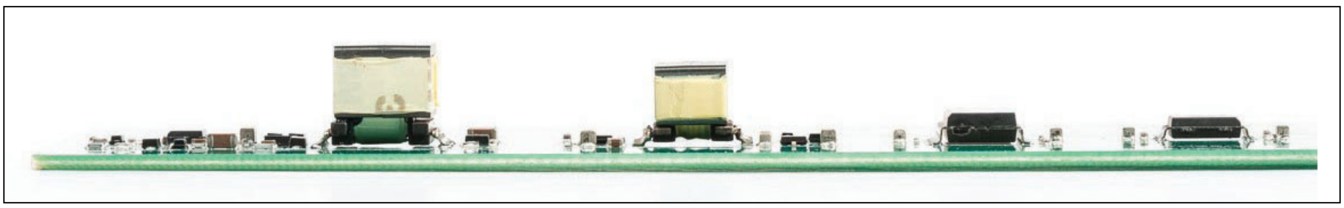


Figure 4. Side view of the evolution of isolated bias-supply solutions

Revolutionary materials powering the future of electronics

Two recent reports from Polaris Market Research predict a bright future for compound semiconductors and GaN in particular.

The global semiconductor industry is undergoing a profound transformation, driven by the rise of compound semiconductors and the growing adoption of wide-bandgap materials such as gallium nitride (GaN) and silicon carbide (SiC). Unlike traditional silicon-based devices, these materials offer superior electronic and optical properties that enable high-speed operation, high efficiency, and robust thermal performance - qualities increasingly demanded across telecommunications, electric vehicles (EVs), renewable energy, and data centers.

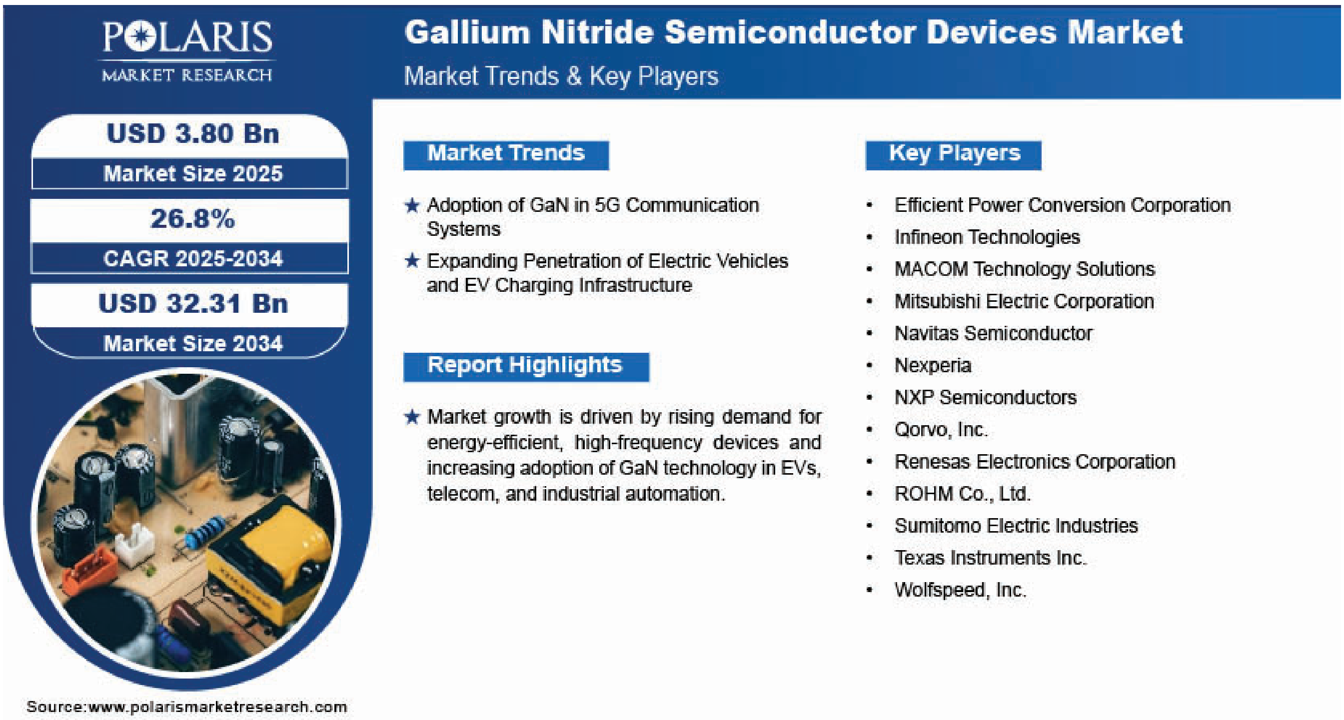
According to comprehensive research from Polaris Market Research, the global compound semiconductor market was valued at USD 49.29 billion in 2025 and is projected to reach USD 87.61 billion by 2034, reflecting a compound annual growth rate (CAGR) of 6.6%. Within this broader market, GaN semiconductor devices are experiencing explosive growth, with forecasts suggesting the global GaN market will expand to USD 32.31 billion by 2034, at a striking CAGR of 26.8%. These figures underscore the accelerating momentum behind advanced semiconductor materials and their transformative impact on modern electronics.

The compound semiconductor advantage

Compound semiconductors are formed by combining elements from two or more groups of the periodic table, creating materials with unique electrical, optical, and thermal properties. Key materials include GaAs, GaN, and SiC, which provide higher electron mobility, higher breakdown voltages, and better thermal stability compared to silicon.

These advantages make compound semiconductors indispensable for applications where conventional silicon cannot deliver the required performance. High-frequency RF devices, high-power electronics, and energy-efficient systems all rely on these materials to achieve performance levels necessary for next-generation technologies.

The industry has witnessed remarkable innovation, driven by demand from telecommunications providers, automotive manufacturers, and consumer electronics companies. By leveraging GaN and SiC, manufacturers can produce devices that operate



at higher voltages, frequencies, and temperatures, opening the door to applications previously unattainable with traditional silicon.

Power Electronics: Driving market expansion

Within the compound semiconductor market, power electronics has emerged as the dominant segment. GaN and SiC semiconductors have become critical components in power devices due to their efficiency, reliability, and ability to operate under extreme conditions.

The expansion of power electronics is closely tied to the global transition toward sustainable energy systems. Electric vehicles, renewable energy infrastructure, and advanced industrial applications are all driving demand for high-performance power semiconductors. SiC devices, for instance, enable faster EV charging, extended driving ranges, and improved vehicle efficiency, positioning these materials as essential to the automotive electrification movement.

GaN devices are similarly transforming the power electronics landscape. High-electron-mobility transistors (HEMTs) and integrated power ICs allow for compact, low-loss designs in applications ranging from data center power supplies to renewable energy converters. By reducing energy losses and minimizing thermal constraints, GaN devices enable smaller, more efficient systems - an advantage increasingly valued in both consumer and industrial electronics.

Telecommunications: High-Frequency demands

The telecommunications sector is another key driver of compound semiconductor adoption. The global rollout of 5G networks has created unprecedented demand for high-frequency, high-efficiency RF components. GaN and GaAs devices are integral to power amplifiers, switches, and other RF systems that enable high-capacity, low-latency communications.

As mobile data usage continues to soar and networks evolve toward 6G, the need for compound semiconductors will only intensify. GaN's ability to operate efficiently at high frequencies with low power loss makes it particularly well-suited for massive-MIMO base stations and next-generation wireless infrastructure, ensuring that it remains at the heart of telecom expansion strategies.

Government Support: Fuelling innovation

Strategic government initiatives are accelerating the growth of compound semiconductor and GaN markets. In the United States, the CHIPS and Science Act of 2022 allocated USD 52.7 billion to support domestic semiconductor manufacturing and research. Similar programs are being implemented across Europe and Asia to bolster local production capacity, encourage innovation, and strengthen supply chain resilience.

These policies not only provide direct financial support but also create an ecosystem conducive to rapid technological advancement. By facilitating investment in research and manufacturing, governments are enabling companies to scale production, reduce costs, and accelerate the deployment of next-generation semiconductor devices.

Regional market dynamics

Asia Pacific has emerged as the largest regional market for compound semiconductors, accounting for a significant portion of global demand. The region's robust electronics manufacturing base, coupled with aggressive 5G infrastructure deployment, has driven demand for high-performance semiconductors. For example, China had deployed approximately 3.22 million 5G base stations by October 2023, highlighting the scale of investment in next-generation communications infrastructure.

In addition to China, countries such as Japan, South Korea, and Taiwan are investing heavily in compound semiconductor production. These investments include new fabrication facilities, wafer scaling initiatives, and technology development programs, positioning the region as a global leader in semiconductor innovation.

North America and Europe are also intensifying efforts to strengthen their domestic semiconductor capabilities. In Europe, scaling BCD and SiC processes to larger wafer diameters improves device performance while reducing production costs. Similarly, North American companies are reshoring manufacturing and expanding IDM and foundry capabilities to enhance resilience and sovereignty in critical semiconductor production.

GaN semiconductor devices: A high-growth segment

GaN semiconductor devices, a subset of the broader compound semiconductor market, are experiencing remarkable growth. Their wide-bandgap properties allow higher electron mobility, greater power density, and superior high-frequency performance compared to silicon, making them ideal for applications in power electronics, RF communications, consumer electronics, and EV infrastructure.

Market forecasts suggest GaN semiconductor devices will reach USD 32.31 billion by 2034, reflecting a CAGR of 26.8%. This rapid growth is fueled by multiple high-demand applications:

- **5G Communications:** GaN's efficiency at high frequencies makes it indispensable for RF and microwave devices in 5G base stations and satellite communications. Massive-MIMO and high-power amplifiers benefit from the material's low-loss, high-performance characteristics.
- **Electric Vehicles & Charging Infrastructure:** GaN power devices enable faster switching, smaller form factors, and higher efficiency in EV inverters and chargers, supporting the global electrification of transportation.
- **High-Efficiency Power Electronics:** GaN devices allow compact, energy-efficient designs in consumer electronics, data centers, and renewable energy systems, helping reduce losses and improve operational reliability.

Manufacturing innovation and wafer scaling

The adoption of GaN is being accelerated by advances in manufacturing. Companies are scaling wafer production to larger diameters and integrating GaN-on-Si technologies to reduce costs and improve yields. These innovations enhance competitiveness with silicon while enabling broader commercial adoption of GaN devices.

The industry is also exploring new device architectures, such as vertical GaN, which promise higher voltage handling and further efficiency gains. Combined with embedded digital control and advanced packaging techniques, these innovations are expanding GaN's application potential and making it a key enabler of next-generation electronics.

Competitive landscape and strategic developments

The compound semiconductor and GaN markets are highly competitive, with established leaders and emerging innovators vying for technological and commercial advantage. Key players include Wolfspeed, Skyworks Solutions, Qorvo, Infineon Technologies, and Samsung Electronics.

Recent developments illustrate the pace of innovation and strategic positioning:

- Qorvo introduced a high-gain 100-watt L-band GaN-on-SiC power amplifier module for commercial and defense radar applications, demonstrating the material's versatility and performance advantages.
- Infineon Technologies and II-VI Incorporated entered a multi-year agreement to supply SiC wafers, highlighting the importance of securing raw materials and ensuring supply chain stability.

These moves underscore the strategic importance of both innovation and supply chain management in maintaining leadership within the rapidly growing markets for GaN and compound semiconductors.

Future Outlook: Innovation driving growth

Looking ahead, the combined markets for compound semiconductors and GaN devices are set for sustained expansion. Growth will be driven by several converging factors:

- **Technological Advancement:** Ongoing research in material quality, device architecture, and process efficiency is improving performance while reducing costs.
- **Electrification and Renewable Energy:** EV adoption, solar energy systems, and high-efficiency power electronics continue to expand, creating a steady demand for SiC and GaN devices.
- **Telecommunications Evolution:** 5G deployment, upcoming 6G technologies, and expanding wireless infrastructure will drive demand for high-frequency GaN and GaAs components.
- **Data Center Growth:** High-performance computing, AI workloads, and digital infrastructure require highly efficient power devices capable of handling extreme densities and thermal loads.

The convergence of these factors positions compound semiconductors, particularly GaN and SiC, as essential technologies in the global transition toward energy-efficient, high-performance electronics.

Shaping the electronics of tomorrow

Compound semiconductors and GaN devices are no longer niche materials - they are central to the evolution of the electronics industry. Their ability to deliver higher efficiency, smaller footprints, and enhanced thermal and electrical performance makes them critical for applications ranging from EVs and renewable energy to 5G telecommunications and advanced data centers.

As governments worldwide invest in semiconductor research and manufacturing, and as manufacturers continue to innovate in device design and production, the global compound semiconductor and GaN markets are poised for continued expansion. Companies that embrace these materials and invest in advanced technologies stand to gain a competitive advantage in a rapidly evolving market.

In essence, compound semiconductors and GaN devices are not just powering electronics, they are redefining what electronics can do, enabling the high-performance, energy-efficient systems that will define the next decade of technological progress.

As governments worldwide invest in semiconductor research and manufacturing, and as manufacturers continue to innovate in device design and production, the global compound semiconductor and GaN markets are poised for continued expansion. Companies that embrace these materials and invest in advanced technologies stand to gain a competitive advantage in a rapidly evolving market.

CHIPX establishes advanced front-end manufacturing capabilities in Malaysia

Chinmoy Baruah, CEO and Founder, CHIPX, explains how the semiconductor startup, which is building one of the world's first decentralised, resilient and sustainable ecosystems for the semiconductor industry, has developed a major collaboration to establish a state-of-the-art wafer fabrication facility in Malaysia.

The global power electronics landscape is entering a decisive phase. As demand accelerates across electric vehicles, AI data centres and energy infrastructure, the industry is being reshaped by two powerful forces: the transition to wide bandgap materials and the urgent need for more resilient semiconductor supply chains. Against this backdrop, ChipX's plan to establish Southeast Asia's first 8-inch front-end wafer fabrication facility dedicated to gallium nitride (GaN) and silicon carbide (SiC) technologies marks a significant strategic milestone.

Located in Malaysia, the new fab signals not only a technological upgrade for the region but also a shift in how and where advanced power semiconductors are developed and manufactured. For an industry long dominated by established players in East Asia, Europe and the US, the move introduces a new node in the global ecosystem—one that could play a critical role in the next decade of electrification and digital infrastructure growth.

A strategic bet on Malaysia

Malaysia is no newcomer to semiconductors. With more than five decades of experience, the country has built a strong reputation in back-end assembly, test and packaging. However, front-end wafer fabrication - particularly for compound semiconductors - has remained relatively underdeveloped.

ChipX's decision to invest in Malaysia aligns closely with the government's National Semiconductor Strategy (NSS 2026), which aims to elevate the country's position in the global value chain. The strategy emphasises attracting high-value manufacturing, developing local talent, and fostering advanced R&D capabilities.

For ChipX, the appeal is clear: a mature industrial base, a skilled workforce, and a policy environment actively supporting semiconductor expansion. The company also sees Malaysia as a natural extension of its existing operations in Taiwan, where it has developed expertise in epitaxial wafer production and high-yield manufacturing processes.

Crucially, this is not a commodity play. ChipX is targeting high-growth, high-value segments - power electronics, AI infrastructure, and advanced computing - where performance, efficiency and reliability outweigh cost considerations.

Why 8-inch matters

While 6-inch wafers have been the industry standard for many compound semiconductor processes, the transition to 8-inch substrates represents a critical step forward in scalability and cost efficiency.

In practice, many facilities claiming 8-inch capability still operate in a hybrid 6–8-inch mode, limiting throughput and consistency. ChipX's commitment to a true 8-inch platform positions it at the forefront of this transition, enabling higher wafer yields, improved economies of scale, and better alignment with the needs of large-volume customers.

This is particularly important for GaN and SiC devices, where demand is expected to grow at double-digit compound annual rates through the end of the decade. As applications expand beyond niche markets into mainstream automotive and data centre deployments, the ability to manufacture at scale becomes a defining competitive advantage.

GaN-on-SiC: Bridging performance and efficiency

At the heart of ChipX's strategy is its focus on GaN-on-SiC technology - a combination that leverages the strengths of both materials.

Wide bandgap semiconductors such as GaN and SiC offer superior electrical properties compared to traditional silicon, including higher breakdown voltages, faster switching speeds and lower conduction losses. When combined, GaN-on-SiC devices can deliver enhanced thermal performance and efficiency, making them particularly well-suited for high-power, high-frequency applications.

One of the key advantages lies in thermal management. Improved heat dissipation reduces the need for complex cooling systems, allowing devices to operate closer to ambient temperatures. This not only simplifies system design but also contributes to overall energy savings - an increasingly critical factor in applications such as AI data centres.

Additionally, the material's electronic properties, such as high electron mobility, enable faster switching and lower losses, directly translating into higher efficiency and reduced energy consumption.

Powering the AI era

Few sectors illustrate the urgency of energy efficiency better than AI data centres. As compute demands surge, driven by machine learning models and high-performance GPUs, power consumption has become a primary constraint.

ChipX is positioning its GaN-on-SiC devices as a direct response to this challenge. By enabling higher efficiency power conversion and improved thermal performance, these devices can help reduce the energy footprint of data centre infrastructure.

The company's roadmap includes support for high-voltage applications, with devices targeting 800 V and 1200 V classes - key requirements for modern data centre power architectures. These solutions are designed to support next-generation GPUs and accelerators, including those used in large-scale AI deployments.

The underlying principle is straightforward: achieve more computational output with less energy input. In an environment where energy costs and thermal limits are increasingly restrictive, even incremental efficiency gains can have significant economic and environmental impacts.

Beyond Power: The role of silicon photonics

While the Malaysian fab will focus on power semiconductor manufacturing, ChipX is also investing heavily in silicon photonics - a complementary technology with profound implications for data centre architecture.

High-bandwidth optical interconnects, particularly co-packaged optics (CPO), are emerging as a critical enabler of next-generation AI systems. By replacing traditional electrical interconnects with optical links, these technologies can dramatically increase data transfer speeds while reducing latency and energy consumption.

ChipX's strategy is to combine its power semiconductor portfolio with advanced photonics solutions, offering customers a more integrated approach to system design. The goal is to reduce energy consumption not only at the power conversion level but also across the entire data transmission chain.

Few companies currently operate across both domains, giving ChipX a potentially unique position in the market. For customers, this could translate into simplified supply chains and more optimised system-level performance.

Building a resilient supply chain

The COVID-19 pandemic and subsequent geopolitical tensions exposed significant vulnerabilities in the global semiconductor supply chain. In response, there has been a growing push towards regional diversification and localisation.

ChipX's Malaysian facility is part of this broader trend. By establishing front-end manufacturing capabilities outside traditional hubs, the company aims to contribute to a more decentralised and resilient ecosystem.

This is particularly relevant for power semiconductors, which are increasingly seen as critical components in energy, transportation and digital infrastructure. Ensuring a stable and diversified supply of these devices is essential for both economic and national security.

At the same time, ChipX's long-standing partnerships in Taiwan provide a foundation of process maturity and technological expertise. This combination of established know-how and new regional capacity could help accelerate time-to-market while maintaining high yield and quality standards.

From back-end strength to front-end capability

One of the key questions surrounding the project is whether Malaysia can successfully transition from its traditional back-end focus to advanced front-end manufacturing.

ChipX is optimistic. The country's extensive experience in semiconductors provides a strong foundation, and the primary gap - advanced process technology - can be addressed through technology transfer and international collaboration.

Central to this effort is the development of local talent. ChipX plans to invest in training programmes, joint engineering teams and centres of excellence, aimed at building long-term expertise

in power semiconductor design and manufacturing.

This emphasis on in-country value creation reflects a broader industry trend. As competition intensifies, access to skilled engineers and researchers is becoming as important as access to capital and equipment.

Target Applications: Automotive and beyond

In its initial phase, ChipX will focus on two key markets: automotive and AI/data centre infrastructure.

In the automotive sector, the shift towards electric vehicles is driving demand for high-efficiency power devices capable of handling higher voltages and switching frequencies. GaN and SiC technologies are widely seen as critical enablers of this transition, offering improved efficiency and reduced system size.

Beyond these core markets, the company's roadmap includes potential expansion into renewable energy, aerospace and other high-reliability applications. However, the initial focus reflects a pragmatic approach - targeting sectors with the strongest immediate demand and growth potential.

Supporting decarbonisation goals

Energy efficiency is not just a technical challenge; it is also a policy priority. Malaysia's semiconductor strategy is closely linked to its broader energy transition goals, and advanced power semiconductors play a key role in this context.

By enabling devices to operate more efficiently and at lower temperatures, GaN-on-SiC technology can reduce the need for energy-intensive cooling systems. This has direct implications for carbon emissions, particularly in large-scale installations such as data centres.

In essence, better semiconductors lead to more efficient systems, which in turn contribute to lower overall energy consumption. As governments and industries worldwide pursue decarbonisation targets, such improvements are becoming increasingly valuable.

Looking Ahead: A regional catalyst

Over the next five to ten years, the impact of ChipX's Malaysian fab could extend well beyond the company itself.

The project is expected to create thousands of jobs, attract further investment, and stimulate R&D activity across the region. It may also encourage other semiconductor companies to consider similar investments, reinforcing Malaysia's position as a growing hub for advanced manufacturing.

Perhaps more importantly, it represents a shift in the global distribution of semiconductor capabilities. As demand for wide bandgap devices continues to grow, new centres of production will be essential to meet that demand.

ChipX's initiative suggests that Southeast Asia is ready to play a more prominent role in this landscape. By combining advanced materials, scalable manufacturing and a focus on high-value applications, the company is positioning itself, and Malaysia, at the forefront of the next wave of power electronics innovation.

Conclusion

The establishment of an 8-inch GaN and SiC wafer fab in Malaysia is more than a regional milestone; it is a reflection of broader industry trends shaping the future of power electronics.

From the rise of AI-driven data centres to the electrification of transportation and the push for decarbonisation, the demand for high-performance, energy-efficient semiconductors is set to increase dramatically. Meeting this demand will require not only technological innovation but also a more resilient and geographically diverse supply chain.

ChipX's strategy addresses both challenges. By leveraging its expertise, partnerships and long-term vision, the company aims to deliver advanced solutions while contributing to the development of a new semiconductor hub in Southeast Asia.

If successful, the project could mark the beginning of a significant shift - one in which Malaysia becomes a key player in the global wide bandgap ecosystem, and a new chapter in power electronics begins.

Advancing Power efficiency with SiC merged-PiN Schottky (MPS) diodes

RIR Power Electronics is introducing SiC MPS diodes designed to meet the demanding requirements of next-generation EVs, renewable energy systems, industrial drives, aerospace, and green hydrogen infrastructure.

BY PERRY SCHUGART, CMO & HEAD OF BUSINESS DEVELOPMENT, RIR POWER

Understanding SiC schottky and merged-PiN schottky diodes

Conventional SiC Schottky Barrier Diodes (SBDs)
SiC Schottky diodes are majority-carrier devices that offer:

- Near-zero reverse recovery charge (Qrr)
- Extremely fast switching
- Low switching losses

However, at higher voltages and temperatures, traditional SiC Schottky diodes face inherent limitations:

- Increased leakage current
- Reduced surge current capability
- Higher sensitivity to overload and short-term fault conditions

These factors can constrain their robustness in demanding applications such as traction inverters, grid-connected converters, and industrial power supplies.

SiC Merged-PiN Schottky (MPS) Diodes
The Merged-PiN Schottky (MPS) structure integrates a PiN diode region within the Schottky architecture. Under normal forward operation, the device behaves like a Schottky diode, maintaining low forward voltage and fast switching. Under high current or high voltage stress (surge current), the PiN regions become active, dramatically enhancing device ruggedness.

This intelligent self-adapting behaviour allows MPS diodes to deliver the best attributes of both Schottky and PiN devices - without their traditional drawbacks.

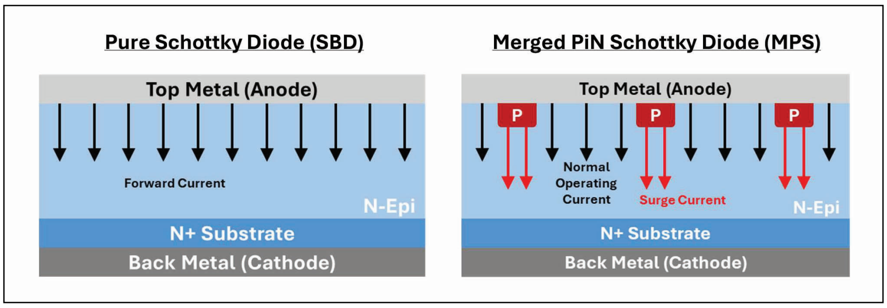
Comparison of SiC MPS vs. SiC schottky diodes

As depicted in **table 1**, RIR Power's MPS diodes remove the need to choose between efficiency and ruggedness.

Key performance advantages of SiC MPS vs. SiC schottky diodes

One of the key advantages of SiC MPS diodes is in the forward conduction loss curve, RIR Power's SiC MPS diodes closely match SiC Schottky diodes at low to nominal current, maintaining low forward voltage and high efficiency during normal operation. At higher current and overload conditions, MPS diodes exhibit lower incremental conduction loss as the embedded PiN regions conduct, stabilizing forward voltage and reducing thermal stress compared to conventional SiC Schottky diodes.

- **Superior surge current capability**
  MPS diodes can safely conduct significantly higher surge currents due to the activation of PiN regions during overload events. This makes them far more robust in real-world systems exposed to inrush currents, short circuits, and grid disturbances.
- **Lower leakage at high temperature**
  While standard SiC Schottky diodes experience rapidly increasing leakage current as junction temperature rises, MPS structures suppress leakage through their PiN regions - enabling stable operation at elevated temperatures.
- **Improved avalanche and blocking robustness**
  The merged structure enhances high-voltage blocking stability and avalanche capability, making MPS diodes better suited for high-voltage DC-link and grid-tied applications.
- **Near-Zero reverse recovery performance**
  Like Schottky diodes, SiC MPS diodes remain majority-carrier devices during normal operation, preserving ultra-fast switching and negligible reverse recovery losses—critical for high-frequency power conversion.
- **Enhanced system reliability**
  By combining efficiency with fault tolerance, MPS diodes reduce the need for over design, snubber circuits, and excessive derating, improving overall system reliability and lowering total cost of ownership.



Application impact

RIR's SiC MPS diodes enable higher system efficiency and reliability across demanding applications by combining Schottky-like switching performance with enhanced surge, thermal, and high-voltage robustness. This makes them ideally suited for EV traction inverters, renewable energy systems, industrial drives, aerospace, and green hydrogen applications where high-power density, efficiency, ruggedness, and thermal performance are equally critical:

- **Electric vehicles (EVs & HEVs):**
  Traction inverters, onboard chargers, and DC-DC converters benefit from reduced losses, higher efficiency, and improved fault tolerance.

- **Data centers & AI infrastructure:** High-efficiency UPS, PDU, and server power systems benefit through reduced switching losses, higher power density, and enhanced reliability under continuous high-load operation - critical for hyperscale, edge, and AI-driven data centers with stringent uptime and energy-efficiency requirements.
- **Renewable energy & grid infrastructure:** Solar inverters, wind power converters, and energy storage systems gain higher power density and improved reliability under grid disturbances.
- **Industrial power supplies & motor drives:** High-frequency switching, improved thermal margins, and surge robustness enable compact, high-performance industrial designs.
- **Aerospace & defense power systems:** Extreme environmental resilience, fast switching, and high voltage capability align with mission-critical reliability requirements.
- **Green hydrogen & electrolysis systems:** High-efficiency rectification and robust high-voltage performance support continuous operation and long service life.

Value proposition

RIR's SiC MPS diode portfolio offers several decisive advantages:

- **Higher system efficiency** – Reduced switching and conduction losses across operating conditions.
- **Greater ruggedness** – Enhanced surge, avalanche, and thermal robustness.
- **Design flexibility** – Simplified protection and reduced derating requirements.
- **Lower system cost** – Smaller passives, reduced cooling needs, and fewer external protection components.

Conclusion

As power electronics systems push toward higher voltages, higher switching frequencies, and more demanding operating environments, RIR Power's SiC Merged-PiN Schottky diodes emerge as a clear advancement over conventional SiC Schottky devices. By combining efficiency with ruggedness, MPS technology enables designers to achieve higher performance without compromising reliability.

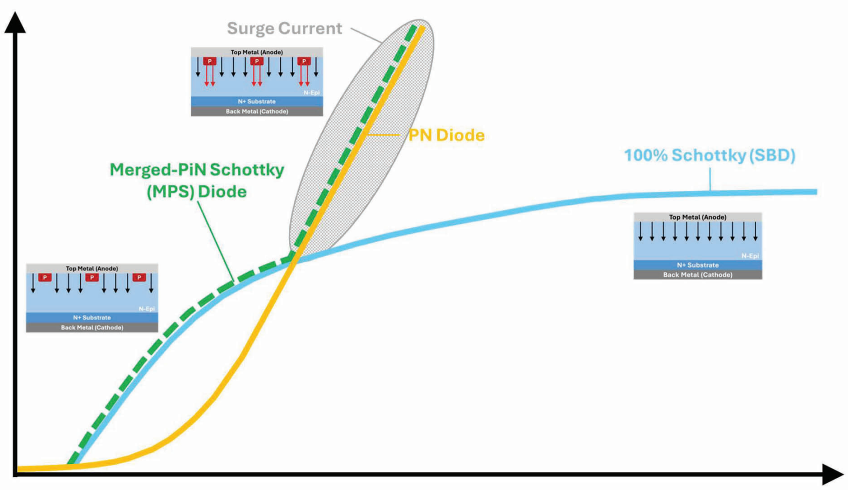
Parameter	SiC Schottky Diode (SBD)	SiC Merged-PiN Schottky (MPS) Diode	Customer Value
Conduction Mechanism	Majority carrier (Schottky)	Majority carrier with PiN assist	Best of both worlds
Reverse Recovery	Near-zero	Near-zero	High-frequency efficiency
Forward Voltage (Nominal Load)	Low	Low	Comparable efficiency
Forward Voltage (High Current / Surge)	Increases rapidly	Stabilized via PiN conduction	Improved overload handling
Leakage Current @ High Temperature	Higher	Significantly lower	Better high-temp reliability
Surge Current Capability	Limited	High	Robust against inrush & faults
Avalanche Capability	Limited	Enhanced	Grid and industrial resilience
Thermal Stability	Moderate	Superior	Extended operating range
System Derating Required	Higher	Lower	Smaller, lower-cost systems
Typical Use Case	Light to medium duty	Mission-critical, High stress	Broader applicability

Table 1

With the launch of its SiC MPS diodes, RIR Power Electronics Limited reinforces its leadership in high-power semiconductor innovation - delivering devices that are not only technologically advanced, but also engineered for real-world deployment across EVs, data centers, renewables, industrial systems, aerospace, and green hydrogen.

RIR is not merely supplying components, it is enabling the next generation of efficient and reliable power electronics solutions for the world.

Forward Surge Capability, I_{FSM}



Simplifying WBG semiconductor testing for labs and engineers

Nick Dajda, Sales and Marketing Director at ipTEST, discusses the launch of the company's two turnkey platforms for power device characterization: **Quasar^{200} and Pulsar^{600}**. With a plug-and-play approach, they are designed to simplify experimental workflows by eliminating the need for custom equipment and reducing manual operations such as soldering and complex test setups.

As wide bandgap semiconductors continue to reshape the performance envelope of power electronics, the demands placed on test and measurement infrastructure are undergoing a profound transformation. Devices based on gallium nitride (GaN) and silicon carbide (SiC) are switching faster, operating at higher voltages and currents, and pushing the boundaries of efficiency. Yet these same characteristics make them significantly more challenging to characterise and validate.

Against this backdrop, IP Test's introduction of its new Quasar 200 and Pulsar 600 platforms reflects a broader shift in how the industry approaches power device testing. By bridging the gap between laboratory characterisation and high-volume production, the company is aiming to simplify workflows, improve data correlation, and accelerate time to market for next-generation devices.

A legacy of production testing

IP Test's roots lie firmly in production environments. For more than three decades, the company has specialised in manufacturing end-of-line test systems - tools designed to act as the final quality gate before semiconductor devices are shipped to customers.

These systems are built for speed, robustness, and reliability. Operating 24/7 in high-throughput environments, they verify that each device meets datasheet specifications while providing critical yield data to manufacturers. In doing so, they also serve as an early warning system, helping identify upstream process issues before they escalate.

Over time, however, a notable trend began to emerge. Customers started deploying these production testers beyond the factory floor, using them in characterisation laboratories and new product introduction (NPI) environments. The reasons were compelling.

Firstly, the systems were easy to use, enabling engineers to generate datasheet-level measurements quickly and efficiently. Secondly, and perhaps more importantly, they offered direct hardware correlation between lab and production. The same platform used to evaluate early-stage devices could be used later to validate them at scale, eliminating the need to qualify multiple test systems.

This convergence of use cases ultimately laid the foundation for the Quasar 200 and Pulsar 600.

Purpose-built for the lab

While production testers are inherently flexible - often configured to work with different handlers, test flows and device types - laboratory environments have a different set of requirements. Engineers need rapid setup, minimal configuration overhead, and the ability to move seamlessly from device insertion to meaningful data.

The defining feature of the new platforms is their "plug-and-play" approach. Rather than requiring users to design custom fixtures, interfaces or measurement setups, the systems provide a complete, ready-to-use solution. From packaged devices to bare die or known-good die, the entire test chain is supplied - from physical interface through to data output.

This is particularly valuable in the context of wide bandgap devices, where the interface between the device and the tester becomes a critical determinant of measurement quality.

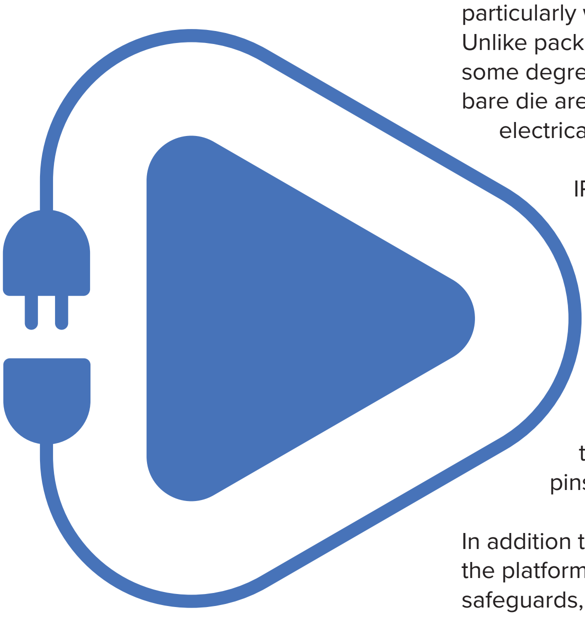
The challenge of parasitics

Testing GaN and SiC devices is fundamentally different from testing traditional silicon components. Their high electron mobility enables extremely fast switching speeds, which in turn introduces sensitivity to parasitic effects, especially inductance.

Even small amounts of parasitic inductance can distort switching waveforms, introduce measurement errors, and obscure the true behaviour of the device under test. In real-world applications, designers mitigate these effects by tightly integrating components within compact layouts. In a test environment, however, the physical separation between tester and device makes this far more challenging.

IP Test's approach focuses on minimising parasitic inductance - typically to below 30 nH in AC test configurations - through careful fixture design. This involves managing current paths, reducing loop areas, and mitigating stray magnetic fields that can interfere with measurements.

For many customers, designing such fixtures in-house has become a significant distraction from core engineering tasks. By delivering pre-engineered interfaces optimised for high-speed switching, the new platforms aim to remove this burden and enable more accurate, repeatable results.



High-Current Testing: Precision under extreme conditions

The Pulsar 600, in particular, targets one of the most demanding areas of power device validation: short-circuit testing.

In automotive applications, especially electric vehicles, power devices must be able to withstand fault conditions such as shoot-through events in inverter circuits. These scenarios can result in extremely high current surges, with energy rapidly dissipated through the device.

To simulate these conditions, the Pulsar 600 supports short-circuit testing at up to 1,000 A DC and beyond 10,000 A in AC pulse scenarios. Delivering such currents in a controlled and repeatable manner presents multiple engineering challenges.

The first, as discussed, is managing parasitic inductance. The second is ensuring system safety, particularly when devices fail. Under high-stress conditions, failures can be catastrophic.

To address this, the system incorporates ultra-fast protection mechanisms capable of shutting down current flow within 200 to 400 nanoseconds. This rapid response limits the energy delivered to a failing device, reducing the risk of explosion or damage to the test system and surrounding hardware.

Safety by design

Safety is a central consideration in high-power testing environments, particularly when dealing with bare die. Unlike packaged devices, which offer some degree of physical containment, bare die are directly exposed to electrical and thermal stress.

IP Test's "Socket Safe" technology is designed specifically for these scenarios. By monitoring current distribution at the contact interface, the system can detect early signs of localised failure, such as current crowding through individual contact pins, and respond immediately.

In addition to electronic protection, the platforms incorporate mechanical safeguards, including enclosed, interlocked test chambers. These ensure that operators are shielded from potential hazards while maintaining visibility during testing.

Together, these measures enable high-stress testing to be conducted safely, even in laboratory environments where manual device handling is common.

Modularity and flexibility

A key design principle behind both platforms is modularity. Power semiconductor testing spans a wide range of voltage, current and device configurations, and no single setup can address all scenarios without compromise.

On the DC side, the systems support voltage testing up to 3 kV as standard, with optional modules extending this to 10 kV. Current capabilities range from 200 A to 1,000 A, enabling detailed analysis of on-state performance and conduction losses.

On the AC side, modular "daughter boards" provide tailored interfaces for different device types, from standard packages such as TO-247 to bare die configurations. These boards are designed to minimise parasitics while optimising performance for specific test cases.

This approach allows users to balance flexibility and specialisation. A general-purpose setup can accommodate a wide range of tests, while dedicated configurations can be developed for applications requiring maximum performance, such as short-circuit characterisation.

Accuracy and measurement fidelity

Achieving high measurement accuracy, on the order of ±0.1% across voltage and current waveforms, requires careful attention to every stage of the measurement chain.

Signal conditioning, bandwidth and sampling rates all play a role, particularly when capturing fast switching events. However, accuracy is not solely a function of instrumentation; it also depends on ensuring that the conditions applied to the device match those intended.

To this end, the systems incorporate multiple layers of verification, continuously monitoring applied voltages and currents during testing. This ensures that any deviation is detected and accounted for.

Equally important is the use of multiple measurement ranges. Rather than relying on a single, wide-range measurement system, which can compromise resolution, IP Test employs range switching to maintain high precision across different operating conditions.

Calibration and traceability

In high-volume manufacturing, consistency is as important as accuracy. Devices tested on different systems, in different locations, must yield identical results.

To achieve this, IP Test relies on precision "checker boxes" containing calibrated resistors. These are used to verify system performance and ensure alignment with recognised standards. Importantly, the calibration process is traceable to national metrology institutes, such as the UK's National Physical Laboratory.

Regular recalibration, typically on a 12-month cycle, ensures that systems remain within specification over time. Because all testers share a common hardware architecture and calibration methodology, reproducibility between systems is maintained.

This is particularly valuable for multinational operations, where R&D and production may be located in different regions. By ensuring consistent measurement frameworks, companies can streamline qualification processes and reduce variability.

Bridging lab and production

One of the most significant advantages of the Quasar 200 and Pulsar 600 is their ability to maintain correlation between laboratory characterisation and production testing.

Traditionally, these environments have relied on different equipment, leading to discrepancies in measurement results and the need for extensive cross-calibration. By using a common platform, IP Test eliminates this divide.

Engineers can characterise devices using the same hardware that will later be used for end-of-line validation. This not only simplifies workflows but also reduces the risk of unexpected behaviour when transitioning from development to production.

Meeting automotive demands

The automotive sector represents one of the most demanding applications for power semiconductors. With zero-defect expectations and stringent reliability requirements, testing must be both rigorous and fully traceable.

IP Test's systems are designed with these requirements in mind. Comprehensive traceability ensures that every measurement, configuration and software change is recorded and auditable. Regression testing and version control processes provide transparency, enabling customers to track system performance over time.

Equally important is the company's emphasis on openness and collaboration. In an industry where trust and reliability are paramount, clear communication and strong partnerships are essential.

Early feedback and market response

Although the Quasar 200 and Pulsar 600 are newly launched as dedicated lab platforms, their underlying technology is far from unproven. Built on decades of production test experience, they inherit a mature architecture that has already been validated in demanding industrial environments.

Early deployments in research and NPI settings have yielded positive feedback, particularly regarding ease of use, measurement consistency and the elimination of custom fixture design. Beta testing with select customers has further refined the configurations, ensuring that the final products meet real-world requirements.

As first shipments begin, IP Test is optimistic about adoption, particularly among organisations seeking to streamline development workflows and accelerate product qualification.

Enabling the next generation of power electronics

As the power electronics industry continues its transition towards wide bandgap technologies, the importance of accurate, reliable and scalable testing cannot be overstated.

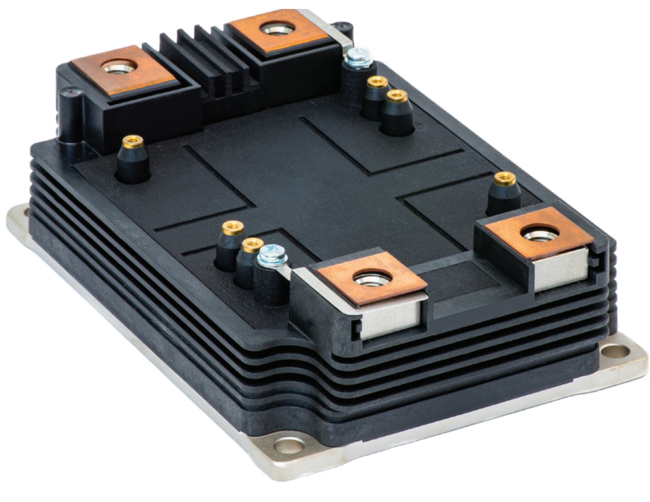
The Quasar 200 and Pulsar 600 represent more than just new products; they reflect a shift towards integrated, end-to-end test solutions that span the entire device lifecycle. By unifying lab and production environments, reducing complexity, and addressing the unique challenges of GaN and SiC devices, these platforms are helping to redefine how power semiconductors are evaluated.

In doing so, they enable engineers to focus on innovation rather than infrastructure—a critical advantage in a field where performance gains are increasingly hard-won, and time to market is a key competitive differentiator.

As wide bandgap adoption accelerates across automotive, industrial and energy applications, such advances in test technology will play a crucial role in ensuring that the devices at the heart of these systems deliver on their promise.

HV LinPak

After establishing itself as the new standard in the railway application with the Low Voltage (Viso=6kV) variant, the LinPak is now offering a High Voltage variant (Viso=10.2kV). While delivering the higher isolation voltage, it keeps the key features that made the LV variant a big success: phase leg configuration with very low stray inductance, high current density, separation of DC and AC terminals for ideal busbar and gate drive design. With these technical features, it accommodates Si IGBT as well as SiC MOSFET dies with blocking voltage 3.3kV, 4.5kV and 6.5kV.



hitachienergy.com/semiconductors

Magnachip bets on power semiconductors for recovery

After shuttering its display business, Magnachip Semiconductor is pivoting to a pure-play power chip supplier, but a tough market is testing its strategy.

Power semiconductor suppliers currently face a mixed market. While long-term demand is being driven by electrification, renewable energy systems and data-centre infrastructure, many firms are also grappling with pricing pressure and intensifying competition.

Against this backdrop, Magnachip Semiconductor is attempting to reposition itself as a pure-play power chip supplier, and despite lack-lustre fourth quarter 2025 sales - that fell 35.6% year-on-year to $40.57 million - remains resolute in its strategy. In March last year, the South Korea-based company announced plans to wind down its display arm following no takers to buy this business. This move was expected to cut the firm's annual operating expenses by up to 35% while it focused on manufacturing power semiconductors to drive revenue growth.

"Navigating the unpredictable macroeconomic headwinds will likely pose significant challenges to all companies over the coming few quarters," stated Young-Joon Kim, chief executive at the time. "Our strategic pivot to focus exclusively on Power discrete and Power IC businesses is designed to position the Company for a return to profitability."

The move made clear sense: the firm's power segment supplied devices to a broad set of large end markets characterised by longer product cycles and more predictable long-term growth. In contrast its display business only served the smartphone market. At the time, Kim also highlighted how Magnachip's power businesses had generated $185 million in revenue in 2024, up 13% from 2023, and that the company expected mid-to-high single-digit revenue growth in 2025.

Yet, fast-forward to today, and Magnachip's power business failed to achieve its 2025 single-digit revenue growth. Power analog revenue has declined by around 3.8% while power IC revenue has dipped by some 3.4%, both year-on-year. The company attributes the disappointing revenues to intense pricing pressure on legacy products, particularly from China-based competitors, as well as manufacturing plant operating below optimal capacity.

Still, declining revenues aside, Magnachip launched 55 'new-generation' products in 2025, compared with four in 2024. The firm also increased R&D spend and invested in its surviving South Korea Gumi fab - dedicated to manufacturing power semiconductors - to boost mid- to long-term competitiveness. All in all, $21.4 million was spent in 2025 on the Gumi fab upgrade, of which $17.0 million was funded through equipment financing loans.

Much of this activity took place under Kim's successor and long-time board member, Camillo Martino, who stepped up to the role of interim chief executive in August 2025 to accelerate the company's power semiconductor transition. At the time he emphasised the company's commitment to more than halving capital expenditure, whilst maintaining critical power investments. And at the firm's Q4 2025 Investor Conference Call he asserted: "[The product launches] are a massive acceleration by our engineering team and reflects targeted investment for longer-term growth... [They] are designed to improve our competitiveness and improve our product margin structure over time."

"We need highly competitive products to win - where we do have competitive products, we can absolutely win," he added. "That's the core point behind our product strategy."

➤ Magnachip is targeting solar and energy storage systems markets with its new generation of Insulated Gate Bipolar Transistors (IGBTs). [Magnachip]

Power proliferation

Magnachip's rapid delivery of new power semiconductor devices is intended to increase its market competitiveness and ultimately raise profit margins. The jury remains out on the success of this strategy but the proliferation of products across many markets can hardly be missed.

In early 2025, the company unveiled 650V IGBTs for solar inverters alongside 600V–700V super-junction MOSFETs targeting AI, industrial systems and smart home appliances, including laptop adapters, appliance inverters, power supplies and lighting. Meanwhile, 650V SJ MOSFETs were released for consumer electronics including gaming monitors and chargers, and eventually AI data centres.

Along the way, 80V MOSFETs were delivered, targeting e-scooters and light electric vehicles - these devices have already been supplied to a 'leading global motor manufacturer'. And Magnachip closed 2025 on a deal with long-time partner Hyundai Mobis to develop high-performance IGBTs for automotive traction inverters – Mobis plans to start mass production of EV inverters, incorporating the IGBTs, this year.

For 2026, plans are firmly in place to introduce more than 50 products that will target automotive, industrial/motor control, solar and energy-related applications, server and data infrastructure, and eventually robotics markets. Both 650V and 1200V IGBTs for solar inverters and industrial energy storage systems have already been released with 750V devices promised later this year. Meanwhile, a 24V MOSFET for battery protection circuits in next-generation tri-fold smartphones, wearable devices and tablets has been released. According to Magnachip, the 24V MOSFET is in mass production and is currently being supplied to a major global smartphone manufacturer.

Product development plans are accompanied by robust market forecasts. For example, global tech research firm, Omdia, recently reported the global IGBT market value exceeded $11 billion in 2024 and is set to expand from $12.3 billion in 2025 to $16.9 billion by 2028.

Omdia also predicted the global solar inverter and industrial energy storage systems market to grow from

In March 2025, Magnachip delivered super junction MOSFETS for AI, industrial applications and smart home appliances [Business Wire]

approximately $1.4 billion in 2024 to $2.7 billion in 2029, representing a CAGR of approximately 10.6%. The firm has also forecast the global market for silicon power MOSFETs below 40V, including smartphone batteryFETs, to increase from $4.2 billion in 2025 to $5.2 billion in 2029 – that's a CAGR of 4.6%.

Wide bandgap semiconductors

Amid the product development and buoyant market forecasts, Martino has remained bullish on his company's future financials. At the latest investor call he stated: "We expect new generation products to comprise approximately 10% of our total revenue in the fourth quarter of 2026, up from 2% for the full year 2025."

"Looking back at 2025, we have implemented many changes to lay the foundation to improve the financial and go-to-market fundamentals which we believe will result in a positive and consistent recovery over time," he said. "We are investing responsibly in areas where we see great potential, while staying disciplined and realistic about what it takes to turn a power semiconductor business around."

As well as expanding its power MOSFET, IGBT and IC businesses, the company will now develop modules, combining multiple dies into a package to increase product content per application. Development of silicon carbide products - described as a "multi-year initiative" - is also planned.

"Our entry into the silicon carbide market will be thoughtful and deliberately targeting markets where we have long term revenue visibility and in which return on invested capital and payback are demonstrably attractive," said Martino. "We believe our reputation and geographical location should enable us to access such attractive markets segments."

Undoubtedly, Magnachip's focus on power products also makes it a more straightforward acquisition target. The company has previously explored options - in 2021 Chinese equity firm, Wide Road Capital, tried and failed, to acquire the firm - and could now attract interest from larger semiconductor firms or private equity investors if its power business succeeds.

In the meantime, Martino remains realistic about the challenges ahead, pointing out how any new products will take time to qualify, ramp and then contribute to 'meaningful revenue'. "Turnaround will take time," he acknowledged. "In 2026 we still expect legacy products to represent the vast majority of revenue, and pricing pressure affecting these products to continue."

"So, 2026 will remain a challenging period - especially for gross margin - as we transition the portfolio and scale new-generation products," he added. "We believe we are taking the right corrective actions to improve our competitive position and create a path to meaningful value creation."

Data centre demand drives WBG materials adoption and smart power management

Cedric Malaquin, Service Director (Power, analog, RF) at TechInsights, discusses the semiconductor information platform's Power Outlook Report 2026, which highlights a number of trends, including: skyrocketing data centre power demand; silicon carbide market consolidation; a 'new set of rules' for GaN; China moving towards WBG self-sufficiency; and an increased focus on smart power management.

The power electronics landscape is entering an era of rapid transformation, driven by surging demand from data centers, evolving wide bandgap technologies, and an increasingly complex global semiconductor ecosystem. In the recently released 2026 Power Outlook Report by Tech Insights, several trends have emerged that paint a vivid picture of the opportunities and challenges facing the industry over the next 12–18 months.

We spoke with Tech Insights' senior analysts to explore the key findings, from the explosive growth in data center power consumption to the shifting dynamics of silicon carbide (SiC) and gallium nitride (GaN) markets, and the increasing focus on smart power management.

Data centers and the AI-driven power surge

Unsurprisingly, artificial intelligence is driving a massive increase in data center power demand. According to Tech Insights, the compute density of modern IT racks - whether hyperscaler custom racks or the latest NVIDIA Grace Blackwell and Vera Rubin systems - is expanding rapidly. This growth has pushed annual data center compute capacity additions from a historical 5–6 gigawatts per year to a staggering 10–20 gigawatts.

"This is really an exciting market to be in," Tech Insights noted. "The installed capacity for data center compute is growing faster than ever, and the resulting demand for power semiconductors is off the charts."

Meeting this demand is not without its challenges. High power density is critical; the power required to support AI workloads must fit into racks without expanding their physical footprint. Wide bandgap technologies, including GaN and SiC, are becoming essential. These materials offer the high efficiency and thermal performance necessary to handle increased power without the losses associated with traditional silicon-based devices.

Efficiency pressures are further amplified by the high cost of energy at large data centers, making the performance gains from wide bandgap devices indispensable. Beyond materials, availability remains a concern, particularly for hyperscalers striving to secure a stable, cost-effective power supply.

Tech Insights projects that the market for data center power solutions will reach $5 billion by the end of 2026, growing at double-digit rates - a testament to the substantial opportunity this sector presents.

Silicon Carbide: Consolidation and commoditization risks

While wide bandgap technologies are on the rise, SiC is facing a period of market recalibration. Following two years of strong demand from the electric vehicle (EV) sector, the SiC market experienced excess inventory and regulatory pressures in 2025, leading to a decline in demand and downward pressure on substrate prices.

"This is what we mean by commoditization risk," explained Tech Insights. "When you have extra capacity and lower prices, weaker players may be acquired by larger companies or exit the market altogether. 2026 is expected to be a year where this consolidation materializes."

However, the long-term outlook for SiC remains strong. As inventories normalize and EV adoption continues, demand for SiC devices is poised to rebound. Beyond automotive, the burgeoning data center market provides additional avenues for growth.

GaN: A market in transition

The gallium nitride market is also undergoing significant shifts. Historically dominated by a fabless-foundry business model, GaN production is now facing a turning point with TSMC's announced exit from the market in 2027. This shift will require fabless companies to find new foundries and requalify their devices, a complex and time-intensive process.

Meanwhile, integrated device manufacturers (IDMs) with in-house fabrication capabilities are well-positioned to capture market share. Their ability to control the entire manufacturing process and obtain critical performance feedback from customers gives them a strategic advantage in a competitive landscape.

Tech Insights also highlights the technical evolution of GaN devices, including higher voltage ratings and emerging vertical GaN architectures, which are bringing new applications within reach. This evolution, combined with market transitions, will define the GaN landscape in 2026 and beyond.

China's push for wide bandgap self-sufficiency

China's semiconductor ambitions are becoming increasingly influential in the power electronics sector. With a robust legacy semiconductor industry, the country has recently invested heavily in wide bandgap technologies, seeking self-sufficiency in SiC and GaN.

> Digital controllers, advanced multiphase management systems, and microcontrollers embedded within power circuits are enabling rapid response, higher efficiency, and real-time optimization.

"China now has installed capacity for both materials and devices, and some companies have even sampled automotive-grade devices to OEMs," noted Tech Insights. Companies like CRRC and BYD Semiconductor are developing product lines to integrate SiC into EV supply chains, creating a competitive local ecosystem.

As China's capabilities mature, these players are expected to increasingly compete with international suppliers, impacting pricing, availability, and global market dynamics.

Smart power management: digital control and efficiency

Another key trend highlighted in the report is the growing focus on smart power management, particularly in high-demand applications like data centers. With GPUs and other high-density computing systems requiring precise voltage regulation, digital control of power devices is becoming essential.

Digital controllers, advanced multiphase management systems, and microcontrollers embedded within power circuits are enabling rapid response, higher efficiency, and real-time optimization. The industry is also scaling advanced BCD (bipolar-CMOS-DMOS) processes to integrate more features directly on-chip, including memory and compute resources, which can be leveraged for power management.

Packaging innovations, such as integrating inductance directly adjacent to power stages, are also improving performance and efficiency. These developments represent a broader shift towards intelligent, software-driven control in power electronics, allowing designers to manage complex power systems more effectively than ever before.

Emerging applications beyond data centres

While data centers and EVs are the headline drivers of power electronics demand, other sectors are also showing significant growth potential:

- **Renewable Energy:** Photovoltaics (PV) are increasingly adopting SiC and GaN devices to enhance inverter efficiency and system performance. As global energy generation moves toward renewables, this market represents a steady growth opportunity.
- **Industrial Robotics and Automation:** Robotics, including industrial and humanoid robots, are driving innovation in high-efficiency power electronics, with early deployments ramping up in 2026.
- **Circuit Protection:** Solid-state circuit breakers and advanced protection devices are becoming more common, particularly in high-voltage data center applications, offering faster response times than traditional electromechanical breakers.

These applications, along with the dominant markets of data centers and EVs, collectively define the near-term growth trajectory for power electronics technologies.

Geopolitics and regional dynamics

Global semiconductor supply chains are increasingly shaped by geopolitical considerations. Tech Insights notes several trends:

- **Europe:** The region is leveraging its ecosystem to enhance production capabilities and cost competitiveness. Scaling up wafer diameters in BCD and SiC production improves performance and allows for integration of more features, strengthening Europe's position in the global market.
- **North America:** Similar reshoring efforts are underway, with IDMs

and foundries expanding production to increase resiliency and maintain sovereignty over critical power semiconductor technologies.

- **China:** As discussed, the country continues to pursue self-sufficiency in wide bandgap technologies, impacting global market competition.

Overall, regional strategies are converging around the need for local production, advanced capabilities, and resilience in supply chains, all of which will influence market dynamics through 2026 and beyond.

Outlook for 2026 and beyond

Tech Insights' 2026 Power Outlook Report paints an optimistic picture for power electronics, tempered by structural challenges in materials, supply, and geopolitical complexity. Key takeaways include:

- **Data Center Dominance:** AI and high-performance computing continue to drive explosive growth in power demand, with wide bandgap technologies essential for meeting density and efficiency requirements.
- **SiC Market Consolidation:** Following inventory normalization, the EV and data center markets will provide renewed growth opportunities, while weaker players exit or are acquired.
- **GaN Market Evolution:** Transitions in foundry partnerships and vertical GaN innovations are reshaping the GaN market, offering new avenues for differentiation.
- **Global Wide Bandgap Expansion:** China's self-sufficiency ambitions and regional initiatives in Europe and North America are creating a more complex, competitive landscape.
- **Smart Power Management:** Digital control, advanced BCD processes, and packaging innovations are enabling highly efficient and intelligent power management across multiple applications.
- **Emerging Applications:** Renewable energy, industrial robotics, and circuit protection represent growth areas beyond the headline data center and EV sectors.

Transitions in foundry partnerships and vertical GaN innovations are reshaping the GaN market, offering new avenues for differentiation.

For the power electronics industry, 2026 promises both opportunity and disruption. Companies that can navigate the technical, commercial, and geopolitical shifts are likely to thrive, while those unable to adapt may face consolidation pressures.

As AI continues to reshape computing, as wide bandgap devices mature, and as global supply chains evolve, the coming year will be pivotal for the direction of power electronics innovation.

Accelerating semiconductor innovation through machine learning-driven modelling

A look at how AI and ML revolutionise semiconductor device modelling by replacing slow, manual workflows with fast, automated solutions. Focusing on neural network based and hybrid modeling approaches that capture nonlinear behaviours directly from data, as well as ML-driven extraction techniques that reduce hundreds of steps to just a few.

BY YIAO LI, DEVICE MODELING APPLICATION ENGINEER AT KEYSIGHT

AI/ML for device modelling

AI and ML are transforming semiconductor device modeling by offering fast, data-driven alternatives to traditional physics-based workflows. Deep learning, in particular, has become a powerful tool for capturing the highly nonlinear relationships in device behavior. Instead of solving differential equations, neural networks approximate IV, CV, and QV characteristics with high accuracy and reduced computational cost. Several architectures are widely used in device modeling:

- **Feedforward Neural Networks** are simple yet powerful architecture for semiconductor device modeling. It maps operating conditions to electrical outputs through layers of nonlinear transformations, using a one-way flow without feedback loops. This makes FNNs efficient for capturing complex static relationships, often outperforming traditional compact models in accuracy and flexibility [2].
- **Physics-Informed Neural Networks (PINNs)** embed equations such as Poisson's or continuity equations into the loss function, ensuring physical consistency even with limited or noisy training data [3].
- **Recurrent Neural Networks (RNNs)** are specialized for sequential data, where the output at each step depends on previous inputs. In semiconductor modeling, RNNs are useful for capturing time-dependent behaviors, such as transient responses or dynamic switching events. Their architecture includes feedback loops that allow the network to retain memory of past states, enabling it to model processes that evolve over time [4].

Parameter extraction, a major bottleneck in modeling, also benefits greatly from AI/ML. Modern compact models can include thousands of parameters, making traditional iterative tuning slow and sensitive to initialization. ML-based extractors provide faster, more scalable alternatives:

- **Neural Network-Based Parameter Mapping** learns a direct relationship between device curves and model parameters, avoiding derivative-based optimization and improving robustness against local minima. One promising architecture is the autoencoder-based extractor [1][5], which compresses device data into a latent space and then reconstructs it while simultaneously linking the latent representation to model parameters.
- **Gradient-Based Methods** incorporate ML techniques into numerical optimization, using gradients to efficiently minimize error between measured and modeled characteristics. These methods are fast but require careful regularization to handle highly nonlinear regions.
- **Derivative-Free Optimizations (DFO)** are well-suited for parameter extraction when gradients are unavailable or unreliable in highly nonlinear or discontinuous spaces. Instead of relying on derivatives, these methods use iterative search strategies that handle non-smooth objective functions and complex compact models with strong robustness to local minima. Although generally more evaluation-intensive than gradient-based methods, DFO techniques effectively support multi-objective extraction and offer reliable performance across challenging parameter landscapes [6].

Reinforcement Learning (RL) is well-suited for solving sequential decision-making problems, where an agent interacts with an environment by taking actions to maximize cumulative long-term reward. Unlike supervised learning, RL must handle uncertainty, delayed rewards, and the exploitation trade-off. It is widely applied in domains such as robotics and autonomous driving, where environments are dynamic and short-term rewards may not clearly indicate optimal behavior [7]. Currently, as with many AI algorithms applied to model parameter extraction, the high dimensionality of the number of parameters involved remains a major bottleneck.

In summary, AI/ML introduces powerful, scalable solutions for both device behaviour modelling and compact model parameter extraction, dramatically reducing manual effort, improving robustness, and enabling faster deployment of next-generation technologies.

AI/ML applications in device modelling

Neural Network-Based Modelling

Neural network-based modelling is emerging as a powerful solution for advanced semiconductor technologies, especially during early development stages when no mature compact models are available. Neural network models eliminate the need for complex analytical derivations and manual parameter extraction by learning directly from experimental data, enabling faster and more flexible model creation.

Applications of neural network-based modeling, such as NeuroFET [8] and DynaFET [9], have demonstrated strong performance. In parallel with these developments, neural network-based modeling has evolved into a versatile framework that can be applied across a broad range of device types. For example, in the case of GaAs pHEMT devices, separate neural network circuit components were trained by measured data to model the drain and gate currents and charges, then seamlessly integrated into a Verilog-A framework. Figure 1 shows excellent agreement between simulation and measurement. Both the IV characteristics and small-signal parameters exhibited highly consistent and accurate matching, confirming the robust potential

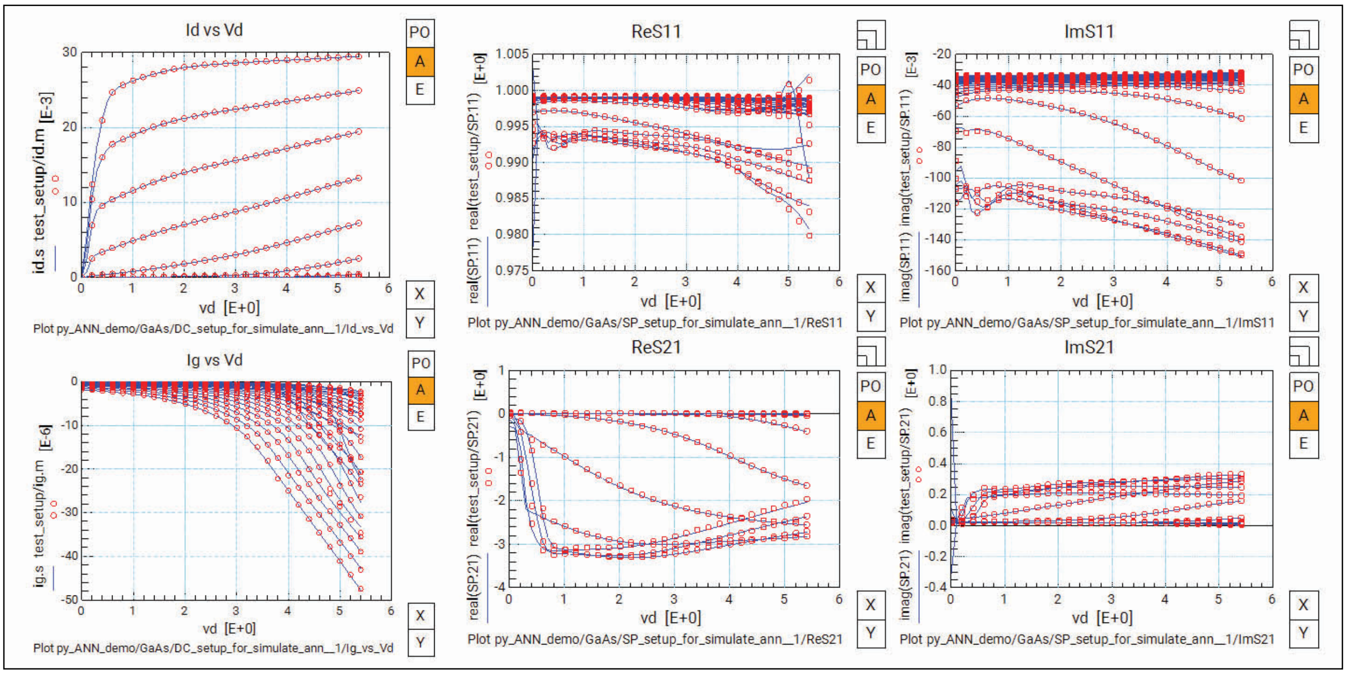


Figure 1. IV characteristics and S-parameters predicted by the neural network model, demonstrating accurate modeling of the GaAs device across multiple bias conditions.

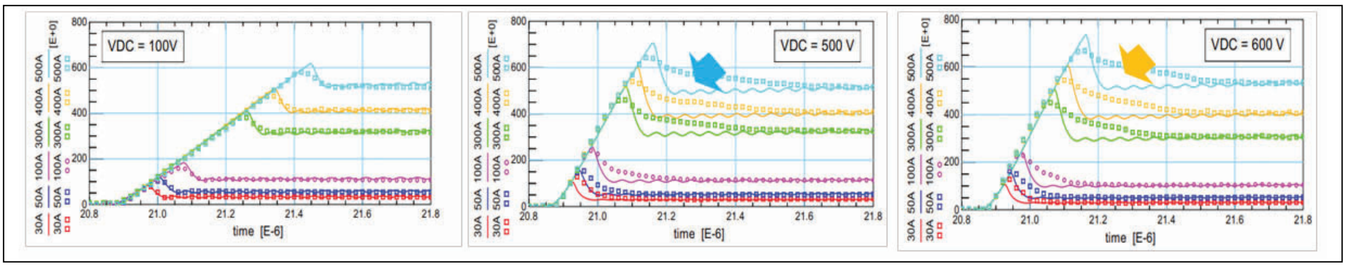


Figure 2. Reverse recovery fitting results for the IGBT model at different biases and room temperature. The model accurately fits the reverse recovery behavior at VDC = 100V, but struggles to achieve precise fitting at higher voltages, specifically VDC = 500V and 600V. conditions.

of neural network-based modeling for compound semiconductor devices.

The main insight from this case is that it enables rapid model generation for fast device and circuit evaluation while capturing complex nonlinear behavior directly from data, eliminating the need for explicit physical equations.

Hybrid Neural Network Modelling

For hybrid neural network applications, numerous publications [10][11] and practical use cases have demonstrated their effectiveness in modelling advanced devices such as power MOSFETs, III-V transistors, and FinFETs. This approach can address the limitations of industry-standard models and significantly improve modelling accuracy within a shorter development cycle. Unlike a purely data-driven neural network, the hybrid neural network method retains the physical foundation of traditional models, offering better interpretability of device characteristics and enhanced stability when dealing with device scaling challenges.

Building on the hybrid neural network concept, a practical application is modelling the reverse recovery behaviour of IGBT devices under various bias conditions [10]. This phenomenon, validated using the industry-standard Double Pulse Test (DPT), is critical for accurately predicting transient current surges during device switching.

Conventional models describe reverse recovery with nonlinear differential equations, which struggle to maintain accuracy across varying biases and temperatures, as shown in Figure 2. To address this, a hybrid approach is employed: neural networks are used to model key parameters (such as charge storage and release time constants) as functions of voltage, current, and temperature. These neural network modules are then incorporated into the compact model, enabling them to adapt dynamically to different operating conditions.

Figure 3 illustrates how the hybrid IGBT neural network model significantly improves the fitting of the reverse recovery waveform, particularly the rising edge, peak current, and falling behavior, across a wide range of voltages.

Notable improvements are observed at high voltages, such as 500 V and 600 V. This demonstrates that the hybrid neural network approach is a powerful and practical method for enhancing the accuracy and robustness of device modelling.

From this use case, several key takeaways can be highlighted:

- Combines physics-based models with data-driven learning to capture complex effects beyond traditional formulations.
- Improves fitting accuracy for highly nonlinear and transient behaviours.
- Significantly shortens model development time and effort.

ML-Driven Model Parameter Extraction

ML-driven modelling is a versatile tool for device modelling, simplifying the process even for users with limited experience. As device dimensions shrink, short-channel effects and other complex phenomena become more pronounced, significantly increasing the complexity of the modelling process. Engineers must strike a careful balance between extraction, accuracy, and their expertise, often relying on years of experience to navigate these challenges effectively.

In light of these challenges, one critical objective remains: achieving a repeatable and reliable extraction flow that minimizes development time. Automated, streamlined workflows not only reduce the risk of manual errors but also accelerate the entire modelling process, enabling faster and more consistent device development across generations of technology.

Unlike traditional gradient-based algorithms, which can get stuck in local minima, the derivative free algorithms explore the entire parameter space to find the best global solutions. They apply to a wide range of device types, provided the underlying model captures key characteristics, automating the search for optimal parameters. This reduces manual tuning and enhances both accuracy and robustness, speeding up modelling workflows.

To demonstrate the effectiveness of the new ML-driven modelling, a comprehensive MOSFET modelling workflow is created using the BSIM4 model. The project covers 36 different device sizes and remarkably requires only 5 to 6 streamlined steps, compared to traditional modelling flow, which often involves over 100 steps. During model fitting, more than 80 model parameters are simultaneously optimized to capture device characteristics, including Id-Vd, Id-Vg, and gm-Vg. As shown in Figure 4, the results demonstrate robust performance across all device sizes, highlighting the workflow's efficiency, repeatability, and capability to handle complex device scaling with minimal development time.

Another powerful application of advanced device modelling is the use of the VBIC model for bipolar transistors. Traditional modelling of such devices requires numerous interdependent parameters and fragmented extraction steps, resulting in a complex and time-consuming process. By applying ML optimization, this workflow is streamlined into just three key steps. This approach efficiently locates the global optimum in a single day, reducing manual intervention and enhancing accuracy. Additionally, the ML-driven method is highly adaptable to a wide range of devices and models, including types such as III-V and FinFET, offering a more efficient and consistent modeling process with minimal effort.

From the new ML-driven modelling, several key takeaways can be highlighted:

- Simplifies extraction steps from hundreds of steps to 5-6.
- Automates modelling with minimal manual effort and errors, enabling stable, repeatable modelling.
- Adapts easily to different device types and compact models.
- Reduces dependency on user expertise, allowing both beginners and experts to achieve high quality fits.

Performance benchmark

DynaFET Model

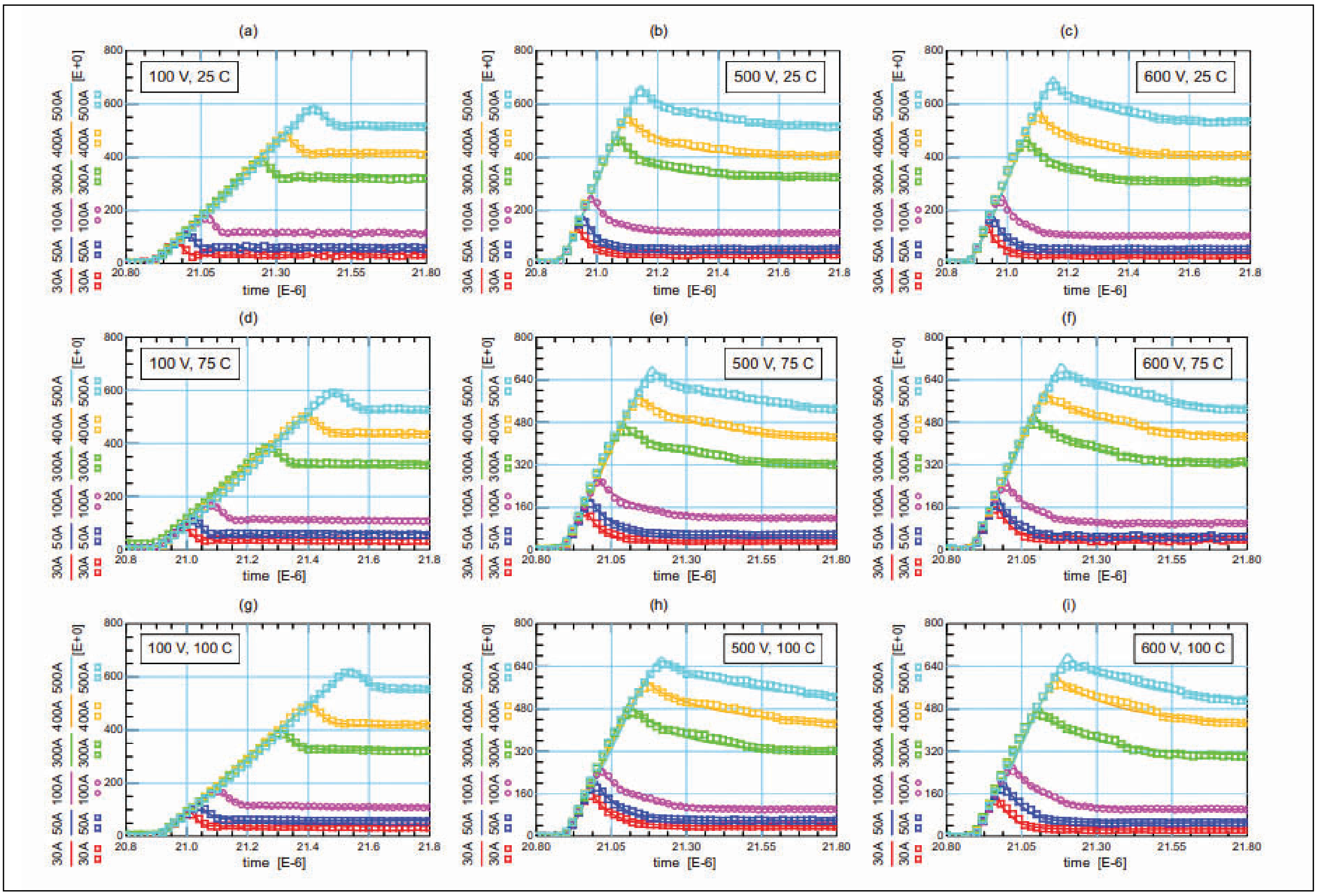
To demonstrate the advantages of the neural network-based model, a benchmark was established based on the DynaFET model, focusing on its predictive accuracy, robustness, and simulation efficiency using a comprehensive measurement. The benchmark employed a 150 nm, 6 × 60 μm GaN HFET from Raytheon Integrated Defense Systems, a device optimized for power amplifier, low-noise amplifier, and switch applications across the 1 to 40 GHz frequency range. Model extraction utilized large-signal data at 100 MHz and S-parameter data at 3.5 GHz obtained from the NVNA setup [11].

Results and comparison

DC validation: The DynaFET model reproduces measured DC characteristics at 55 °C with high fidelity, accurately capturing nonlinear drain current, gate leakage behavior, and turn-on characteristics. These features, typically difficult for analytical compact models to reproduce, are inherently captured through the neural network's ability to learn coupled electro-thermal and trap related dynamics.

Broadband S-parameters: The model exhibits excellent agreement with measurements from 0.5 GHz to 50 GHz. This demonstrates the accuracy of the neural network model across the frequency spectrum, as dynamic charge and dispersion effects are implicitly learned from the training data.

➤ Figure 3. Reverse recovery fitting results using the hybrid neural network approach. The model achieves accurate fitting for VDC = 100V, 500V, and 600V under different temperatures.



Large-signal and power performance: The comparison of gain compression, bias current, Power Added Efficiency (PAE), and harmonic distortion under large-signal excitation. The DynaFET model accurately predicts both the magnitude and shape of the compression and harmonic trends up to 7 dB of gain compression, while traditional models typically diverge at high power due to fixed functional assumptions and missing dynamic terms.

Two-tone intermodulation and load-pull: Modelled and measured results for third- and fifth-order Intermodulation Distortion (IMD) and load-pull metrics confirm that the neural network-based model captures complex nonlinear interactions and dynamic self-heating effects without any additional parameter re-extraction. The agreement extends over a wide range of bias conditions and frequencies, highlighting the robustness and adaptability of the approach.

Key takeaways

The benchmark highlights that the neural network-based DynaFET model provides superior accuracy, robustness, and usability with 150 nm, 6 × 60 µm GaN HFET. By directly learning complex device behavior from measurement, it eliminates repetitive tuning cycles, improves predictive capability across a wide operating range, and streamlines RF and power electronics design workflows.

Hybrid ASM-HEMT model

This benchmark compared a hybrid modelling workflow that combines a neural network module with the ASM-HEMT physical model against a baseline using ASM-HEMT alone. The objective was to evaluate the overall improvements in fitting accuracy.

Results and comparison

The benchmark is conducted on a GaN-on-SiC HEMT device featuring a gate length of 150 nm and a total gate width of 4 × 50 µm. The simulation using the ASM-HEMT model (version 101.4) provides accurate DC fitting while maintaining strong physical interpretability.

Under the biased conditions of V_D to 25 V and V_G = –3 to –1 V, and within a frequency range of 250 MHz to 50 GHz, the S-parameter fitting exhibits noticeable deviations, as shown in Figure 5(a). In the figure, the red dots denote measured data, while the blue solid lines represent simulation results.

To enhance high-frequency accuracy, a hybrid ASM-HEMT with neural network model was developed by introducing three additional capacitances and two resistances into the ASM-HEMT baseline. As illustrated in Figure 5(b), this hybrid model significantly improves the agreement between measured and simulated S-parameters, achieving excellent fitting accuracy across the entire frequency range.

Figure 6 illustrates the measured and simulated Pout, PAE, and dynamic load lines (ΔP_{in} = 3 dBm) at a fundamental frequency of 10 GHz with Z_s = 50 Ω and Z_L = 87.2 + j71.3 Ω and biased at Z_D = 20 V and Z_G = -2 V. The simulation using load-dependent X-parameters with the hybrid ASM-HEMT neural network model aligns well with the nonlinear measurements obtained from NVNA measurements.

In contrast, the baseline ASM-HEMT model (without modifications) is less accurate regarding the gain curve and dynamic load lines. This is also evident in the case of S-parameters across a wide range of biased conditions [11].

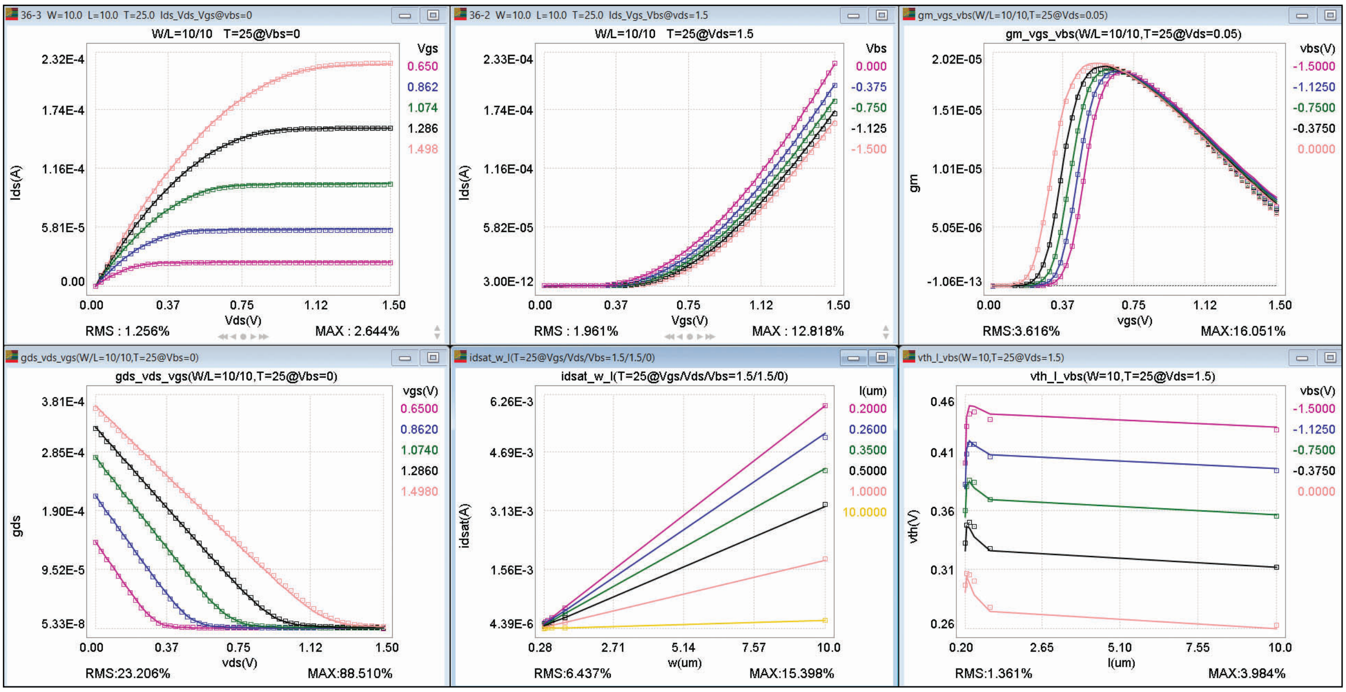
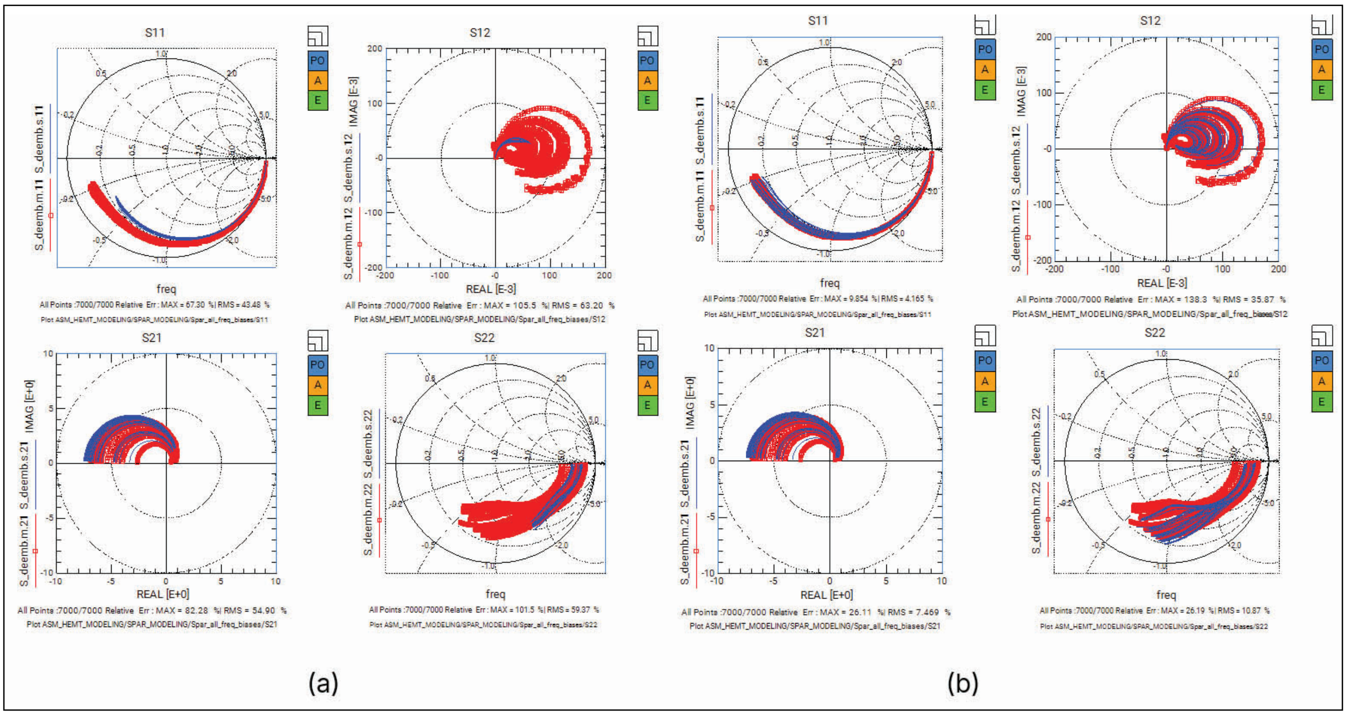


Figure 4. Final fitting results with BSIM4 of key characteristics and scaling plots for the large device, obtained through global optimization across 36 device sizes.



➤ Figure 5. (a) Fitting of S-parameters without neural network. The simulation is done with ASM-HEMT 101.4. (b) Improved fitting of S-parameters with the hybrid ASM-HEMT neural network model.

Key takeaways

Hybrid neural network modelling combines the data-driven adaptability of neural networks with the robustness of physical models, offering a scalable and flexible solution to modern device modelling challenges. It enables faster model development, improved accuracy, and preservation of physical integrity.

ML-Driven BSIM4 Modelling

To evaluate the performance of the ML-driven modelling flow, a benchmark was conducted using the BSIM4 model. The objective was to assess improvements in extraction complexity, fitting accuracy, and workflow robustness across different device geometries and operating conditions.
Both optimization flows were tested under identical initial conditions using the same measured IV datasets and parameter initial settings. 36 devices with both large and small sizes and 80+ parameters are included in the flow. The ML-driven modelling applied a gradient-free global search strategy, while the traditional flow used a gradient-based local optimization algorithm. Each flow aims to achieve the best fitting of Id-Vd, gds-Vd, Id-Vg, and gm-Vg characteristics over multiple bias regions and device sizes.

Results and comparison

(see table 1)

Key takeaways

- Streamlined modelling process: Automates parameter extraction and reduces flow complexity, enabling an intuitive, efficient workflow that boosts productivity.
- Rapid technology adaptation: Allows engineers to quickly reuse or adapt modeling flows for new or similar device types, accelerating deployment.
- Flexible global optimization: Supports easy definition of parameter ranges, initial values, and fitting regions to efficiently achieve stable, globally optimal results.
- Reduced expertise dependence: Minimizes the need for deep modeling knowledge, allowing engineers of all experience levels to achieve high-quality, consistent outcomes.
- Seamless python integration: Enables easy automation and customization of extraction flows within Keysight's EDA platform, without requiring advanced programming skills.

Business impact - enhancing competitiveness through smarter modelling

As semiconductor technologies advance and process nodes evolve rapidly, delivering accurate and timely PDKs has become a critical differentiator. Faster, more reliable model development directly influences PDK

> This phenomenon, validated using the industry-standard Double Pulse Test (DPT), is critical for accurately predicting transient current surges during device switching

Table 1

Performance	ML-driven Modeling Flow	BSIM4 Traditional Modeling Flow
How many steps	5-6 steps	200+ steps
Sensitivity to Initial Guess	Not sensitive	Sensitive
Multi-Objective Handling	Efficiently optimizes multiple objectives simultaneously, 120+ plots in one step; extraction flow is simple	Poor at handling multiple objectives, few plots in one step; extraction flow is complex
Parameter Correlation Management	Handles parameter correlation well; 80+ parameters can be included in a single step	Poor at handling parameter correlation; only a few parameters can be tuned per step
User Intervention / Manual Tuning Effort	Easily finds global optimum; minimal manual tuning required	Requires many iterations and significant manual tuning
Ease of Setup	Easy to build a modeling flow without extensive prior experience with better accuracy	Requires deep modeling knowledge and experience
Parameter Bound Control	Parameter boundaries are important, but more flexible	Highly sensitive to parameter boundaries
Reusability of Settings	Easy to reuse the created flow for other technologies	Difficult to reuse; requires extensive adjustments

release schedules, customer adoption timelines, and ultimately, the commercial success of New Production Introduction (NPI). In this environment, adopting AI/ML driven modelling is not merely a technical enhancement; it is a strategic business imperative.

AI-enhanced compact modelling significantly shortens development cycles by automating traditional manual and iterative extraction workflows. By reducing hundreds of extraction steps to fewer than ten and minimizing reliance on expert-intensive tuning, engineering teams can accelerate model delivery from weeks to days. This compressed cycle time enables earlier design starts for customers, faster validation of new technology nodes, and increased competitiveness in securing early market share.

The improvement in modelling accuracy and predictive fidelity also reduces costly redesigns and post-silicon surprises. High-quality models that closely reflect real device behaviour strengthen customer confidence, reduce performance gaps between simulation and silicon, and improve first pass success rates. For foundries and Integrated Device Manufacturers (IDMs), this translates into more efficient PDK adoption and stronger engagement with ecosystem partners.

Beyond operational efficiency, AI/ML-based modelling enables scalable reuse and repeatability across process nodes, device geometries, temperatures, and corner conditions. Automated optimization and seamless integration with measurement and data-processing workflows allow engineering teams to manage increasing complexity without expanding resources. This creates a sustainable path to innovation, allowing organizations to respond quickly to technological shifts and customer requirements.

Ultimately, intelligent modelling powered by AI/ML enhances productivity, lowers development risk, and accelerates time-to-market—delivering measurable strategic and financial value. By adopting these capabilities today, semiconductor companies position themselves for leadership in a rapidly evolving industry landscape.

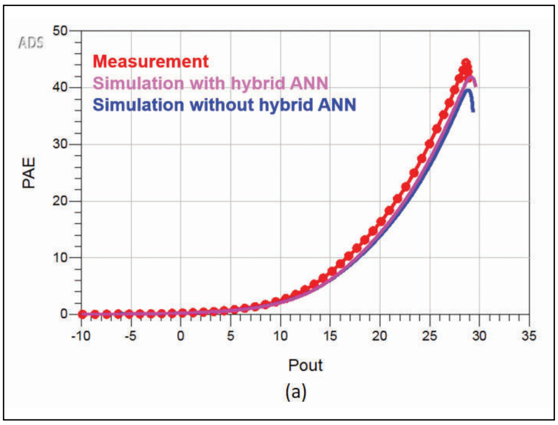
Conclusion

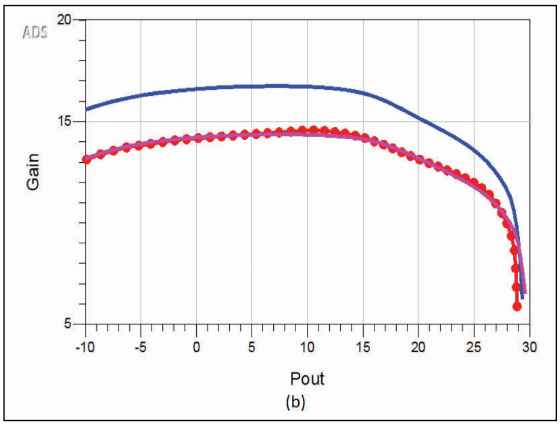
As the semiconductor industry advances into an era defined by heterogeneous integration, novel device architectures, and system-level co-optimization, the demands placed on modeling frameworks have grown exponentially. Traditional modeling approaches are increasingly challenged by the complexity, scale, and speed required in modern design environments.

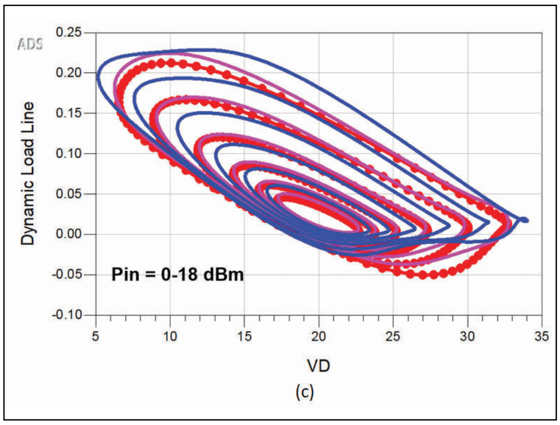
This article has outlined how AI and ML are advancing the landscape of semiconductor device modelling. From neural network-based models that eliminate the need for manual parameter tuning to hybrid neural network architectures that blend physical insight with data-driven adaptability and ML-powered modelling workflows, these technologies are enabling faster, more accurate, and more scalable modelling solutions.

The applications and benchmarks presented demonstrate that AI/ML-based modelling not only improves predictive accuracy across DC, RF, and large-signal regimes but also reduces development time, enhances generalization across device variants, and lowers the barrier to entry for model developers. These capabilities closely align with the principles of DTCO, enabling tighter integration among devices, circuits, and system design.

In this rapidly transforming landscape, embracing intelligent modelling frameworks is not just an opportunity; it is a necessity for staying competitive, agile, and future-ready.







➤ Figure 6. Large-signal simulation results compare measurement, the model without neural network parameters, and the hybrid neural network model. (a) PAE, (b) Gain, and (c) Dynamic Load Line. The hybrid neural network model shows improved agreement with measurement across all metrics, demonstrating its effectiveness in capturing nonlinear large-signal behavior.

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Pakal powers up silicon's next act

With its IGTO(t) switch and Hitachi Energy deal, can Pakal Technologies bolster silicon's edge in high-voltage power electronics and challenge IGBTs and SiC devices?

BY REBECCA POOL, TECHNOLOGY EDITOR

Earlier this year, US-based silicon power semiconductor firm, Pakal Technologies, and Hitachi Energy, Switzerland, joined forces to deliver next-generation power modules to rail, renewables, energy storage, AI and data centre markets. By integrating Pakal's insulated gate turn-off (thyristor) power switch into Hitachi Energy's high voltage (≥ 3.3 kV) modules, the partners intend to reduce energy losses and improve overall efficiency in high-voltage power conversion - a key challenge in large-scale electrification.

"We have proven reliability, manufacturability and scalability, and we believe markets have been asking for this as long as there have been power semiconductors," says Pakal Technologies CEO and co-founder, Benjamin Quinones. "This is a direct drop-in replacement for IGBTs, and many applications will be helped [by the technology]. Now is the time to share this with the world."

Pakal Technologies launched in 2017 to develop and commercialise the IGTO(t), which is described as the "first new high-voltage silicon power switch since the IGBT". The firm's leadership is impressive. Alongside Quinones, trench MOSFET inventor, Richard Blanchard, and advanced power diode tech innovator, Vladimir Rodov - who pioneered Diodes Incorporated's Super Barrier Rectifier (SBR) and the Field Effect Rectifier Diode (FERD) from STMicroelectronics - are co-founders. Blanchard also serves as Executive Chair while Rodov is Chief Scientist – both have now developed the IGTO(t) power switch.

As Quinones puts it: "We have these innovative, creative, thoughtful fellows asking hard questions in silicon, and I think they both agree the IGTO will be bigger than all of these [past devices] combined."

Silicon compromises

Power switching in silicon involves balancing voltage rating, current capacity and switching speed. In high-power applications, thyristors - built on a four-layer structure of alternating positive- and negative-type semiconductor regions - are robust and have low conduction losses. However, these devices are limited in controllability and cannot be turned-off via their gate, making them impractical for compact, high-speed power conversion. In contrast, MOSFETs lack the four-layer bipolar structure of the thyristor, and instead rely on majority charge carrier devices. These devices can achieve very high switching speeds, but are restricted by conduction loss efficiency and thermal limits.

IGBTs were developed to circumvent these issues, combining the high voltage and current capability of thyristors with the ease of drive of MOSFETs. Still, these devices rely on a three-layer bipolar structure, fundamentalwly limiting current density and conduction efficiency compared to the four-layer thyristor.

Given these constraints, Rodov and Blanchard set out, more than a decade

[Hitachi Energy]

➤ Pakal Technologies' silicon power semiconductors are being integrated to high-voltage power modules from Hitachi Energy.

ago, to develop a high voltage silicon switch that combines the efficiency and low conduction losses of thyristors with the switchability of IGBTs. They combined a thyristor-like four-layer architecture with the gate-controlled switching of the IGBT, creating the IGTO(t). Using a novel trench gate design to actively manage the electric fields and carrier dynamics within the silicon, their new device was able to achieve low conduction losses through dual-carrier operation while retaining turn-on and turn-off capability via an insulated gate.

According to the firm, the IGTO(t) achieves up to 30% lower conduction losses than state-of-the-art IGBTs at high current and temperatures while maintaining IGBT-like switching performance. "We really have this tremendous advantage here," points out Quinones.

The company claims its devices already beat the efficiency of the best IGBTs, and with equalized switching, offer dramatically lower VCE(sat) (often >0.40 V lower) under real-world operating conditions and temperatures. And because the voltage gate drive switching mechanism is the same as that of the IGBT, the device can serve as a direct drop-in upgrade in many applications. "We've managed to get the best of all worlds here… and that's what will make our company extremely profitable," says Rodov.

Manufacturing promises to be straightforward. According to Quinones, the IGTO(t) can be fabricated using fully-amortised legacy silicon facilities. As Blanchard notes: "The same fabs can be used to fabricate both the trench IGBT and the trench IGTO – it's an easy transition into the fab."

Likewise, the Pakal Technologies executives expect the IGTO(t) cost to be on par with an IGBT. "The numbers of layers and masks, and process steps, for the trench IGBT and trench IGTO are shockingly similar," says Quinones. "At high volume, our cost will be comparable to that of a high quality IGBT manufacturer."

Following a supply partnership with Richardson Electronics, US, initial shipments of both 650V and 1200V IGTO(t) power switches are underway. So far, devices target sub-20 kHz, medium frequency high power applications, including industrial motor drives, electric vehicle traction inverters, renewable energy inverters, uninterruptible power supplies and welding equipment. Right now, this places the IGTO in the operating window where silicon remains dominant; applications that demand high efficiency at moderate switching frequencies but do not justify the cost of wide bandgap materials.

"From day one we've been targeting IGBT use-cases and will now be going up the switching frequency ladder," says Quinones. "We hope and expect to replace many, many IGBTs in different applications."

Alternative technologies

But what about silicon carbide MOSFETs? Analysts have predicted the SiC MOSFET market to rapidly grow at around 30% CAGR over the next decade, reaching upwards of $20 billion by 2035 – with these devices steadily capturing market share from silicon IGBTs along the way.

Quinones affirms that for applications above 80 kHz, the fast-switching SiC MOSFETs come into their own. "Where customers really need that high frequency switching with relatively high power, they can pay the price increase and should 100% use silicon carbide, and not the silicon IGBT or our IGTO," he comments.

"In reality, we think silicon carbide will always be about twice the cost of the corresponding silicon," he adds. "But the market is already large, it's rapidly growing, and there's room for many winners here… And where silicon persists, which we think will be around 70% of the [power semiconductor] market, then big chunks are going to go to the IGTO."

Blanchard also adds perspective on the broader semiconductor market, questioning the rationale for turning to wide bandgap semiconductor devices. "When you consider both performance and cost, at what point, if at all, are either SiC or GaN superior [to silicon]," he asserts. "[For manufacturing], you're also going to need to have a certain number of GaN and SiC fabs to supply the market-place."

Beyond hitachi

With Hitachi Energy now incorporating the IGTO(t) silicon power switch to its ≥3.3 kV power semiconductor modules, Pakal Technologies is eyeing other tech opportunities. Quinones is confident the IGTO(t) can scale from 650V all the way to 10 kV. "We will be filling out the voltage families now," he says.

The firm will also be looking to deliver numerous variants of its products, which will follow in the next few years. Both a bi-directional and an ultra-fast IGTO can be expected, as well as a reverse-conducting IGTO. "In all of these, we will be bringing the industry better and better performance with each product generation," says Quinones.

The CEO also highlights how he and Pakal Technologies colleagues are eager to partner with a global automotive industry player, integrating their IGTOs into power modules rated up to 2.5 kV, targeting mainstream EVs through to heavy-duty traction systems. Key applications would include rail, range extenders for electric vehicles, hybrid inverters that currently combine SiC and silicon devices, ANPC (Active Neutral Point Clamped) 3-level inverters and solid-circuit breakers. "If it comes down to an IGBT or us, then we firmly believe a global partner in the automotive space should use our technology," asserts Quinones.

In the meantime, investment is set to follow soon. Pakal Technologies secured $25 million in its Series B funding round back in January 2025, which was led by London- and Connecticut-based venture capital firm, New Science Ventures. Additional funds came from high-tech VC firm and past investor Translink Capital as well as energy efficiency VC investor, Arborview Capital.

"We're raising Series C financing as we speak, and will use these resources to develop our additional products," says Quinones.

For Rodov, Pakal Technologies' journey is just beginning. "This is a new animal in the field - we've got some new physics and a new construction," he says. "Our optimization of our products has just started and while we see many many possibilities ahead of us, there will be many more we have yet to discover."

Building the UK's semiconductor future

Professor Owen Guy, CISM, Swansea University and Director of the Centre for Nanohealth in the College of Engineering at Swansea University, explains that Swansea University is to lead a major national initiative, The UK Semiconductor Industry Future Skills (UK-SIFS) CDT, to address the UK's semiconductor skills gap. The new Centre for Doctoral Training (CDT) will deliver advanced doctoral-level training in semiconductor skills that are critical to the UK's ambitions for a resilient and competitive semiconductor manufacturing sector.

The global semiconductor industry is undergoing a profound transformation. Driven by accelerating demand from artificial intelligence (AI), electric vehicles (EVs), renewable energy systems, and data infrastructure, the need for advanced semiconductor technologies - and critically, the talent to develop and manufacture them - has never been greater. Against this backdrop, the UK is taking a strategic step forward with the creation of the UK Semiconductor Industry Future Skills (UKSiFS) Centre for Doctoral Training, led by Swansea University.

This initiative represents far more than a conventional academic programme. It is a coordinated response to a rapidly evolving industrial landscape, designed specifically to close the gap between cutting-edge research and real-world semiconductor manufacturing. With strong industrial alignment, access to advanced facilities, and a focus on commercially relevant innovation, UKSiFS aims to strengthen the UK's position in key semiconductor domains, particularly in power electronics and compound semiconductors.

A convergence of timing, infrastructure, and regional growth

The timing of the programme's launch is closely linked to the readiness of the Centre for Integrative Semiconductor Materials (CISM), a £60 million facility that has recently become fully operational in South Wales. This alignment is particularly significant because the region itself is experiencing rapid growth as part of the South Wales Compound Semiconductor Cluster.

Major industry players such as KLA Corporation and Vishay Intertechnology have expanded their presence in the area, investing heavily in both manufacturing and research activities. Alongside them, companies including IQE plc, Edwards Vacuum, and Space Forge are contributing to a dynamic and interconnected semiconductor ecosystem.

This concentration of industrial and academic capability is critical. It enables faster knowledge transfer, fosters collaboration, and supports the development of a skilled workforce. UKSiFS is positioned at the centre of this ecosystem, acting as a bridge

> Most of the doctoral projects are expected to be co-developed and supported by industrial partners, ensuring that the research is both academically robust and directly relevant to commercial challenges. Students will engage with real-world problems that reflect the immediate and future needs of the semiconductor industry

between education, research, and industrial application.

Redefining doctoral training for industry needs

While doctoral training centres are well established within the UK, UKSiFS introduces a model that is much more deeply embedded in industrial priorities. Traditional PhD pathways often allow for industry engagement, but this programme is fundamentally structured around it.

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The scope of research is deliberately broad but consistently aligned with industry demand. It includes efforts to make semiconductor fabrication more energy efficient, particularly by reducing emissions from fabrication facilities. There is also a strong emphasis on power semiconductor devices, which are essential for applications such as AI data centres, electric vehicles, and energy systems. In addition, the programme addresses advanced materials such as silicon carbide and gallium nitride, as well as emerging processing and packaging technologies.

The result is a training model that produces graduates who are not only highly capable researchers but also equipped with the practical skills and commercial awareness needed to contribute effectively within industry from the outset.

Deep industry integration in research

The strength of UKSiFS lies in the depth of its collaboration with industry, which is reflected in the nature of its research projects. For example, partnerships with KLA Corporation allow students to explore gallium nitride process development at the cutting edge. This includes developing fabrication techniques that have the potential to transition directly into industrial use.

Access to industrial-grade equipment at Swansea enables a much smoother transfer of knowledge from the research environment to manufacturing. This significantly reduces the time required to move from concept to practical implementation.

Similarly, work with Vishay Intertechnology focuses on silicon carbide technologies. Research in this area may involve detailed investigation of material interfaces, including the chemistry and physics that influence device performance and reliability. These are highly specialised topics, but they have direct implications for the efficiency and durability of power electronic devices.

Across the programme, projects are designed not only to advance knowledge but also to ensure that outcomes are scalable and commercially viable.

Expanding and diversifying the talent pipeline

A key objective of UKSiFS is to address the growing shortage of semiconductor skills by expanding the talent pipeline. This involves not only training new graduates but also creating opportunities for professionals from other high-skill sectors to transition into the semiconductor industry.

To support this, Swansea has developed intensive cleanroom training programmes that provide hands-on experience in semiconductor fabrication. Participants can learn to manufacture a compound semiconductor device within a week, gaining exposure to the full fabrication process in a real-world environment. This level of practical training is relatively rare in academic settings and represents a significant advantage.

In addition to cleanroom training, the programme offers a range of specialised modules covering areas such as plasma and etch technologies, power electronics, compound semiconductors, photonics, and

emerging thin-film technologies. These modules form part of a structured training package that complements the research component of the PhD.

Flexibility as a core principle

Flexibility is a defining feature of the UKSiFS approach, reflecting the diverse backgrounds and needs of its participants. The programme accommodates full-time and part-time PhDs, as well as industry-based research roles.

This flexibility has already demonstrated its value in earlier, less formal programmes. Experienced professionals working in industry have been able to undertake doctoral research alongside their existing roles, contributing practical insights to the academic environment while benefiting from access to advanced research facilities.

The integration of students with different levels of experience creates a richer learning environment. It allows for the exchange of knowledge between academia and industry, benefiting both sectors and enhancing the overall impact of the programme.

Advanced facilities driving innovation

The facilities supporting UKSiFS are among the most advanced available in the UK. The CISM facility at Swansea houses approximately £30 million worth of equipment, capable of processing 200 mm wafers, which remain widely used in semiconductor manufacturing.

The centre includes a pilot line for silicon carbide processing, positioning it as a national hub for this technology. It also hosts the National Centre for Gallium Oxide Growth, providing capabilities for developing next-generation materials. Advanced etching systems are tailored to specific materials, while molecular vapour deposition tools enable high-throughput deposition of ultra-thin films.

These capabilities are supported by highly skilled technical staff, whose expertise is essential for both operating the equipment and training students. The University of Leeds contributes additional facilities and experience, creating a complementary partnership that enhances the overall capability of the programme.

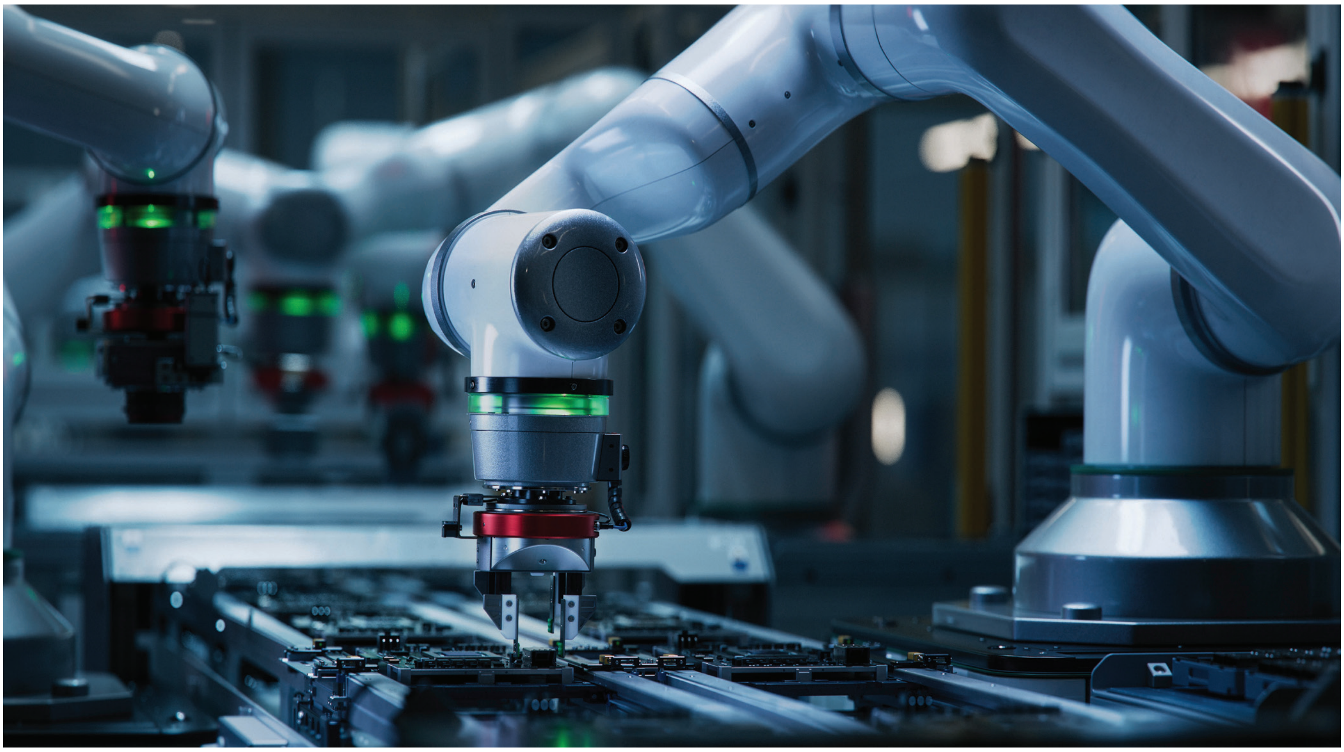
Aligning with industry growth and national priorities

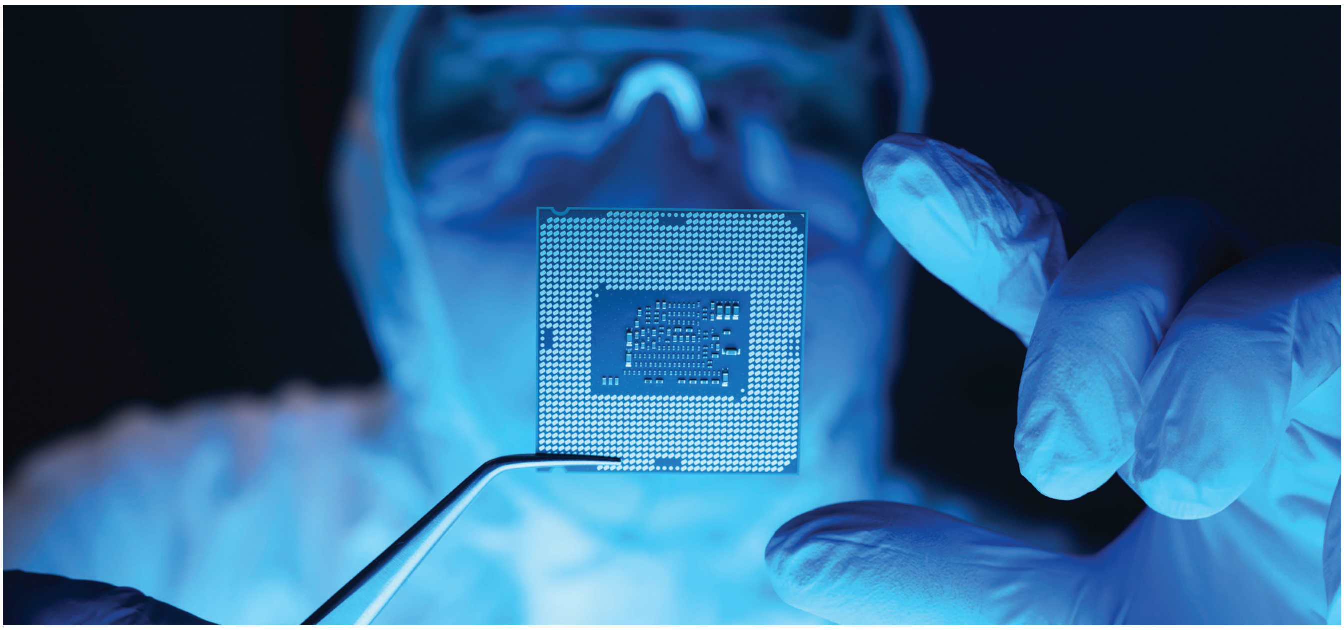
The semiconductor industry is entering a period of sustained growth, driven by multiple converging trends. UKSiFS is designed to align closely with these developments, ensuring that its graduates are prepared to meet both current and future demands.

The integration of students with different levels of experience creates a richer learning environment. It allows for the exchange of knowledge between academia and industry, benefiting both sectors and enhancing the overall impact of the programme

AI data centres are a major driver of semiconductor demand, requiring not only advanced computing chips but also highly efficient power management systems. Electric vehicles are another key area, with the number of semiconductor components per vehicle continuing to rise. Renewable energy systems and the broader transition to net zero are also heavily dependent on efficient power conversion technologies.

By focusing on these application areas, the programme ensures that its research and training remain





relevant to the most significant opportunities within the global semiconductor market.

Bridging the gap between innovation and commercialisation

The UK has long been recognised for its strength in research and innovation, but it has often struggled to translate this into commercial success. UKSiFS seeks to address this challenge by embedding commercial awareness into its training framework.

Students are encouraged to think beyond the technical aspects of their work and to consider issues such as intellectual property protection, scalability, and market viability. They are also introduced to entrepreneurial concepts, including the potential to create spin-out companies based on their research.

Close collaboration with industry partners ensures that promising innovations are identified early and developed with a clear pathway to commercialisation. This increases the likelihood that new technologies will be successfully brought to market within the UK.

Defining the UK's role in a global industry

In the global semiconductor landscape, the UK is unlikely to compete directly with regions that dominate large-scale logic and memory chip production. However, it has significant strengths in other areas that offer substantial opportunities for growth.

Power semiconductors represent one such area, as they do not require the smallest process nodes but are essential for a wide range of applications. Compound semiconductors, used in photonics, radio frequency technologies, and sensing applications, are another area of expertise. In addition, the UK has a strong presence in semiconductor equipment and process technologies.

By focusing on these areas, the UK can build a competitive and sustainable position within the global market while avoiding direct competition with the most capital-intensive segments of the industry.

Future opportunities and strategic importance

Looking ahead, several key trends are expected to shape the semiconductor industry. Artificial intelligence will continue to drive demand for both advanced computing and efficient power delivery. Electric vehicles will require increasing numbers of semiconductor devices, while the transition to net zero will depend on improvements in energy efficiency across the entire power chain.

One example of this challenge can be seen in offshore wind energy, where significant power losses occur during transmission from turbines to end users. Advanced semiconductor technologies such as silicon carbide and gallium nitride offer the potential to reduce these losses significantly, improving overall system efficiency.

Charging infrastructure for electric vehicles represents another major opportunity, as it relies heavily on the same advanced power semiconductor technologies.

Conclusion

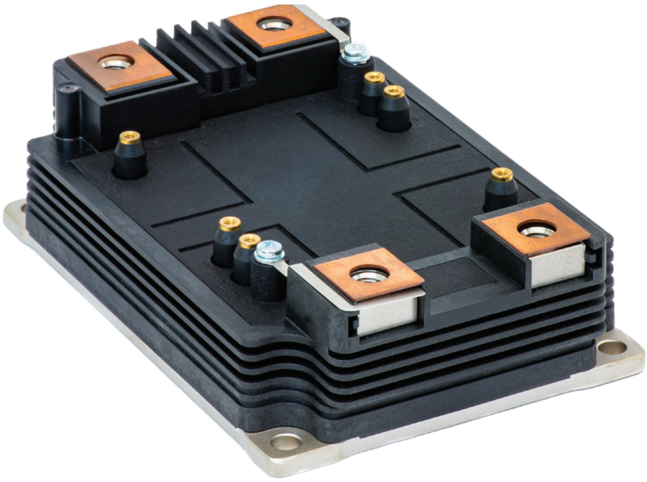
The UKSiFS Centre for Doctoral Training represents a strategic investment in the future of the UK semiconductor industry. By combining academic excellence with strong industrial engagement, it addresses one of the most pressing challenges facing the sector: the need for a highly skilled and adaptable workforce.

More importantly, it reflects a broader ambition to ensure that innovation generated within the UK is translated into tangible economic value. By fostering closer collaboration between academia and industry, and by equipping students with both technical and commercial skills, UKSiFS has the potential to play a pivotal role in shaping the future of the UK's semiconductor ecosystem.

For the power electronics community, the significance of this initiative is clear. The technologies that will define the next generation of energy systems, transportation, and digital infrastructure depend not only on scientific breakthroughs but also on the people capable of bringing those breakthroughs to life.

HV LinPak

After establishing itself as the new standard in the railway application with the Low Voltage (Viso=6kV) variant, the LinPak is now offering a High Voltage variant (Viso=10.2kV). While delivering the higher isolation voltage, it keeps the key features that made the LV variant a big success: phase leg configuration with very low stray inductance, high current density, separation of DC and AC terminals for ideal busbar and gate drive design. With these technical features, it accommodates Si IGBT as well as SiC MOSFET dies with blocking voltage 3.3kV, 4.5kV and 6.5kV.



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