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Wolfspeed raises \$1.25bn • ROHM buying Solar Frontier plant
ST/Sanan SiC fab JV for China • China Ga & Ge export controls



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p17 Solar Frontier's Kunitomi Plant in Japan, being acquired by ROHM to expand SiC power device production.



p48 Taiyo Nippon Sanso's new UR26K-CCD MOCVD system for the mass production of gallium nitride.



p54 Cree LED's new HQ at the Park Point campus in Research Triangle Park, North Carolina.



Cover image: Diodes Inc has enhanced its wide-bandgap product range by releasing automotive-compliant N-channel SiC MOSFETs for EV/HEV automotive subsystems such as battery chargers, on-board chargers, high-efficiency DC-DC converters, motor drivers and traction inverters. **p21**

China Ga and Ge export controls loom

As announced on 3 July by the China government, 1 August is due to see the start of controls on the export of gallium- and germanium-related semiconductor raw materials from China, citing reasons of national security. However, this follows the USA's imposition of restrictions on exporting leading-edge semiconductor manufacturing equipment into China, and is targeted at the USA's dependence on importation of materials for the manufacture of devices vital to defense applications, as well as the US Government's lack of a strategic stockpile of gallium.

Since 3 July, there have been responses from North America-based manufacturers of RF microelectronic devices based on gallium nitride, namely Transphorm, Navitas, GaN Systems and Wolfspeed (pages 8–9).

Wolfspeed reckons that its supply chain "will not be impacted", adding that it will continue to periodically review its supply chain. Both Navitas and GaN Systems say that their GaN-on-silicon wafer subcontract manufacturer has verified that their production will not be directly impacted, given that there are multiple sources of gallium worldwide, so they do not expect customer deliveries to be adversely affected.

Transphorm confirms that its primary trimethylgallium suppliers are not based in China, so it sees no direct impact on operations or long-term sourcing issues, and it can meet forecasted demand without interruption.

US-based Coherent expects minimal impact due to ample inventories of gallium and germanium, and the ability to source them from outside China, as well as efficient recycling programs at both it and its supply chain partners.

However, although firms may not directly source raw gallium from China, their suppliers may well do so. According to January's Mineral Commodity Summaries of the US Geological Survey (USGS), in 2022 China accounted for 86% of the world's primary low-purity (99.99%-pure) unrefined gallium production capacity, especially since China's increased production capacity and hence reduced pricing has driven producers elsewhere out of the market.

US-based AXT, which makes GaAs and Ge substrates and raw materials in China is seeking the required export permits from the Chinese authorities. However, the firm notes that in first-quarter 2023 GaAs and Ge substrates exported outside of China contributed \$4.3m, just 22% of AXT's total revenue.

The effect of China's export restrictions largely depends therefore on the prevalence of permits

Even if existing inventories can buffer any supply chain disruption in the short term, any restriction of exports from China threatens to raise market prices, especially if exacerbated by stockpiling.

The restriction of supply from China can be mitigated somewhat by an increase in production elsewhere.

For example, US-based American Elements said that it will significantly increase production of gallium and germanium from its Salt Lake City plant in order to replace Chinese imports with US domestic supply.

Also, driven especially by increased pricing, Germany could restart production of primary gallium, while a mothballed production facility in Australia could feasibly be restarted.

As may yet transpire with the US-led restrictions on equipment exports to China, restrictions on materials exports from China may impact the targeted country adversely in the short term, but longer term can provide a stimulus to domestic production that helps to mitigate the previous dependence.

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Semiconductor Today covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices

(e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers and LEDs in wireless and optical communications, etc).

Regular issues contain:

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- conference reports;
- event calendar and event previews;
- suppliers' directory.

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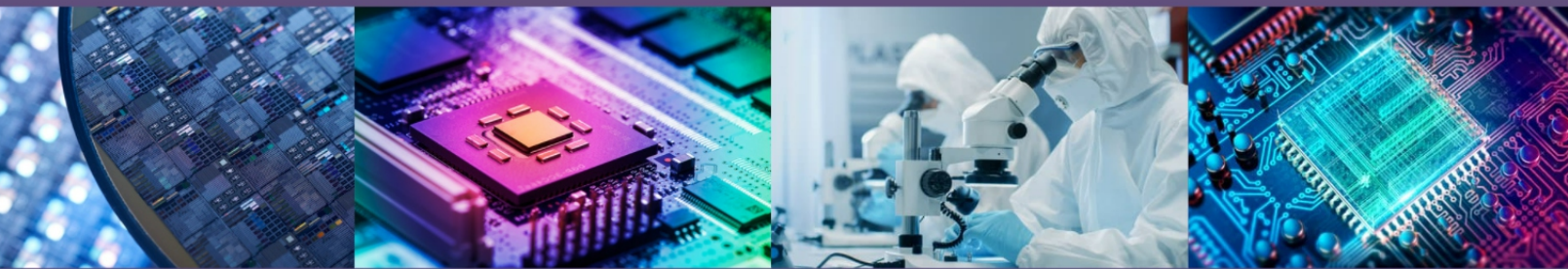
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After 23% drop in 2022, LED chip market to rebound by 5% to \$2.92bn in 2023

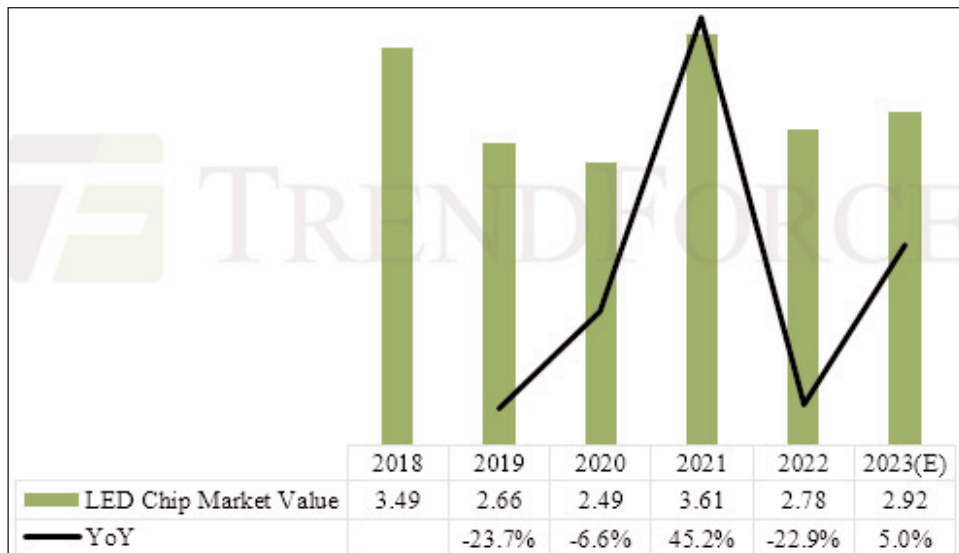
Prices of low-power light chips to surge by 3–5%

Market research firm TrendForce has reported a significant decline in global LED demand throughout 2022, resulting in a noticeable downturn in both LED lighting and video wall markets. The industry was faced with an LED chip surplus, which led to a continuous drop in prices throughout the year.

The combined impact of volume and price reduction resulted in a sharp 22.9% annual decrease in the global LED chips market in 2022, shrinking to just US\$2.78bn. Despite this challenging landscape, it is predicted that the LED industry will recover in 2023, driven primarily by a resurgence in the LED lighting market. The anticipated rebound could boost LED chip production by 5% to US\$2.92bn for 2023.

LED commercial lighting is expected to lead the comeback in the broader LED lighting market. From a supply chain perspective, the LED lighting industry hit a low point in 2018, leading to an exodus of several small- and medium-sized enterprises. Moreover, some lighting LED chip manufacturers have been consistently transitioning into more profitable sectors such as display technology. This shift resulted in reduced supply and correspondingly lower inventory levels.

In response to these changes, several LED companies opted to increase their prices. The primary



LED chip market, 2018–2023 (in US\$bn). N.B. Only firms with external LED chip revenue are included in the statistical analysis. Source: TrendForce, June 2023.

increase has been seen in the price of LED chips specifically used for lighting applications. The most significant price increase was seen for low-power light chips with an area of 300mil² or less, which saw a price rise of 3–5%. In certain cases, the price hike for chips of unique sizes reached up to 10%.

TrendForce survey data indicated a growing trend among LED supply chain companies toward raising prices. This trend is expected to persist due to the high demand for LED chips. Many companies see this price adjustment as a means to mitigate losses and actively reduce orders with low gross margins.

TrendForce's analysis underscores that most of the world's LED chip

suppliers are based in China. In recent years, heightened industry competition has forced some companies to exit the LED chip market. At the same time, Chinese LED chip makers have decreased their focus on the chip sector. Most of the suppliers that have remained in the market have reported consistent losses over an extended period.

In China, the recent price rise for low-power light chips is viewed as a short-term strategy to bolster profitability. Looking ahead, TrendForce predicts that, by striking a balance between supply and demand, and increasing industry concentration, the LED industry will gradually return to a state of normalcy.

www.trendforce.com

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Smartphone production falls by record 19.5% year-on-year to ten-year quarterly low of 250 million units in Q1/2023 Q2 to rebound 5% to 260 million, but still down 10% year-on-year

Market research firm TrendForce reports that global production of smartphones fell by a record 19.5% year-on-year to only 250 million units in first-quarter 2023, a historic low in quarterly production since 2014, as the ongoing global economic downturn continues to impact consumer confidence in the market.

Samsung produced 61.5 million units, down 16.7% year-on-year but up 5.5% quarter-on-quarter due to the launch of its Galaxy S23 series. However, TrendForce predicts a nearly 10% drop in Q2 production due to weakening demand for new models.

Apple's production fell by 11.9% year-on-year and 27.5% quarter-on-quarter to 53.3 million units in Q1. The new iPhone 14 series accounted for about 78% of this, an improvement on a year ago. However, as the firm navigates the transition period between model launches, production is expected to fall by 20% in Q2.

In light of unsatisfactory market conditions and necessary inventory adjustments, brands such as China's Oppo (which includes Oppo, Realme and OnePlus) made strategic moves to reduce production

in Q1, by 17% quarter-on-quarter to 26.8 million units. However, TrendForce forecasts a more than 30% rise in production in Q2, due to successful inventory management and a moderate demand resurgence in Southeast Asia and other regions. In addition to continuously strengthening its market share of high-end models in China, Oppo has achieved notable sales success in South Asia, Southeast Asia, and Latin America. In fact, its overseas market accounts for nearly 60% of its total sales.

Xiaomi (which includes Xiaomi, Redmi and POCO) saw its production volume fall by 27.4% quarter-to-quarter to 26.5 million units in Q1. This can be attributed largely to a global dip in consumer confidence and an overstocked inventory of finished products at Xiaomi, leading to restrained production plans. Due to ongoing inventory adjustments in Q2, quarterly production growth is projected to be capped,

to a modest estimated increase of about 20%.

Concurrently, Vivo (including Vivo and iQoo) saw its production fall by 14.2% quarter-to-quarter to 20 million units in Q1. While China continues to be the primary market for Vivo's sales, Chinese market demand remains stagnant in Q2, following the reopening of the country's borders. Production is hence expected to grow only modestly, by about 10%.

The continuous economic slump has led to increased activity in the used phone and repair markets, which could potentially hinder total smartphone production growth in Q2. Nevertheless, production is forecasted to grow by about 5% quarter-on-quarter in Q2, to 260 million units. However, due to the unfavorable economic environment, TrendForce forecasts that smartphone production will still fall by 10% year-on-year.

www.trendforce.com

Global Market Share of Top 5 Smartphone Brands for 1Q23

Ranking	Company	1Q23 Market Share	QoQ	YoY
1	Samsung	24.6%	5.5%	-16.7%
2	Apple	21.3%	-27.5%	-11.9%
3	Oppo	10.7%	-17.0%	-33.8%
4	Xiaomi	10.6%	-27.4%	-40.4%
5	vivo	8.0%	-14.2%	-12.3%

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North American device makers confirm continuity of gallium sourcing despite China's export restrictions

Firms emphasizing global sources of gallium

North America-based producer of gallium nitride (GaN) power devices have responded to China's imposition of export restrictions on gallium and germanium with statements affirming their continuity of supply.

On 3 July, China's Ministry of Commerce (MOFCOM) and General Administration of Customs (GAC) announced that export control measures on gallium- and germanium-related semiconductor raw materials would be put in place from 1 August. Gallium nitride (GaN) wafer materials are listed as being affected by these regulations.

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes GaN field-effect transistors (FETs) for high-voltage power conversion — confirmed that its primary trimethylgallium (TMGa) suppliers are not based in China and that they are well positioned to meet forecasted demand, so it is securely positioned to continue manufacturing and supplying GaN devices without interruption.

The firm also notes that gallium is generally a byproduct resulting from refinement processes used to produce common metals such as aluminium from bauxite ore, and that aluminium is produced in numerous countries including Australia, Brazil, India, Jamaica, and the USA.

Transphorm says that it will continue to monitor the situation as necessary but sees no direct impact on its current operations. Nor does it see long-term sourcing issues.

Navitas Semiconductor Inc of Torrance, CA, USA has confirmed continued supply of its GaN power ICs. The firm says that its GaN-on-silicon wafer subcontract manufacturer has verified that their production remains unaffected by the export restrictions, given the multiple sources of gallium worldwide. It hence does not expect customer deliveries to be impacted or its business to be adversely affected by the export restrictions. Navitas notes that it not use germanium in any product.

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of GaN-based power switching semiconductors for power conversion and control applications) has confirmed with its GaN-on-silicon wafer supplier that the

Navitas says its GaN-on-Si wafer subcontract manufacturer has verified that their production remains unaffected by the export restrictions, given the multiple sources of gallium worldwide

announced export restrictions on gallium and germanium raw materials will not directly impact wafer production, given that there are multiple sources of gallium worldwide. The firm hence does not see any major impact on material supplies that would disrupt its ability to supply its GaN power products to customers.

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — says that, following an internal review, its supply chain will not be impacted by the export restrictions on gallium and germanium.

"Wolfspeed strives to manage its supply chain with our supply partners through principles such as quality, availability, social responsibility, and cost," states spokesperson Melinda Walker. "We appreciate that global events can lead to dynamic market conditions that will require us to periodically review our supply chain, and we will continue to do so to ensure Wolfspeed's needs are fulfilled."

www.wolfspeed.com

www.gansystems.com

www.transphormusa.com

www.navitassemi.com

www.mofcom.gov.cn/article/zwgk/gkzcfb/202307/20230703419666.shtml

Coherent sees minimal to no impact from China's export restriction of gallium and germanium

Firm stresses ample inventories and sources outside China

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA (formerly II-VI Inc before it acquired Coherent in July 2022) has provided its initial assessment of the export restriction of gallium and germanium from China

expected to begin on 1 August.

The firm believes that the restriction will have minimal to no impact on its sales and prospects due to ample inventories of these materials at both Coherent and its supply chain partners, and the ability to source the materials from

outside China. In addition, efficient recycling programs already exist at both Coherent and its supply chain partners, the firm adds.

The company says that it will continue to monitor and assess any changes in the global supply.

www.Coherent.com

AXT to seek permits from China to export gallium and germanium substrate products

AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — has addressed the potential impact of the announcement of China's new export control regulations on gallium- and germanium-related materials, which take effect on 1 August.

China-based wafer manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd is seeking permits from the applicable Chinese authorities to export gallium and germanium substrate products. Indium phosphide substrates are not included in the new regulations and will not require exports approval. In first-quarter 2023, gallium arsenide and germanium sub-

strates exported outside of China contributed about \$4.3m to AXT's revenue, primarily for consumer, automotive, display and industrial applications.

"We are actively pursuing the necessary permits and are working to minimize any potential disruption to our customers," says CEO Morris Young.

www.axt.com

American Elements to boost production of Ga and Ge

Los Angeles-headquartered American Elements says that it will significantly expand production of gallium and germanium from its Salt Lake City plant to address the announcement on 3 July by China's Ministry of Commerce (MOFCOM)

and General Administration of Customs (GAC) of export control measures on gallium- and germanium-related semiconductor raw materials from 1 August. "US domestic supply will not be impacted by this short-sighted

decision of China," states CEO Michael Silver.

American Elements says that it will continue to supply its Chinese customers from American Elements' manufacturing facilities in Asia.

www.americanelements.com



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CSA Catapult expands across the UK to South West & North East England and Scotland

South Wales-based compound semiconductor cluster to build supply chains and clusters across UK

Compound Semiconductor Applications (CSA) Catapult in Newport, South Wales is expanding across the UK to Bristol, the North East of England, and Scotland.

Established in 2017 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a not-for-profit organization focused on accelerating the adoption of compound semiconductors in three key areas (the road to Net Zero, future telecoms and intelligent sensing). Headquartered in South Wales, it works across the UK in a range of industry sectors, from automotive to medical, and from digital communications to aerospace.

CSA Catapult hence plays a leading role in the UK's compound semiconductor ecosystem, helping companies fully embrace compound semiconductor technology and bring their innovations to market.

Future Telecoms Hub in Bristol

With the support of Innovate UK, this Autumn CSA Catapult will open a Future Telecoms Hub at the Bristol and Bath Science Park in the South West of England. The Catapult has identified significant opportunities for growth in the UK telecoms hardware sector. The Future Telecoms Hub will support companies developing telecoms hardware.

The Future Telecoms Hub will allow CSA Catapult to deepen and accelerate its expertise in telecoms by building technology platforms and ecosystems for telecoms hardware.

Driven by the growth of 5G networks and the adoption of next-generation technologies such as artificial intelligence (AI) and the Internet of Things (IoT), the global telecom equipment market is forecasted to rise at a compound annual growth rate (CAGR) of 6.9%

from \$538.9bn in 2021 to \$967.9bn by 2030.

Support for the North East compound semiconductor cluster

CSA Catapult will also establish a presence in the North East of England, where there is a cluster of companies working on telecoms, satellite communications and defence technologies. Based at NETPark in Sedgefield, County Durham, CSA Catapult North East will work with companies in the area as a neutral convener. It aims to facilitate market adoption of new compound semiconductor-based technologies, and build supply chains in telecoms, satellite communications and defence.

CSA Catapult North East will offer direct digital access to the prototyping capabilities in Newport, reducing the time and cost to produce advanced semiconductor modules to serve these markets.

CSA Catapult has entered into a partnership agreement to deliver a co-ordinated program with the Satellite Applications Catapult to help support the cluster's ambitions for growth. It will have a presence at the Space Enterprise Lab and work closely with Satellite Applications Catapult.

CSA Scotland to develop high-power electronics support in Scotland

Opening this Autumn based at the University of Strathclyde's Technology Innovation Centre in Glasgow, CSA Scotland will work with the regional cluster of companies developing technologies for high-power electrification in markets such as energy, marine, rail and off-highway.

CSA Scotland will draw on the expertise of Strathclyde University and the National Manufacturing Institute Scotland (NMIS), offering direct digital access to CSA Catapult

facilities in South Wales, allowing companies to rapidly design and prototype advanced power electronic modules for these markets.

"CSA Catapult's purpose is to deliver long-term benefit to the UK economy and accelerate UK economic growth in industries where applying compound semiconductors creates a competitive advantage," says CSA Catapult's CEO Martin McHugh. "Expanding across the UK means we can support more companies and bring more products to market through our technology expertise, supply chain creation and building compound semiconductor clusters. Setting up new centers in Bristol, Scotland and the North East will allow us to grow the ecosystem to support these new and emerging technologies in the UK," he adds. "We will collaborate with universities, start-ups and larger companies to build new UK-based supply chains in telecoms hardware. We want to support and attract companies leading R&D in the UK. These critical markets, using compound semiconductors, will create significant jobs and growth in the future," he believes.

"Innovate UK is committed to supporting growth and increased productivity across the UK, with the Catapults having a significant role in developing local economies," states Dean Cook, director – Place and Levelling Up, Innovate UK. "This new investment by Compound Semiconductor Applications Catapult will build on its foundations in South Wales and connect this national capability to opportunities across the telecoms industry and their applications in support of business innovation in Scotland, the North East of England and the South West of England."

www.csa.catapult.org.uk

ITRI to strengthen Taiwan–UK collaboration

ITRI offering consultation services for advanced packaging pilot lines, facilitating pre-production evaluations, and strengthening supply chain resilience

During an initial exchange with the UK's newly established Department for Science, Innovation and Technology (DSIT), Dr Shih-Chieh Chang, general director of Electronic and Optoelectronic System Research Laboratories at Taiwan's Industrial Technology Research Institute (ITRI), suggested that Taiwan can become a trustable partner for the UK and that the partnership can leverage collective strengths to create mutually beneficial developments.

In mid-May, the DSIT released the UK's National Semiconductor Strategy, according to which the UK government plans to invest £1bn over the next decade to support the semiconductor industry. This funding aims to improve access to infrastructure, power more R&D and facilitate greater international cooperation.

Chang says that ITRI looks forward to more collaboration with the UK on semiconductors to enhance the resilience of the supply chain. While the UK possesses capabilities in semiconductor IP design and compound semiconductor technology, ITRI has extensive expertise in semiconductor technology R&D and trial production. As a result, ITRI is well positioned to offer consultation services for advanced packaging pilot lines, facilitate pre-production evaluation, and link UK semicon-

ductor IP design companies with Taiwan's semiconductor industry chain. "The expansion of British manufacturers' service capacity in Taiwan would create a mutually beneficial outcome for both Taiwan and the UK," says Chang.

The British Office Taipei stated that, over the last few years, the UK has been increasing collaboration with Taiwan on semiconductors. In 2020, the Compound Semiconductor Applications Catapult (CSA Catapult) signed a memorandum of understanding with ITRI, paving the way for a long-lasting collaborative partnership. The Department for Business and Trade (DBT) is also focusing the Digital Trade Network in Taiwan to increase the UK's capability to support semiconductor trade and investment. Recognizing ITRI as a crucial driving force for Taiwan's semiconductor industry development, the British Office Taipei looks forward to more cooperation with ITRI for technological innovation, supply chain collaboration and stronger partnership.

Chang indicated possible collaboration that can be forged to align the goals of the UK's National Semiconductor Strategy and the positive impact to be expected. He suggested that ITRI can assist in establishing relevant pilot lines by introducing necessary resources to address existing gaps or offering

consultation services covering design, packaging and testing prior to mass production. This would help to reduce the UK's reliance on external suppliers and thus create job opportunities. To minimize the risk of supply chain disruptions, the linkage of Taiwan's complete semiconductor industry chain can significantly enhance the UK's resilience in the global market as more comprehensive solutions can shorten time-to-market for innovative products and accelerate overall industrial development.

Other than the collaboration with CSA Catapult on gallium nitride (GaN) semiconductor technologies, ITRI partnered with a British semiconductor equipment manufacturer in 2021, resulting in achievements in areas such as high-brightness light-emitting diodes (HB-LEDs), micro-electro-mechanical systems (MEMS), micro-LEDs, silicon photonics, and nanoscale analysis. In the same year, ITRI worked with a British semiconductor IP manufacturer to jointly build a platform that assists startup companies in leveraging key patents to develop competitive new products. Based on the results, ITRI is set to expand its collaborative efforts with the UK in 2023.

www.itri.org.tw/eng

www.gov.uk/government/publications/national-semiconductor-strategy

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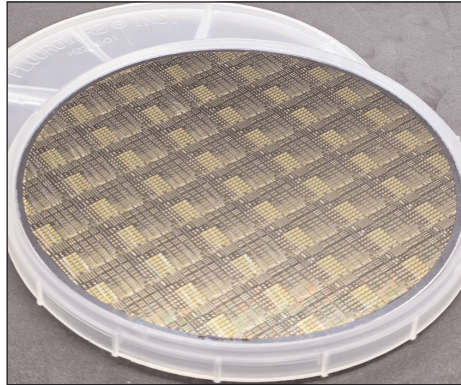
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WIN releases next-gen mmWave E-mode/D-mode GaAs pHEMT technology

PQG3-0C platform integrates optimized power and low-noise transistors, PN diodes, E/D logic and RF switches on single chip

WIN Semiconductors Corp of Taoyuan City, Taiwan — which provides pure-play gallium arsenide (GaAs) and gallium nitride (GaN) wafer foundry services for the wireless, infrastructure, and networking markets — has announced the commercial release of its PQG3-0C next-generation integrated millimeter-wave (mmWave) GaAs platform.

Targeting mmWave front ends, the PQG3-0C technology combines individually optimized enhancement-mode (E-mode) low-noise and depletion-mode (D-mode) power pseudomorphic high-electron-mobility transistors (pHEMTs) to enable what is claimed to be best-in-class power amplifier (PA) and low-noise amplifier (LNA) performance on the same chip. The E-mode/D-mode pHEMTs have a threshold frequency (f_t) of 110GHz and 90GHz respectively, and both employ 0.15 μ m T-shaped gates fabricated by deep-ultraviolet stepper technology. Deep UV photolithography is a proven, high-volume manufacturing technique for short-gate-length devices and



eliminates the throughput constraints of traditional electron-beam patterning. Offering two application-specific mmWave transistors with RF switches and ESD protection diodes, PQG3-0C supports a wide range of front-end functions with increased on-chip functionality.

Both E-mode and D-mode transistors can be used for mmWave amplification and operate at 4V. The D-mode pHEMT targets power amplifiers and provides over 0.6W/mm with 11dB linear gain and close to 50% power-added efficiency (PAE) when measured at 29GHz. The E-mode pHEMT operates best as a single-supply LNA and delivers

minimum noise figure below 0.7dB at 30GHz with 8dB associated gain, and third-order output intercept (OIP3) of 26dBm.

The PQG3-0C platform is manufactured on 150mm GaAs substrates and provides two interconnect metal layers with low-k dielectric crossovers, PN-junction diodes for compact ESD protection circuits, and RF switch transistors. With a final chip thickness of 100 μ m, a backside groundplane with through-wafer vias (TWV) are standard and can be configured as through-chip RF transitions to eliminate the adverse impact of bond wires at millimeter-wave frequencies. PQG3-0C also supports flip-chip packaging and can be delivered with Cu-pillar bumps fabricated in WIN's internal bumping line.

WIN showcased its compound semiconductor RF and mm-Wave solutions at the 2023 International Microwave Symposium in San Diego, CA, USA (11–16 June).

www.ims-ieee.org/ims2023

www.winfoundry.com

MACOM gives live demos of new products at IMS

MACOM Technology Solutions Inc of Lowell, MA, USA hosted live demonstrations of a wide range of new products and foundry services at the IEEE's International Microwave Symposium (IMS 2023) in San Diego, CA, USA (13–15 June).

The RF & Microwave IC and Module design, product management and applications engineering teams provided explanations of MACOM's solutions. Demonstrations featured new product additions to the firm's portfolio of RF and microwave IC and module solutions.

High-power and high-frequency demos included the following:

- 70nm mHEMT low-noise amplifier (LNA) for V-band mmWave receivers;
- 100nm GaN for Q-band 10W power amplifiers;
- 140nm GaN for X-band, K-band and Ka-band power amplifiers;
- 100V S-band pulsed 1.5kW MACOM PURE CARBIDE amplifier;
- Analog linearization of 20W K-band GaN MMIC for SATCOM applications;
- E-band upconverter with 1W output;
- 2.6GHz GaN-on-silicon M-MIMO power amplifier for scalable and cost-optimized applications;
- Low-leakage and fast-recovery Ka-band high-power limiter. Wideband and multi-band demos
- DC to 67GHz digital attenuators, voltage variable attenuators and switches utilizing silicon-on-insulator (SOI) technology;
- High-isolation, 50MHz to 60GHz AlGaAs PIN diode multi-throw switches;
- Low-loss, high-power, 6–20GHz SPDT PIN diode switch in SMT packages;
- Multi-band small-cell PA, receiver switch and LNA front-end solution;
- Chip-scale bulk acoustic wave switched filter bank;
- 50GHz multi-throw connectorized switch with integrated driver.

www.ims-ieee.org/ims2023

Qorvo releases new circuit simulation software to boost power and analog design productivity

Improved simulation speed, functionality and reliability with QSPICE

Qorvo Inc of Greensboro, NC, USA has released QSPICE, a new generation of circuit simulation software that is said to provide power and analog designers significantly higher levels of design productivity through improved simulation speed, functionality and reliability.

As well as advancing the state of the art in analog simulation, QSPICE allows designers to simulate complex digital circuits and algorithms. Its combination of modern schematic capture and fast mixed-mode simulation suits solving the increasingly complex hardware and software challenges faced by system designers, adds the firm.

"QSPICE enables an entirely new generation of mixed-mode circuit simulation," says Jeff Strang, general manager for Qorvo's Power

Management business. "In the past, power designers relied on analog circuits and silicon power switches. Today, digital control and compound semiconductors are common elements of advanced power designs. Whether an engineer is developing AI algorithms for EV battery charging, optimizing a Qorvo pulsed-radar power supply or evaluating the newest silicon carbide FETs, QSPICE is the perfect platform for innovation," he claims.

Available free of charge, QSPICE offers enhancements over legacy analog modeling tools including:

- Complete support for advanced analog and digital system simulations, such as those used in AI and machine-learning applications.
- An upgraded simulation engine that uses advanced numerical

methods and is optimized for modern computing hardware, including a GPU-rendered user interface and SSD-aware memory management, to provide dramatically higher speed and accuracy.

- Reduced overall run-times and a 100% completion rate, based on Qorvo benchmark tests with a suite of challenging test circuits. This compares with a failure rate of up to 15% with these same test circuits using other popular SPICE simulators.

- Availability of a regularly updated QSPICE model library featuring Qorvo's silicon carbide and advanced power management solutions, making it easy to evaluate and design with Qorvo power.

www.QSPICE.com
www.qorvo.com

Qorvo earns second Raytheon's Premier Award for Technology & Innovation and Collaboration & Customer Service

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) says that Raytheon Technologies has recognized Qorvo with its 2022 Premier Award for performance and overall excellence. This is the second con-

secutive year that Qorvo has been honored with the Premier Award.

The Premier Award is an annual recognition platform under the Raytheon Technologies Performance+ Program to honor suppliers with superior performance who have provided exceptional value to Raytheon Technologies in

one of the four key categories: Cost Competitiveness, Technology & Innovation, Business Management, and Collaboration & Customer Service. For 2022, Qorvo was selected for two: Technology & Innovation and Collaboration & Customer Service.

www.rtx.com

Guerrilla RF ships 175 millionth RFIC/MMIC

Guerrilla RF Inc (GRF) of Greensboro, NC, USA has shipped its 175 millionth RFIC/MMIC (radio-frequency integrated circuit/monolithic microwave integrated circuit), up 17% on 150 million just seven months ago.

Since its founding in 2013, Guerrilla RF has seen rapid growth in multiple markets including wireless infrastructure, automotive infotainment, RFID, and wireless audio. The firm has over 120 products in its growing catalog business serving 300+ customers.

"Guerrilla RF's stellar performance and increase in shipments happened in a backdrop where the general semiconductor and RF industry has been experiencing considerable slowdowns and headwinds," notes chief business officer Kellie Chong. "The first quarter of 2023 was the second largest quarter in the company's history even as backlog increased 30% year-over-year and 2022 turned out to be a record year in terms of revenues. We have achieved this by

continuing to execute our market diversification strategy entering into new verticals that include satellite communications, aerospace and defense," she adds. "Though general market visibility may be limited, we continue to outperform the market, underpinned by the breadth of our product portfolio, depth of wireless expertise, and focus on RF innovation and performance combined with robust customer support."

<http://guerrilla-rf.com>

CEA-Leti and Intel to co-develop atomically thin 2D TMDs on 300mm wafers

Using layer-transfer technology of two-dimensional transition-metal dichalcogenides to extend Moore's Law transistor scaling

Micro/nanotechnology R&D center CEA-Leti of Grenoble, France and Intel of Santa Clara, CA, USA have announced a joint research project to develop layer transfer technology of two-dimensional transition-metal dichalcogenides (2D TMDs) on 300mm wafers with the goal to extend Moore's Law beyond 2030.

2D-layered semiconductors, such as molybdenum- and tungsten-based TMDs, are promising candidates to extend Moore's Law and ensure ultimate scaling of MOSFET transistors, because 2D-FETs provide innate sub-1nm transistor channel thickness. They are suitable for high-performance and low-power platforms due to their good carrier transport and mobility, even for atomically thin layers. In addition, their device body thickness and moderate energy bandgap lead to enhanced electrostatic control, and thus to low off-state currents.

These characteristics position 2D-FET stacked-nanosheet devices as a promising solution for transistor scaling beyond 2030, which will require high-quality 2D channel growth, adapted transfer and robust process modules. To that end, the multi-year project will develop a viable layer-transfer technology of high-quality 2D materials (grown on 300mm preferred substrates) to another device substrate for transistor process integration. Intel brings decades of R&D



CEA-Leti's CEO Sebastien Dauvé (left) and (right) Robert Chau, Intel senior fellow in Technology Development and director of Intel Europe Research.

and manufacturing expertise to the project and CEA-Leti also provides bonding and transfer-layer expertise and large-scale characterization.

"As we are relentlessly pushing Moore's Law, 2D TMD material is a promising option for extending the limits of transistor scaling in the future," says Robert Chau, Intel senior fellow in Technology Development and director of Intel Europe Research. "This research program focuses on developing a viable 2D TMD-based technology in 300mm for future Moore's Law transistor scaling."

Intel brings its expertise in semiconductor and packaging research and technology to work with European partners to develop Moore's Law innovations and advance microelectronics in Europe. In 2022, Chau relocated from the

USA to Europe to lead Intel Europe Research and to drive Intel's R&D with partners on the continent. Intel and CEA-Leti have a long history of collaboration in semiconductor design, processes and packaging technology.

Most recently, in June 2022, they announced a research breakthrough in a new die-to-wafer bonding technology using a self-assembly process for future chip integration. Chau, who visited CEA-Leti's Grenoble headquarters on 16 June to emphasize the importance of their collaborations and the launch of the project, has been a strong supporter of multi-year research collaborations between the two entities.

CEA-Leti's CEO Sebastien Dauvé said industry roadmaps show that 2D materials will be integrated in future microelectronic devices, and that transfer capability in 300mm wafers will be key to that integration. "Due to their high growth temperature exceeding 700°C and high-quality growth on preferred substrates, it is difficult to stack 2D materials as usual thin layers," Dauvé adds. "So, transfer holds the most promise for integrating them in future devices, and CEA-Leti's strengths in this context are its expertise and know-how in transfer development and characterization."

www.intel.com
www.leti.fr

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ROHM and Vitesco form \$1bn SiC power semiconductor supply partnership for 2024–2030

First series production of SiC power electronics for two major customers planned for 2024

Based on a development partnership since 2020 that optimized silicon carbide (SiC) chips for use in automotive inverters, a long-term supply partnership has been formed for Japan-based electronic parts maker ROHM Semiconductor to provide silicon carbide (SiC) power semiconductors worth more than \$1bn during 2024–2030 to Vitesco Technologies of Regensburg, Germany (which develops and manufactures drive technologies and electrification solutions for electro-mobility).

Vitesco's inverters with integrated ROHM SiC chips will be adopted by two customers, to be applied inside electric vehicle power-trains. The firm will start supplying a first series project as early as 2024, ahead of the originally targeted timeline.

Due to its wide energy bandgap, SiC has reduced conversion losses compared to conventional silicon in power electronics. Especially at high voltage levels such as 800V, SiC inverters are more efficient



Dr Kazuhide Ino, ROHM board member, managing executive officer & CFO (left) and Vitesco Technologies' CEO Andreas Wolf (right).

than silicon models. Since 800V is the prerequisite for fast and thus convenient high-voltage charging, SiC devices are at the beginning of a worldwide boom, reckon the firms. Reduced conversion losses in the inverter are also significant for the overall efficiency of electric driving and thus for range. Competition for sufficient capacities in components made of silicon carbide

is correspondingly fierce.

"The supply partnership agreement with ROHM is an important building block for securing Vitesco Technologies' SiC capacities in the years ahead," commented Vitesco's CEO Andreas Wolf at the signing ceremony in Regensburg. "We have had very good experience in our development cooperation so far and are now looking forward not only to continuing it but also to intensifying it further," he adds.

"In the high-growth automotive market, SiC is a pathfinder for higher efficiency," noted Dr Kazuhide Ino, member of the board, managing executive officer & chief financial officer of ROHM Co Ltd. "With an expected higher market share of more than 30%, we are strongly positioned here and have gained a strategic partner in Vitesco Technologies for further market penetration."

www.vitesco-technologies.com
www.rohm.com/products/sic-power-devices

ROHM Semiconductor receives Vitesco's 2022 Supplier of the Year Award in 'Partnering' category

Award follows SiC supply partnership worth over \$1bn until 2030

Vitesco Technologies of Regensburg, Germany (which develops and manufactures drive technologies and electrification solutions for electro-mobility) has honored Japan-based ROHM Semiconductor with its 2022 Supplier of the Year Award in the category 'Partnering' for the company's particularly outstanding performance. Overall, Vitesco has honored the exemplary performance of six of its approximately 17,000 suppliers worldwide.

Vitesco's CEO Andreas Wolf and Peter Reidegeld, head of purchasing

& supplier quality management, presented the awards to the representatives of the international suppliers in a ceremony at the Sorat Hotel in Regensburg.

"The success and growth of Vitesco Technologies – today and tomorrow – depend to a large extent on the support of our suppliers," commented Wolf.

"It reflects our efforts to continuously support our customers in achieving their business goals by providing excellent quality, a stable supply of robust and advanced products as well as good

and reliable services," says ROHM Semiconductor Europe's president Wolfram Harnack.

Vitesco and ROHM entered a strategic development partnership in 2020, and in June they signed a long-term silicon carbide (SiC) supply partnership worth over \$1bn until 2030.

Vitesco's inverters with integrated ROHM SiC chips will be adopted by two major customers – to be applied inside electric vehicle powertrains. Vitesco will start supplying a first series project as early as 2024.

ROHM acquiring Kunitomi Plant from Solar Frontier

Expansion of production capacity targets silicon carbide power devices

Japan-based ROHM Semiconductor has reached a basic agreement with Tokyo-based Solar Frontier K.K. — which manufactures CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — to acquire the assets of its former Kunitomi Plant in Miyazaki, which covers 400,000m² and has a total floor area of 230,000m². Solar Frontier plans to continue to use part of the site and buildings as its business office (on a lease basis).

The acquisition is scheduled to take place in October and will belong to ROHM Group's main production bases.

"This acquisition enables a fast production expansion by utilizing existing infrastructure," notes Wolfram Harnack, president of ROHM Semiconductor Europe of Willich-Münchheide, near Dusseldorf, Germany. "This way, ROHM will continue to quickly and reliably supply its customers," Harnack adds. ROHM is aiming to start operation at the end of 2024.

ROHM notes that the automotive and industrial equipment markets in particular are undergoing



Solar Frontier's Kunitomi Plant in Miyazaki, Japan.

technological innovation such as electrification in order to reduce their environmental impact and achieve carbon neutrality. Demand is hence increasing especially for power and analog semiconductors.

As further expansion of the semiconductor market is expected, the

ROHM Group intends to expand its production capacity continuously, particularly for silicon carbide (SiC) power devices, ensuring a stable supply to its customers.

www.solar-frontier.com
www.rohm.com/products/sic-power-devices

onsemi selected for Nasdaq 100 Index

Market capitalization triples over the last 30 months

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA is to be added to the Nasdaq 100 Index prior to market open on 20 June. The inclusion comes after two consecutive years of record results, tripling the firm's market cap over the last 30 months. The company closed out 2022 with \$8.3bn in revenue and with earnings growing 3x faster than revenue.

"Our addition to the prestigious Nasdaq-100 Index is a testament to the successful execution of our strategy over the last two years," believes president & CEO Hassane El-Khoury. "We are leading with superior technology in our key

end-markets of automotive and industrial, and we intend to deliver above-market revenue growth while maintaining our industry-leading financial performance."

onsemi has been driving structural changes across the company while delivering intelligent power and sensing solutions for the high-growth megatrends in automotive and industrial. The firm is doubling down on its premium businesses to address the market opportunity with silicon carbide, silicon power, power ICs, image sensors and sensor interfaces. The company reckons that, with a proven strategy and committed revenue through

long-term supply agreements, it is well positioned to further accelerate growth in the semiconductor industry.

As one of the world's largest large-cap indexes, the Nasdaq-100 Index consists of the 100 largest non-financial companies listed on the Nasdaq Stock Market and acts as a benchmark for financial products such as options, futures and funds. It is heavily allocated towards top-performing industries such as technology, consumer goods and healthcare.

onsemi was previously added to the S&P 500 index in June 2022.

www.onsemi.com

onsemi to supply EliteSiC MOSFET technology to Magna for electric vehicle traction inverters

Magna investing \$40m in silicon carbide equipment for onsemi's New Hampshire and Czech plants to ensure access to supply

Intelligent power and sensing technology firm onsemi of Scottsdale, AZ, USA has announced a long-term supply agreement (LTSA) for its EliteSiC intelligent power solutions to be integrated into the eDrive systems of mobility technology company Magna International Inc of Aurora, Ontario, Canada (one of the world's largest automotive suppliers).

Magna's eDrive systems will hence be able to offer better cooling performance and faster acceleration and charging rates, improving efficiency and increasing the range of electric vehicles (EVs). Additionally, onsemi's end-to-end silicon carbide (SiC) manufacturing capability, combined with its ability to ramp production quickly, should improve Magna's vertical integration and

simplify its supply chain to meet the growing demand for its SiC-based products for EVs.

"With range anxiety still a top deterrent to EV adoption, our technology enables them to go further, easing the transition to an electrified future," says Asif Jakwani, senior VP & general manager of onsemi's Advanced Power Division. "Our latest EliteSiC MOSFET technology enables increased power density and higher efficiency in traction inverters, resulting in improved gas-equivalent miles per gallon without compromising driving dynamics and safety."

In accordance with the terms of the agreement, Magna will also invest about \$40m for the procurement of new SiC equipment at onsemi's New Hampshire and

Czech Republic facilities to ensure access to future supply. With a limited number of manufacturers and significant demand for SiC-based designs, OEMs and automotive suppliers are increasingly looking to secure long-term, reliable supply.

"We recognize the importance of securing a stable supply of SiC material in order to continue delivering innovative and efficient eDrive systems for our customers," notes Diba Ilunga, president of Magna Powertrain. "As the electric vehicle market continues to grow, we are taking proactive steps to secure access to future SiC supply to help support our electrification strategy and outpace the competition."

www.magna.com

www.onsemi.com

BorgWarner to integrate onsemi EliteSiC 1200V and 750V power devices into VIPER power modules

onsemi and BorgWarner Inc of Auburn Hills, MI, USA (which provides sustainable mobility solutions for the vehicle market) are expanding their strategic collaboration for silicon carbide (SiC), making the total agreement worth over \$1bn in lifetime value. BorgWarner plans to integrate onsemi's EliteSiC 1200V and 750V power devices into its VIPER power modules. The EliteSiC devices join a broad portfolio of onsemi products that are part of the long-standing strategic relationship between the two companies.

onsemi notes that it provides high-performance EliteSiC technology while maintaining the standards of quality, reliability and supply assurance needed for the electric vehicles (EV) traction market. The firm adds that its decades of

experience in the design, development and manufacturing of power semiconductor products support adoption in high-volume automotive applications.

"First and foremost, onsemi's continuous and strategic investment in ramping SiC manufacturing capacity across its end-to-end supply chain gives us confidence in our ability to support the increasing demand for our solutions, now and in the future," comments Stefan Demmerle, VP of BorgWarner and president & general manager, PowerDrive Systems.

BorgWarner's silicon carbide traction inverters are claimed to already offer higher efficiency, better cooling performance, and faster-charging rates in a more compact package than other

options for EVs. By using EliteSiC technology, BorgWarner's solutions are expected to benefit from increased power density and higher efficiency, increasing the range and overall performance of EVs.

"The integration of EliteSiC technology in the traction inverter enables increased gas-equivalent miles per gallon (MPGe), which helps alleviate range anxiety — one of the key barriers to EV adoption," says Simon Keeton, executive VP & general manager, Power Solutions Group, onsemi. "With onsemi's chip-to-system-level support and a track record of execution, we are able to provide industry-leading SiC-based solutions to BorgWarner at an accelerated pace to support its go-to-market requirements."

www.onsemi.com

NoMIS Power gains USAF award to develop SiC devices for aircraft electrical power systems

Firm to develop 1200V SiC MOSFETs with enhanced operational lifetime and improved efficiency

NoMIS Power of Albany, NY, USA — which was spun off from State University of New York Polytechnic Institute (SUNY Poly) in 2020 — has achieved won an award from the US Air Force Research Laboratory (AFRL) to develop rugged silicon carbide (SiC) power devices to support the electrical power systems of aircraft.

NoMIS will develop 1200V SiC power semiconductor devices (PSDs) through the award. The focus will be on metal-oxide-semiconductor field-effect transistors (MOSFETs) with enhanced operational lifetime as well as improved on-state and off-state efficiency at operating temperatures, resulting in lower losses for power electronics engineers to manage.

Solid-state power controllers within aircraft electrical power distribution systems require low

on-state losses to enable passive cooling, as well as surge current and voltage overshoot protection during system start-up and fault interrupt. The proposed 1200V SiC MOSFETs from NoMIS Power will provide airframers and system builders/integrators with the necessary PSD chips capable of high efficiency, long short-circuit withstand time (SCWT), and operational ruggedness for nominal and transient conditions. Moreover, the 1200V rating will not only support current-generation aircraft utilizing 270V_{DC} architecture but also aircraft operating with a +/-270V_{DC} (i.e. 540V_{DC} rail-to-rail) architecture as well.

NoMIS Power says that it overcomes the limitations of commercial-off-the-shelf (COTS) Si and SiC-based PSDs via a novel SiC device design that is achievable

using disruptive manufacturing techniques. As a result, NoMIS SiC devices can withstand higher voltage spikes and current surges during harsh operating conditions, enabling longer power management product lifetime through superior reliability and ruggedness, it is claimed.

“Our team is very excited to get the opportunity to support strategic groups working to improve the capabilities of our armed forces,” states NoMIS Power’s CEO Dr Adam Morgan. “This novel SiC device technology will also have a significant impact on other critical technology markets, such as electric vehicles and grid infrastructure. These efforts will directly support our company’s near-term product launch of next-generation SiC devices.”

<https://nomispower.com>

Toshiba launches SiC 650V Schottky barrier diodes with forward voltage of 1.2V

Third-generation process technology enhances efficiency in industrial applications

Japan-based Toshiba Electronic Devices & Storage Corp (TDSC) — which was spun off from Toshiba Corp in 2017 — has launched twelve 650V silicon carbide (SiC) Schottky barrier diodes (SBDs) based on its latest third-generation technology. Now shipping in volume, the new devices are specifically intended for use in efficiency-critical industrial equipment applications including switching power supplies, electric vehicle (EV) charging stations and photovoltaic (PV) inverters.

The devices in the new TRSxxx65H series use new Schottky metal. The third-generation SiC SBDs chip

optimizes the junction barrier Schottky (JBS) structure of the second-generation products, lowering the electric field at the Schottky interface and reducing leakage current, hence delivering enhanced efficiency.

Compared with second-generation products, the third-generation devices achieve 17% lower forward voltage (V_F) of 1.2V (typical), as well as improved trade-offs between V_F and total capacitive charge (Q_C), which is typically 17nC for the TRS6E65H.

Also improved is the V_F and reverse current (I_R) ratio, with the TRS6E65H achieving a typical

I_R value of 1.1 μ A. All of these improvements reduce power dissipation and contribute to higher levels of efficiency in end-equipment.

Devices in the TRSxxx65H series are capable of forward DC currents ($I_{F(DC)}$) of up to 12A and square-wave non-repetitive surge currents I_{FSM} up to 640A. Seven of the new devices are housed in TO-220-2L packages while the remaining five are provided in compact and flat DFN8x8 SMD packages.

www.toshiba.semicon-storage.com/eu/semiconductor/product/diodes/sic-schottky-barrier-diodes.html

www.scib.jp/en

www.toshiba-tmat.co.jp/en

Infineon makes available new-generation 1200V CoolSiC trench MOSFET in TO263-7 package

Switching loss and junction temperature reduced by 25% from first generation

Infineon Technologies AG of Munich, Germany has made available its new generation of 1200V CoolSiC MOSFETs in TO263-7 packaging for automotive applications. The automotive-graded silicon carbide (SiC) MOSFET generation offers high power density and efficiency, enables bi-directional charging and significantly reduces system cost in on-board charging (OBC) and DC-DC applications.

The 1200V CoolSiC family member offers what is claimed to be best-in-class switching performance through 25% lower switching losses compared with the first generation. This improvement in switching behavior enables high-frequency operation, leading to smaller system sizes and increased power density. With a gate-source threshold voltage ($V_{GS(th)}$) greater than 4V and a very low C_{rSS}/C_{iSS} ratio, reliable turn-off at $V_{GS} = 0V$ is achieved without the risk of parasitic turn-ons. This allows for unipolar driving, resulting in reduced system cost and complexity. In addition, the new generation features a low on-resistance



Infineon's new generation of 1200V CoolSiC MOSFETs in TO263-7 for automotive applications.

($R_{DS(on)}$), reducing conductive losses over the whole temperature range of $-55^{\circ}C$ to $175^{\circ}C$.

The advanced diffusion soldering chip mount technology (.XT technology) is said to significantly improve the package's thermal capabilities, lowering the SiC MOSFET's junction temperature by 25% compared with the first generation.

Moreover, the MOSFET has a creepage distance of 5.89mm, meeting 800V system require-

ments and reducing coating effort. Infineon is offering a range of $R_{DS(on)}$ options to cater to diverse application demands, including the only $9m\Omega$ type in the TO263-7 package currently on the market.

KOSTAL using CoolSiC MOSFET in OBC platform

Automotive charger system supplier KOSTAL Automobil Elektrik has designed-in Infineon's latest CoolSiC MOSFET in its next-generation OBC platform for Chinese OEMs. With its standard platform approach, safe, reliable and highly efficient products are delivered worldwide for various OEM requirements and global regulations.

"As key component for our future-generation OBC platform, Infineon's new 1200V CoolSiC trench MOSFET features high voltage rating and qualified robustness," comments Shen Jianyu, VP technical executive manager at KOSTAL ASIA. "These benefits help us in to create a compatible design to manage our state-of-art technical solutions, cost optimization and massive market delivery," he adds.

www.infineon.com/

STIHL honors Infineon as 'Supplier of the Year 2022'

Global chainsaw market leader STIHL of Waiblingen near Stuttgart has honored Infineon Technologies as 'Supplier of the Year 2022' for being a highly reliable partner in terms of quality and delivery capability, even in a challenging environment. Infineon not only supports STIHL's battery strategy as a main supplier in the semiconductor segment, but also collaborates closely with STIHL in R&D. The collaboration is to generate innovations in energy-efficient motor control for battery-powered

tools using compound semiconductors based on gallium nitride.

"STIHL and Infineon are not only united by a good business relationship, but also by shared basic values, our commitment to people and to the environment," says Richard Kuncic, senior VP & general manager DC/DC business line at Infineon.

"Infineon has proven to be an extremely reliable partner who, even in times of chip shortages, has shown great flexibility in supporting us to further drive our

strategy towards electrification," comments Marc Moser, senior VP global purchasing at STIHL. In particular, Infineon supplies MOSFETs and gate drivers and works with STIHL on application-optimized semiconductors.

STIHL presented the 2022 Supplier of the Year award to five firms that have scored particularly well among all STIHL suppliers worldwide for their outstanding characteristics in terms of quality, technology, innovation, service and price/performance ratio.

Diodes Inc launches automotive-compliant 1200V silicon carbide MOSFETs

Body diodes with low reverse recovery charge enable fast switching with reduced power losses

Power semiconductor product supplier Diodes Inc of Plano, TX, USA has further enhanced its wide-bandgap product range by releasing the DMWSH120H90SM4Q and DMWSH120H28SM4Q automotive-compliant silicon carbide (SiC) MOSFETs. The N-channel MOSFETs respond to the increasing market demand for SiC solutions that enable better efficiency and higher power density in electric and hybrid-electric vehicle (EV/HEV) automotive subsystems like battery chargers, on-board chargers (OBC), high-efficiency DC-DC converters, motor drivers, and traction inverters.

The DMWSH120H90SM4Q operates safely and reliably up to $1200V_{DS}$ with a gate-source voltage (V_{GS}) of $+15/-4V$ and has an $R_{DS(ON)}$ of $75m\Omega$ (typical) at $15V_{GS}$. This device is designed for OBCs, automotive motor drivers, DC-DC converters in EV/HEV, and battery charging systems.

The DMWSH120H28SM4Q operates at up to $1200V_{DS}$, $+15/-4V_{GS}$, and has a lower $R_{DS(ON)}$ of $20m\Omega$ (typical) at $15V_{GS}$. This MOSFET has been designed for motor drivers, EV traction inverters, and DC-DC



converters in other EV/HEV subsystems. Low $R_{DS(ON)}$ enables these MOSFETs to run cooler in applications that require high power density.

Both products have low thermal conductivity ($R_{JC}=0.6C/W$), enabling drain currents up to 40A in the DMWSH120H90SM4Q and 100A in the DMWSH120H28SM4Q. They also have fast intrinsic and robust body diodes with low Q_{rr} reverse recovery charge of 108.52nC in the DMWSH120H90SM4Q and reverse recovery charge of 317.93nC in the DMWSH120H28SM4Q, enabling them to perform fast switching with reduced power losses.

By using the planar manufacturing process, Diodes has created new MOSFETs that are said to offer more robust and reliable performance in automotive applications — and with increased drain current, breakdown voltage, junction temperature and power rings compared with previously released versions. The devices

are available in a TO247-4 (Type WH) package, which offers an additional Kelvin sense pin. This can be connected to the source to optimize switching performance, enabling even higher power densities.

The DMWSH120H90SM4Q and DMWSH120H28SM4Q are AEC-Q101 qualified, manufactured in IATF 16949-certified facilities, and support PPAP documentation. The DMWSH120H90SM4Q is available at \$18 in 1000-piece quantities, and the DMWSH120H28SM4Q is available at \$38 in 1000-piece quantities.

www.diodes.com

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ST and Sanan creating 200mm SiC device fab JV in China Sanan to build 200mm SiC substrate plant to feed joint venture

STMicroelectronics of Geneva, Switzerland and China's Sanan Optoelectronics Co Ltd — which manufactures LEDs, silicon carbide (SiC), optical communications, RF, filters and gallium nitride (GaN) products — have agreed to create a new 200mm silicon carbide device manufacturing joint venture (JV) in Chongqing, China.

The new SiC fab should start production in fourth-quarter 2025. Full buildout is due in 2028, supporting the rising demand in China for car electrification as well as for industrial power and energy applications.

The full buildout of the JV is expected to cost about \$3.2bn, including capital expenditure of about \$2.4bn over the next five years, financed by contributions from ST and Sanan Optoelectronics, local government support, and loans to the JV. Completion of the project is subject to regulatory approvals.

The JV will make SiC devices exclusively for ST, using ST's proprietary SiC manufacturing process

technology, and serve as a dedicated foundry to ST to support the demand of its Chinese customers.

In parallel, Sanan Optoelectronics will build and operate separately a new 200mm SiC substrate manufacturing facility to fulfill the JV's needs, using its own SiC substrate process.

"China is moving fast towards electrification in automotive and industrial, and this is a market where ST is already well-established with many engaged customer programs," says ST's president & CEO Jean-Marc Chery. "Creating a dedicated foundry with a key local partner is the most efficient way to serve the rising demand of our Chinese customers. The combination of Sanan Optoelectronics' future 200mm substrate manufacturing facility with the front-end JV and ST's existing back-end facility in Shenzhen, China will enable ST to offer our Chinese customers a fully vertically integrated SiC value chain," he adds. "It is an important step to further scale up our global

SiC manufacturing operations, coming in addition to our continuing significant investments in Italy and Singapore. This JV is expected to be one of the enablers of the opportunity we see to reach \$5bn+ SiC revenues by 2030. This initiative is consistent with ST's 2025–27 \$20bn+ revenue ambition and the associated financial model, previously communicated to the financial markets," Chery continues.

"The establishment of this joint venture will be a major driving force for the wide adoption of SiC devices on the Chinese market," reckons Sanan Optoelectronics' CEO Simon Lin. "Being an international, well-known, high-quality SiC foundry service company, Sanan will also supply its SiC substrate to this new joint venture, by building a dedicated new SiC substrate factory," he adds. "This is an important step for Sanan Optoelectronics' ambitions as a SiC foundry."

www.sanan-ic.com

www.st.com

Mitsubishi Electric to ship samples of NX-type full-SiC power semiconductor modules for industrial equipment

Tokyo-based Mitsubishi Electric Corp has begun shipping samples of its new NX-type full-SiC (silicon carbide) power semiconductor module for industrial equipment.

Mitsubishi Electric began releasing power semiconductor modules incorporating SiC chips in 2010. The new module features a low-loss second-generation SiC chip and an electrode structure optimized with laminated electrodes to achieve reduced internal inductance of 9nH, 47% less than the existing module.

Reduced internal inductance suppresses voltage surges in order to protect equipment, allowing fast switching while also lowering switching loss and power loss.

The low-loss second-generation SiC chip incorporates junction field-

effect transistor (JFET) doping technology (which increases device density by increasing impurity density in the JFET area). Compared with the existing module (the CM600DX-34T of the 1700V/600A NX-type silicon IGBT module T-series), this reduces power loss by about 72%, contributing to more efficient equipment. Reduced power loss helps to reduce heat generation, allowing the use of smaller and lighter-weight coolers.

With a voltage rating of 1700V and current rating of 600A (and dimensions of 62mm x 152mm x 17mm), the new FMF600DXE-34BN module is expected to contribute to the realization of more efficient, smaller and lighter-weight industrial equipment.

Also, the NX-type package compatibility allows the new module to easily replace the current version. Despite inclusion of the SiC chip, the external dimensions and pin configurations are compatible with the NX-type module, facilitating easy replacements that can help to speed up the design of new equipment.

Development of the SiC module was partially supported by Japan's New Energy and Industrial Technology Development Organization (NEDO).

Mitsubishi Electric says that it will continue to expand its lineup of power semiconductor modules for more efficient, smaller and lighter industrial equipment.

www.MitsubishiElectric.com/semiconductors

Airbus and ST collaborate on SiC and GaN power electronics for aircraft electrification

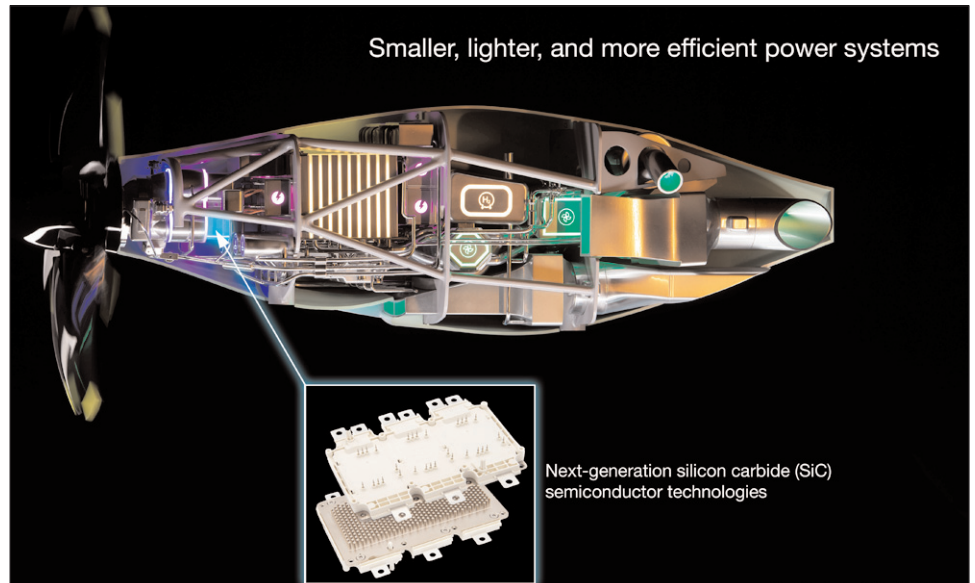
R&D collaboration on power semiconductors to enable transition to hybrid and full-electric aircraft

Aerospace & defence firm Airbus of Toulouse, France and integrated device manufacturer STMicroelectronics of Geneva, Switzerland have signed an agreement to cooperate on power electronics R&D to support more efficient and lighter power electronics, essential for future hybrid-powered aircraft and full-electric urban air vehicles.

The collaboration builds on evaluations already conducted by both companies to explore the benefits of wide-bandgap semiconductor materials for aircraft electrification. Due to their superior electrical properties compared with silicon, silicon carbide (SiC) and gallium nitride (GaN) enable the development of smaller, lighter and more efficient high-performance electronic devices and systems, particularly in applications requiring high-power, high-frequency or high-temperature operation.

The cooperation will focus on developing SiC and GaN devices, packages and modules adapted for Airbus' aerospace applications. The firms will assess these components by conducting research and tests on demonstrators, such as e-motor control units, high- and low-voltage power converters, and wireless power transfer systems.

The collaboration with ST will be key to support Airbus' electrification roadmap, says Airbus' chief technical officer Sabine Klauke. "Leveraging their expertise and experience in power electronics for automotive



and industrial applications with our own record in aircraft and VTOL [vertical take-off and landing] electrification will help us accelerate the development of the disruptive technologies required for the ZEROe roadmap and CityAirbus NextGen," she adds.

"We already have a strong, transformational presence in mobility and industrial applications, reinforced by a vertically integrated global SiC supply chain, to support our customers globally with electrification and decarbonization," says Jerome Roux, president, sales & marketing, STMicroelectronics. "Aerospace is a highly demanding market with specific requirements. Cooperating with Airbus, a global leader in this industry, gives us the opportunity to define together new power technologies the industry

needs to realise its decarbonisation goals."

Airbus' hybridization and electrification roadmap

Decarbonizing flight requires a range of disruptive solutions that mix new fuel types and disruptive technologies. One such solution, hybrid-electric propulsion, can improve the energy efficiency of every aircraft class and reduce aircraft CO₂ emissions by up to 5%. That figure could be as high as 10% for helicopters, which are generally lighter than fixed-wing aircraft. Future hybrid and full-electric aircraft require megawatts of power to operate. This implies huge improvements in power electronics in terms of integration, performance, efficiency, and component size and weight.

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Wolfspeed raises \$1.25bn via Apollo Credit, plus \$750m accordion feature

Investment supports US silicon carbide capacity expansion plans

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — has announced a \$1.25bn secured note financing from an investment group led by Apollo, with an accordion feature for up to an additional \$750m.

The financing supports the firm's US expansion efforts (announced in September 2022) and is a significant step toward achieving its \$6.5bn global capacity expansion plan. Execution of Wolfspeed's US growth plan will accelerate adoption of silicon carbide across a wide array of end markets and support job creation in US semiconductor manufacturing, says the firm.

The 9.875% notes will mature in 2030 and are optionally prepayable by the company based on the terms of the indenture governing

the notes. The investment was led by funds managed by Apollo's ~\$450bn Credit business.

"The group's commitment to Wolfspeed further validates the importance of silicon carbide to the global energy transition," says Wolfspeed's president & CEO Gregg Lowe.

"This important step in our financing provides significant capital to scale up near-term operations at our Mohawk Valley Fab and construction of our Siler City materials facility to help us capture the growing silicon carbide market opportunity. The financing positions Wolfspeed to continue to lead the growth of the industry and focus on the execution of our vertically integrated strategy to meet growing demand," he adds.

"Our agreement with Apollo and its capital partners achieves our near-term funding targets while prioritizing our shareholders with a new, non-dilutive source of financ-

ing," notes chief financial officer Neill Reynolds. "Apollo and its capital partners' investment follows an extensive review of our business and demonstrates their conviction in our team, operating plan and trajectory," he adds.

"Apollo is pleased to provide a dynamic and flexible credit solution to Wolfspeed as it significantly expands its silicon carbide manufacturing capacity," says Apollo Credit partner Joseph Jackson. "The company's growth plan is designed to deliver critical silicon carbide products for a range of automotive and industrial uses, and support sustainability goals with market-leading technology," he comments. "With the help of our capital partners, we have crafted a facility that can provide up to \$2bn to ramp the company's expansion plans."

www.wolfspeed.com

Wolfspeed promotes Priya Almelkar to senior VP, IT & chief information officer

Almelkar promoted from VP of IT manufacturing operations

Wolfspeed has promoted Priya Almelkar to senior vice president, IT & chief information officer. She succeeds David Costar and becomes the fifth female member of Wolfspeed's senior leadership team.

"Over her two-and-a-half-year tenure with Wolfspeed, Priya has consistently showcased exceptional technical expertise and inspiring leadership skills," comments CEO Gregg Lowe.

"Her invaluable contributions have significantly enhanced our company's information systems and processes. Her promotion not only recognizes her skills and contributions, but also reinforces our belief in the power of diverse perspectives and experiences in driving innovation and success."

As VP of IT manufacturing operations, Almelkar played a pivotal role in driving Wolfspeed's transition to automation, empowering its analytics capabilities while ensuring data integrity and accuracy. This data-based transition has enabled enhanced tracking of customer deliveries, valuable market and competitor insights, and has improved operational efficiency.

"Wolfspeed's ambitious growth strategy presents ample opportunities to improve IT process efficiency and compliance," says Almelkar. "I am thrilled to continue collaborating with such knowledgeable and entrepreneurial colleagues to strengthen our digital footprint."

Almelkar has over 25 years of experience in leading core IT

functions and implementing large-scale digital transformations. Prior to joining Wolfspeed, she spent six years at GlobalFoundries, where she held several positions, including head of digital transformation and head of infrastructure. Earlier in her career, she excelled in program management, information security and solution delivery engineering. Almelkar also serves as a sponsor of the Asian American and Pacific Islander (AAPI) Employee Resource Group at Wolfspeed, exemplifying the firm's commitment to diversity and inclusion. In acknowledgement of her leadership and service to the industry, she has been recognized by the National Association of Manufacturers.

Renesas and Wolfspeed sign 10-year silicon carbide wafer supply agreement

\$2bn deposit secures supply of 150mm and 200mm SiC wafers to Renesas and supports Wolfspeed's US capacity expansion plans

Renesas Electronics Corp of Tokyo, Japan has executed a wafer supply agreement and \$2bn deposit to secure a 10-year supply commitment of silicon carbide bare and epitaxial wafers from Wolfspeed Inc of Durham, NC, USA, which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices. The supply deal will pave the way for Renesas to scale production of silicon carbide power semiconductors starting in 2025. The signing ceremony was held at Renesas' headquarters in Tokyo between Renesas' president & CEO Hidetoshi Shibata and Wolfspeed's president & CEO Gregg Lowe.

The decade-long supply agreement calls for Wolfspeed to provide Renesas with 150mm silicon carbide bare and epitaxial wafers scaling in 2025, reinforcing the companies' vision for an industry-wide transition from silicon to silicon carbide power devices. The agreement also anticipates supplying Renesas with 200mm silicon carbide bare and epitaxial wafers after the recently announced John Palmour Manufacturing Center for Silicon Carbide (the JP) is fully operational.



Renesas' president & CEO Hidetoshi Shibata and Wolfspeed's president & CEO Gregg Lowe.

Renesas is moving quickly to address the growing demand for power semiconductors by expanding its in-house manufacturing capacity. The firm recently announced the restart of its Kofu Factory to produce silicon insulated-gate bipolar transistors (IGBTs), and the establishment of a silicon carbide production line at its Takasaki Factory.

"The wafer supply agreement with Wolfspeed will provide Renesas with a stable, long-term supply base of high-quality silicon carbide wafers. This empowers Renesas to scale our power semiconductor offerings to better serve customers' vast array of applications," says

Shibata. "We are now poised to elevate ourselves as a key player in the accelerating silicon carbide market," he believes.

"With the steepening demand for silicon carbide across the automotive, industrial and energy sectors, it's critically important we have best-in-class power semiconductor customers like Renesas to help lead the global transition from silicon to silicon carbide," comments Lowe.

"For more than 35 years, Wolfspeed has focused on producing silicon carbide wafers and high-quality power devices, and this relationship marks an important step in our mission to save the world energy."

Renesas' \$2bn deposit will help support Wolfspeed's ongoing capacity construction projects including the JP, the world's largest silicon carbide materials factory in Chatham County, North Carolina. The multi-billion-dollar facility is targeted to generate a more than 10-fold increase from Wolfspeed's current silicon carbide production capacity on its Durham campus. The facility will produce primarily 200mm silicon carbide wafers.

www.wolfspeed.com
www.renesas.com

NC A&T's Board of Trustees gains Wolfspeed CEO Lowe

Wolfspeed's CEO Gregg Lowe has been elected to serve on North Carolina Agricultural and Technical State University's (NC A&T) Board of Trustees. NC A&T is the USA's top-ranked historically black college or university (HBCU).

"Gregg's leadership and extensive science and technology background will serve as a vital resource for our prestigious university," says chancellor Harold L. Martin Sr. "I look forward to working with

him as we provide new opportunities for our students to pursue the next generation of careers in the green economy," he adds.

"I'm eager to further strengthen our relationship while working together to usher in the next generation of scientists, technologists and innovators," says Lowe.

In 2020, Wolfspeed committed \$4m over five years to the HBCU, the single largest donation in the university's history at that time, to

create the Wolfspeed Endowed Scholars Program. The two entities worked together to establish comprehensive education and training curricula and research and innovation programs. This partnership has opened opportunities for undergraduate and graduate credentials in silicon carbide semiconductor manufacturing, as well as training and career advancement programs for existing semiconductor manufacturing workers.

UK Space Agency funds IceMOS to develop radiation-tolerant, high-voltage power MOSFET incorporating SiC engineered-drain substrate

Commercial applications span efficient data centers, EV fast charging and AI-enabled cloud services

In partnership with ADS, the UK Space Agency has awarded IceMOS Technology (a provider of super-junction MOSFETs, MEMS solutions and engineered substrates) part of £300,000 in funding for a project to further develop a new breed of power transistors for space applications via the Space Technology Exploitation Programme (STEP). The IceMOS manufacturing center of excellence in Belfast, Northern Ireland, is one of three firms chosen to accelerate development in UK space exploration and supply chains.

The IceMOS development program will focus on delivering an advanced engineered substrate, enabling a radiation-tolerant, high-voltage silicon carbide engineered-drain MOSFET for more efficient high-power-distribution electrical systems on spacecraft for low Earth orbit (LEO), middle Earth orbit (MEO) and deep space exploration. The merger of a wide-bandgap (WBG) power MOSFET drain structure that

can be tailored to be robust in harsh space radiation environments will create a new class of vertical power transistors. Commercial applications aim to address society's increasing demand for energy conservation in systems such as artificial intelligence (AI)-enabled cloud services and data centers, fast-charging stations for electric vehicles, photovoltaic energy generation and more.

"With this award IceMOS Technology is uniquely positioned to accelerate advances in the UK space program by making dramatic improvements in high-voltage power radiation-tolerant transistors," says IceMOS Technology's founder & chairman Samuel J. Anderson. "It is an honor to be one of only three companies selected to participate in this prestigious program to enhance UK space capability by developing this leading-edge technology that can lower costs and significantly improve overall

systems performance," he adds.

"Creative talent and technical space expertise can be found across the length and breadth of the UK," comments the UK Space Agency's chief executive Dr Paul Bate. "These projects, delivered in partnership with ADS, are brilliant examples of that from Northern Ireland's growing space sector. They will help catalyse investment, create jobs and develop new capabilities within the space supply chain."

The IceMOS radiation-tolerant power transistor will incorporate the silicon carbide engineered drain substrate to take advantage of the low on-resistance performance from WBG materials that have the potential to revolutionize semiconductor manufacturing for a broad set of applications from power electronics to quantum technology, it is reckoned.

www.icemostech.com
www.adsgroup.org.uk

MACOM awarded \$4m USAF contract to further develop GaN-on-SiC process technology

Contract follows CRADA to transfer AFRL's 0.14µm GaN-on-SiC to MACOM's foundry

MACOM Technology Solutions Inc of Lowell, MA, USA has been awarded a multi-year contract worth about \$4m from the United States Air Force Research Laboratory (AFRL) to develop advanced semiconductor process technology related to gallium nitride-on-silicon carbide (GaN-on-SiC).

Under the contract, MACOM will conduct R&D on GaN-on-SiC process technologies used in millimeter-wave monolithic microwave

integrated circuit (MMIC) products.

"This award supports our strategy to establish leadership in high-frequency and high-power MMIC technologies and products," says president & CEO Stephen G. Daly.

In January 2021, MACOM and AFRL entered a Cooperative Research and Development Agreement (CRADA) to transfer AFRL's production-ready 0.14µm GaN-on-SiC process to MACOM's Massachusetts-based US Trusted Foundry.

This process transfer is complete, and the technology is now available for production.

The newly awarded contract further funds MACOM to develop performance enhancements over existing GaN-on-SiC technologies to support next-generation millimeter-wave aerospace & defense and commercial MMIC applications.

www.afrl.af.mil
www.macom.com

Nidec and Renesas collaborate on SiC and GaN for electric vehicle E-Axle systems

Proof of concept by end-2023 to feature 6-in-1 system with DC-DC converter, OBC and power distribution unit as well as motor, inverter and gearbox

Kyoto-based motor application product maker Nidec Corp and Tokyo-based Renesas Electronics Corp in Japan have agreed to collaborate on the development of semiconductors for a next-generation E-Axle (X-in-1 system) that integrates an EV drive motor and power electronics for electric vehicles (EVs).

EVs are increasingly adopting the 3-in-1 unit E-Axle, which integrates a motor, inverter and gearbox (reduction gear). To realize high-performance and efficiency as well as smaller size, light weight and lower cost, and to accelerate vehicle development, EVs are also integrating power electronics controls such as DC-DC converters and on-board chargers (OBCs). EV manufacturers in advanced markets such as China have developed an X-in-1 platform that integrates multiple functions, accelerating the adoption in many vehicle models.

As X-in-1 integrates multiple functions and increases in complexity, maintaining a high-level of quality in vehicles becomes challenging. Thus, developing preventive safety technologies such as diagnostic functions and failure prediction is crucial for ensuring safety and

security in vehicles. To address this challenge, the two firms agreed to combine Nidec's motor technology and Renesas' semiconductor technology to jointly develop a highly reliable and high-performance proof of concept (PoC) for the X-in-1 system. The PoC is designed to support the industry's highest performance and efficiency as well as smaller size, light weight and lower cost for the X-in-1 system.

The firms plan to launch the first E-Axle PoC by the end of 2023, which will feature a 6-in-1 system with a DC-DC converter, OBC and power distribution unit (PDU) as well as a motor, inverter and gearbox. As a second phase in 2024, Nidec and Renesas plan to develop a highly integrated X-in-1 PoC that incorporates a battery management system (BMS) along with other components. The first PoC will include power devices based on silicon carbide (SiC), and the second PoC will replace the DC-DC and OBC power devices with gallium nitride (GaN), offering excellent performance in high-frequency operation, to further reduce size and cost.

Building on the PoC developed through this collaboration, Nidec

plans to rapidly productize E-Axle systems to add to its portfolio and ramp up to mass production.

Renesas plans to develop and deliver turnkey systems for increasingly complex X-in-1 systems by expanding the jointly developed PoC for E-Axle reference designs.

"By harnessing our strengths in automotive technology and developing PoCs together with Renesas, who is a leader in automotive semiconductor solutions, we aim to lead the market as a world-leading E-Axle provider," says Mitsuya Kishida, executive VP & executive general manager of Nidec's Automotive Motor and Electronic Control business unit.

Nidec has "an exceptional track record of success in E-Axle traction motors," comments Vivek Bhan, senior VP, co-general manager of Renesas' High Performance Computing, Analog and Power Solutions Group. "Our contribution to this collaboration extends beyond hardware design, encompassing software development, which is critical to enabling rapid development of PoCs for our customers."

www.nidec.com/en

www.renesas.com

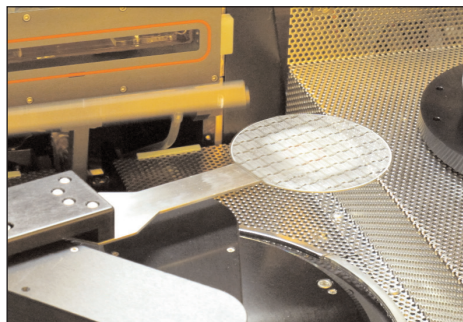
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WIN releases 50V RF GaN for high-power MMICs

Complete X- to Ku-band front-end solution with over 10W/mm output power density, sub-1dB noise figure and rugged switch performance

WIN Semiconductors Corp of Taoyuan City, Taiwan — which provides pure-play gallium arsenide (GaAs) and gallium nitride (GaN) wafer foundry services for the wireless, infrastructure, and networking markets — has announced the commercial release of NP25-20, a 50V 0.25 μ m-gate RF GaN platform, targeting high-performance front-end applications including radio access networks, satellite communications, electronic warfare and radar systems. The NP25-20 technology supports full monolithic microwave integrated circuits (MMICs) enabling customers to design compact, linear or saturated high-power amplifiers, rugged low-noise amplifiers and single-chip front-end solutions through 18GHz.

The NP25-20 gallium nitride technology employs a source-coupled field plate for improved breakdown



voltage and operates at a drain bias of 50V. The technology is fabricated on 100mm silicon carbide (SiC) substrates with through-wafer vias for low-inductance grounding. At X-band, NP25-20 demonstrates what is claimed to be excellent transmit and receive performance with saturated output power of 10W/mm, 18dB linear gain and 60% power-added efficiency (PAE). When biased for noise performance at 10GHz, NP25-20 provides minimum noise figure of 0.8dB with

12dB associated gain. The combination of power density and superb noise figure from NP25-20 enables high-performance single-chip front ends without sacrificing transmit power or receiver sensitivity, claims WIN.

“The performance versatility of NP25-20 is unique for RF gallium nitride technology. A GaN MMIC platform with 10W/mm output power alone is an achievement,” says David Danzilio, senior VP at WIN. “Combining surprising noise performance with high-power switching in the same device creates a new toolset for customers to commercialize market-leading products for a wide range of applications.”

WIN showcased its RF and mm-Wave solutions at the 2023 International Microwave Symposium in San Diego, CA, USA (11–16 June).

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Navitas and Plexim accelerate time-to-market with PLECS models for GeneSiC power semiconductors

Simulation of silicon carbide MOSFETs and MPS diodes delivers virtual prototyping for system-level designs

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA and Plexim GmbH of Zurich, Switzerland, which provides design and testing tools for the power conversion industry, have partnered to release GeneSiC G3 SiC MOSFET and Gen 5 MPS diode PLECS thermal loss models for highly accurate simulations of complete power electronics systems.

Power designers can simulate power and thermal losses in various soft- and hard-switching applications. Proprietary GeneSiC trench-assisted planar-gate MOSFET technology is claimed to deliver the lowest $R_{DS(ON)}$ at high temperature

and the highest efficiency at high speeds, and new MPS diodes with 'low-knee' characteristics drive what are claimed to be industry-leading levels of performance, robustness and quality.

"Accurate, empirically based simulation models maximize the chance of first-time-accurate designs, accelerating time-to-market and time-to-revenue," says Dr Ranbir Singh, Navitas' executive VP for the GeneSiC business line. "For the power designer, understanding the leading-edge performance of GeneSiC MOSFETs and MPS diodes with detailed device characteristics, plus power, efficiency and thermal analysis, is a critical competitive

advantage," he adds.

"The intuitive and highly efficient PLECS lookup-table based approach to simulating thermal semiconductor losses in complex power electronic circuits is key," says Kristofer Eberle of Plexim, North America. "Unlike legacy modeling approaches that are not well suited to new wide-bandgap materials, PLECS uses a simplified, but accurate behavioral description to highlight the superior performance of the GeneSiC MOSFETs."

PLECS models for GeneSiC MOSFETs and MPS diodes are available now via genesicsemi.com.

www.plexim.com/company

www.navitassemi.com

Mouser and Navitas announce global distribution deal

New product introduction (NPI) distributor Mouser Electronics Inc has announced a global distribution agreement with Navitas to offer its range of GaNFast and GaNSense power ICs, in addition to the GeneSiC range of SiC power MOSFETs and diodes, which enable high-frequency performance for applications including electric vehicles, fast-charging devices, consumer electronics, alternative energy and industrial solutions.

"Design engineers now have easy access to Navitas' advanced components, backed by Mouser's unsurpassed customer service and best-in-class logistics," says Kristin Schuetter, Mouser's VP of supplier management.

"Adding GaNFast parts to the existing GeneSiC portfolio greatly amplifies the awareness, interest and ultimately revenue for Navitas via Mouser's established and successful distribution platform," says David Carroll, senior VP worldwide sales at Navitas. "Next-gen products,

ease-of-use, immediate availability and great tech support mean that power designers can quickly deliver high-quality prototypes with both SiC and GaN, on time and ready for mass production."

The GaNFast Power ICs enable switching frequencies six-times higher than discrete GaN solutions, enabling an increase in system energy savings, while reducing system size and weight. GaNFast power ICs are easy to use and compatible with a range of popular topologies and controllers. GaNFast power ICs monolithically integrate GaN power, drive, and control, to create an easy-to-use, high-speed, high-performance 'digital-in, power-out' building block. GaNFast power ICs enable up to 3x faster charging in half the size and weight of old, silicon-based power electronics, or 3x more power without a size or weight increase.

GaNFast power ICs with GaNSense technology integrate critical, real-time, autonomous sensing and

protection circuits which further improve Navitas' reliability and robustness. These single-package solutions reduce component count and footprint compared to existing discretes, which cuts system cost, size, weight, and complexity.

Featuring a supply voltage range of 5.5V to 24V, GaNFast power ICs are suitable for a variety of consumer and enterprise applications.

The GaNFast family of power ICs offers multiple efficiency and reliability benefits in easy-to-use, low-profile, low-inductance, industry-standard PQFN packages. These devices enable fast time-to-prototype and fast time-to-revenue and are designed to enable the next generation of soft-switching topologies, while maximizing GaN's high-speed, MHz+ fast-switching capability. These high-efficiency devices are suitable for mobile and data center applications, as well as industrial motor drives.

www.mouser.com

QPT and GaN Systems sign MoU to develop technologies to extend EV driving range

QPT's power stage technology with GaN Systems' 650V power GaN devices boost efficiency

Independent power electronics company Quantum Power Transformation (QPT) of Cambridge, UK (which was founded in 2020) announced in late May that it had created the drive, control and sense technologies to maximize gallium nitride (GaN) transistor performance and overcome design challenges in the 100kHz to 20MHz frequency range for high-power and high-voltage applications that use hard switching. This technology is now unleashing the power performance in GaN-based designs, most dominantly in the automotive industry.

QPT says that its solution requires high-speed GaN transistors to deliver GaN's promised power efficiencies. The firm has signed a memorandum of understanding (MoU) with GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of GaN-based power switching semiconductors for power conversion and control applications) to investigate the possibilities of developing these technologies, resulting in increased performance and further improvements that can boost the driving range of electric vehicles (EVs).

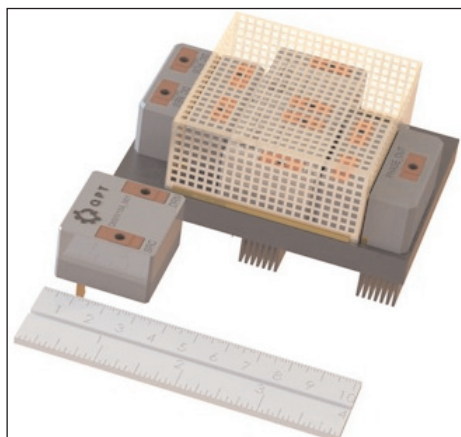
"GaN Systems produces the highest performing 650V power GaN devices, and this allows us to achieve the highest efficiency when combined with our technology," says QPT's founder & CEO Rob Gwynne. "The better the efficiency of power usage, the greater the range of the EV."

QPT has "unlocked functional improvement in performance, resulting in a highly optimized GaN solution for the EV market," comments GaN Systems' CEO Jim Witham. "In partnership, GaN Systems' transistors and QPT technology could dramatically change the GaN market."



The most significant boost to the EV range comes from QPT's ability to drive GaN much more efficiently. GaN transistors can operate at higher frequencies for switching on and off. The higher the switching speed, the less time is spent in transition, and the less energy is lost. GaN transistors can quickly transition from on to off at 1–2ns instead of 20–50ns for silicon and silicon carbide (SiC) transistors. However, achieving maximum performance is challenging in some high-voltage, high-power applications.

QPT's solution enables the GaN transistors to be run at their full potential of up to 20MHz with nanosecond switching to deliver better operational precision without RF interference issues or overheating, it is claimed. The firm's technology enables motors to be driven at up to 99.7% efficiency at peak load with hardly any decrease in efficiency at lower loads. This is



qGaN modules forming a VFD solution.

currently a challenge for conventional designs, where the efficiency can drop off rapidly at lower loads.

An additional boost comes from integrating and shrinking the variable-frequency drive (VFD) that controls the motor speed. Existing VFDs are bulky, so they are invariably located away from the motor itself and then connected by copper cables that are big and heavy to cope with the hundreds of Amps going through them. QPT says that its GaN technology shrinks the size of a VFD to about a 20th of the size, reducing weight. More importantly, the size reduction means that it can be co-located beside the motor.

This integrated motor solution is said to eliminate the need for long, heavy copper cables, which can amount to a significant weight and cost reduction of about half a meter each. Additionally, the copper cables have resistance marking less power loss and reducing the overall system efficiency. All these factors mean that QPT's solution without copper cables can increase the range of the car, it is reckoned.

"Our calculations show that our VFD solution can reduce power usage by around 10% and even more when the motor operates at low speeds," says Gwynne. "Together with the benefits of no long cables, that can significantly increase the range of an EV or a smaller battery for the same range," he adds. "Our technology is encapsulated into modules to form a plug-and-play solution that can be dropped in to replace an existing VFD with the rest of the existing system, such as the microprocessor and software stack, staying the same."

www.q-p-t.com/qgan-module-technical-video-overview

Wise-integration and Savoy launch first GaN charger embedded with e-bike battery

Firm aims to extend GaN solution for e-bike makers across Europe

Wise-integration of Meylan, France — which was founded in 2020 and designs and develops gallium nitride (GaN) integrated circuits and digital-control technologies for power supplies — and France-based tier-1 automotive supplier Savoy Group have announced a new GaN charger for e-bikes embedded with the battery of the new Cocotte electric bike, designed and manufactured by KILOW (a rebranded light e-mobility division of Savoy Group).

Launched at the EUROBIKE 2023 event in Frankfurt Messe, Germany (21-25 June), the urbanized e-bike and on-board charger together are said to free riders of two common

pain-points that they face on the streets: running out of power and packing the added weight of portable chargers.

What is claimed to be the world's first GaN on-board charger and Wise-integration's GaN devices for e-bikes are a highly integrated solution assembled by Savoy Group.

"Our charger is embedded in the battery itself, making it the lightest, most compact and convenient charger on the market," claims Wise-integration's CEO Thierry Bouchet. "This technology enables e-bike users to easily charge their bikes on the go, wherever they are."

"Anything we take away, be it weight, electronics or gadgets, actually gives the user something more in terms of maintenance, ease of use or peace of mind," says Arthur Allamand, marketing director for KILOW.

Wise-integration aims to extend its GaN products and solution for power supply and e-bike manufacturers across the European market. Due to the combination of the WiseWare AC-DC digital controller and WiseGan GaN device, Wise-integration says it is able to improve power density to provide more power for embedded fast-charging capabilities.

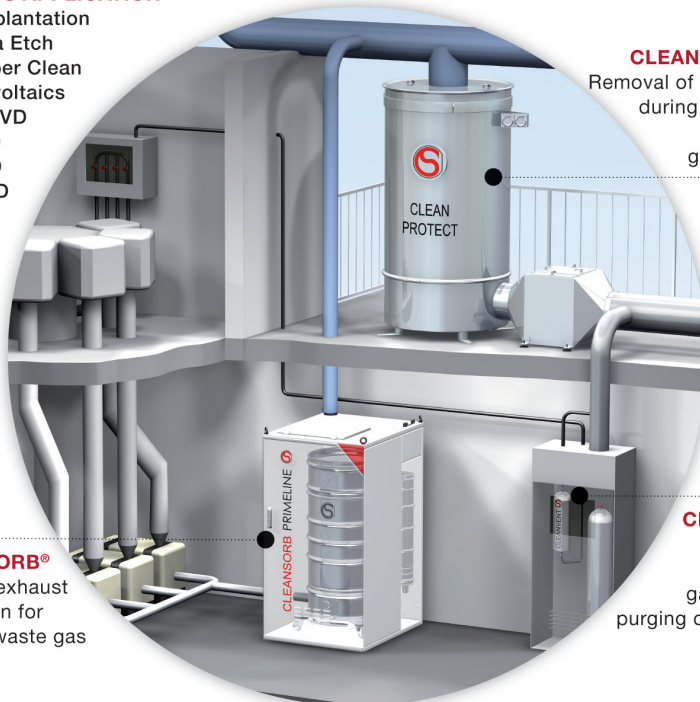
www.wise-integration.com



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Toyoda Gosei develops horizontal GaN power device for high-voltage, high-speed operation

Polarization super-junction GaN power transistor with $\geq 1500\text{V}$ breakdown voltage enables 800V operation and μs on/off time

With support from the Japan Ministry of the Environment's 'Project to Accelerate the Social Implementation and Spread of Components and Materials for Innovative CO₂ Reductions', Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, and Japan-based Powdec K.K. have

jointly developed a high-performance horizontal gallium nitride (GaN) power device that can lead to improved performance in power converters used in solar power generation and other equipment.

As society moves toward carbon neutrality, for power control in industrial machinery, automobiles and home appliances etc there is great focus on the commercialization and adoption of next-generation power devices that can reduce power loss during control holds.

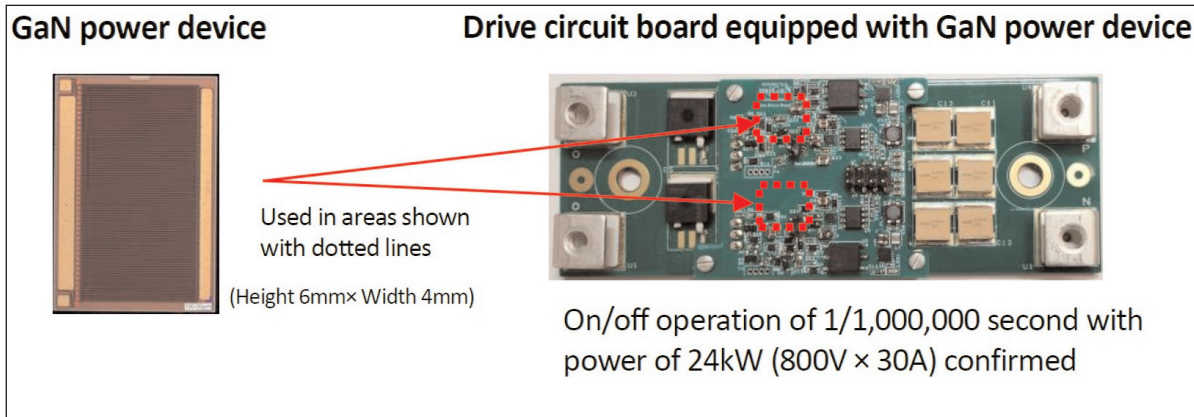
GaN power devices in particular feature high-speed operation, but higher breakdown voltage for higher-power operation has been an issue in wider application.

Using a module equipped with an originally designed polarization super-junction GaN power transistor with a high breakdown voltage of $\geq 1500\text{V}$ under development by Toyoda Gosei and Powdec, performance with both high-voltage operation (800V) and high-speed operation (on/off operation of

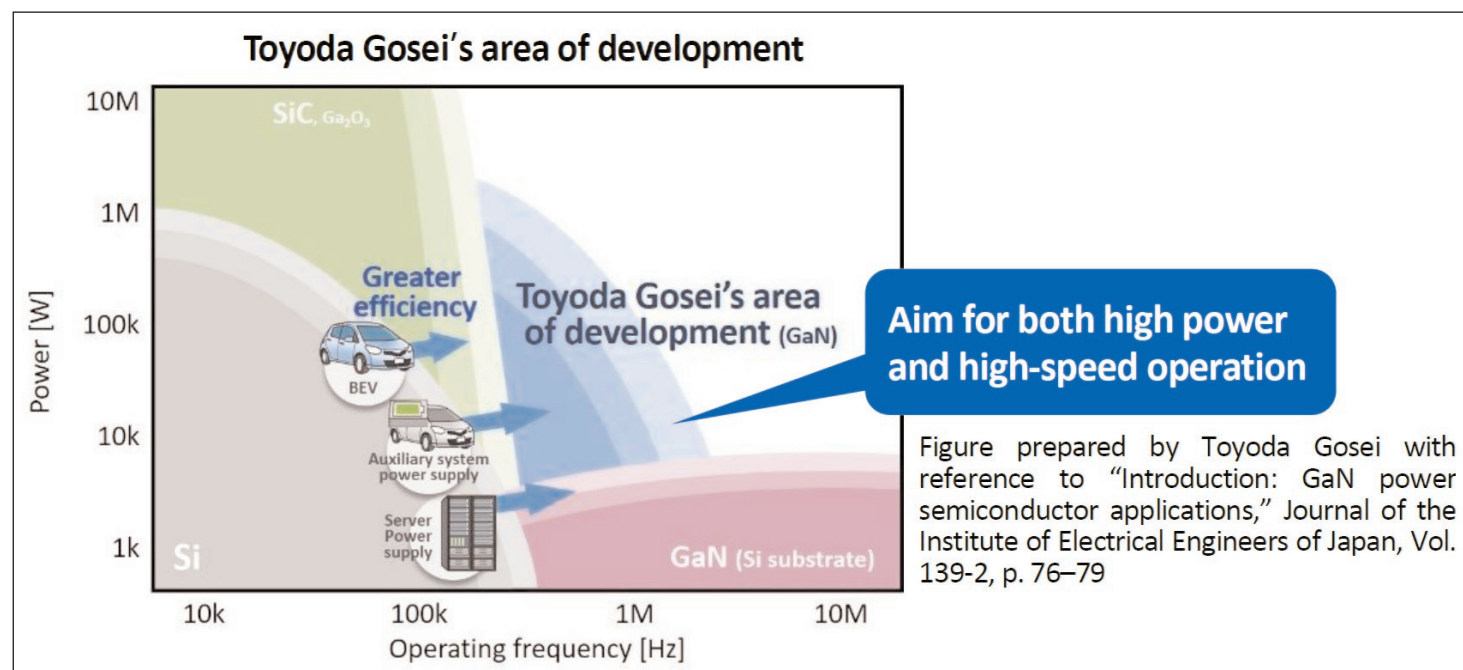
one millionth of a second) is "among the highest in the world", it is claimed.

The demonstration of a power device that offers both high-voltage and high-speed operation is reckoned to be promising for reduced power loss in solar power generation and other benefits. The companies are aiming to assure stable continuous operation and durable quality for early commercialization.

www.toyoda-gosei.com
<http://powdec.co.jp/english/index>



GaN power device and drive circuit board.



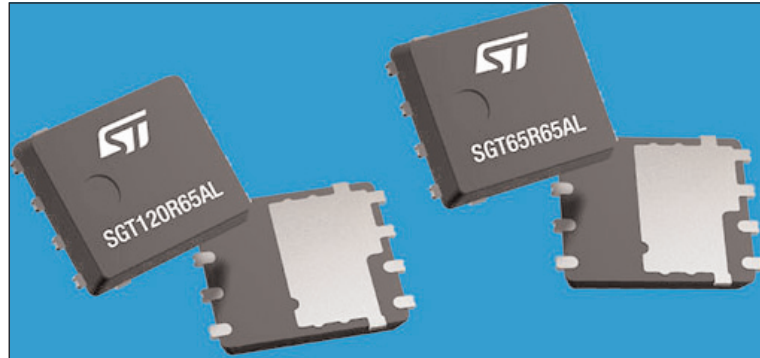
Toyota Gosei's area of development.

ST begins volume production of PowerGaN HEMTs

Initial industrial-qualified 650V normally-off G-HEMTs to be followed by automotive-qualified devices and other power-package options

STMicroelectronics of Geneva, Switzerland has begun volume production of e-mode PowerGaN high-electron-mobility transistor (HEMT) devices that simplify the design of high-efficiency power conversion systems. The STPOWER gallium nitride (GaN) transistors are said to raise performance in applications such as wall adapters, chargers, lighting systems, industrial power supplies, renewable energy applications, and in automotive electrification.

The first two products in the family, the SGT120R65AL and SGT65R65AL, are industrial-qualified 650V normally-off G-HEMT in a PowerFLAT 5x6 HV surface-mount package. They have current ratings of 15A and 25A, respectively, with typical on-resistance ($R_{DS(on)}$) of 75m Ω and 49m Ω at 25°C. Also, 3nC and 5.4nC total gate charge and low parasitic capacitances ensure minimal turn-on/turn-off energy losses. A Kelvin source connection allows optimized gate driving. In addition to the reduced size and weight of the power supplies



and adapters, the two new GaN transistors provide higher efficiency, lower operating temperature, and extended life-time.

In the coming months, ST will introduce new PowerGaN variants, i.e. automotive-qualified devices, as well as additional power-package options including PowerFLAT 8x8 DSC and LPAK 12x12 for high-power applications.

ST says that its G-HEMT devices facilitate the transition to GaN wide-bandgap technology in power conversion. GaN transistors with the same breakdown voltage and $R_{DS(on)}$ as silicon alternatives can achieve lower total gate charge and parasitic capacitances, with zero

reverse-recovery charge. These properties raise efficiency and enhance switching performance, allowing higher

switching frequency that permits smaller passive components, hence increasing power density. Applications can therefore become smaller with higher performance. In the future, GaN is also expected to enable new power conversion topologies that will further improve efficiency and decrease power losses.

ST says that it has high production capacity for PowerGaN discrete products to support customer demand for a very fast ramp to volume manufacturing. The SGT120R65AL and SGT65R65AL in PowerFLAT 5x6 HV packages are available now, from \$2.60 and \$5.00, respectively, for 100-unit orders.

www.st.com/

NexGen and General Motors to receive DoE funding for GaN-based electric drive systems

Vertical GaN to be used in DoE-sponsored inverter drive systems project for electric vehicles

NexGen Power Systems Inc of Santa Clara, CA, USA – which was founded in 2017 to design and manufacture proprietary power conversion devices using patented Vertical GaN (gallium nitride) technologies – says that its collaborative project with General Motors had been awarded funding by the US Department of Energy (DoE) for the development of electric drive systems using its Vertical GaN semiconductors. The joint development project aims to enhance the

efficiency, performance and overall sustainability of electric vehicles and intends to focus on power electronics design, motor integration, thermal management and system-level optimization for electric drive systems.

“This collaboration will help us introduce Vertical GaN-based inverter drive systems to the electric vehicle market and will help enable auto makers to improve range, reduce weight, and enhance system reliability,” says NexGen’s

CEO Shahin Sharifzadeh.

The announcement builds on NexGen’s announcements in February regarding the availability of engineering samples for its 700V and 1200V semiconductors. The firm’s current-generation 1200V, 1 Ω Vertical GaN e-mode Fin-jFETs have successfully demonstrated >1MHz switching at 1.4kV rated voltage, enabling continued performance, reliability and efficiency improvements in the EV market.

www.nexgenpowersystems.com

Transphorm's full-year product revenue grows 21%

Sequential product revenue growth to resume in September quarter

For its fiscal fourth-quarter 2023 (to end-March), Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has reported revenue of \$3.192m, down on \$4.493m last quarter and \$4.927m a year ago. However, this was impacted primarily by a government contract delay (the revenue from which will be recognized starting in fiscal first-quarter 2024). Product revenue was at the targeted \$3.2m.

Full-year revenue has fallen from \$24.05m in fiscal 2022 to \$16.511m for fiscal 2023. However, this was due primarily to an \$8m decrease in licensing revenue. Product revenue rose by 21% to \$14.7m.

On a non-GAAP basis, operating expenses have risen further, from \$4.71m a year ago and \$6.02m last quarter to \$7.55m. Full-year operating expenses rose from \$18.3m in fiscal 2022 to \$24.2m for fiscal 2023.

Net loss was \$7.2m (\$0.13 per share), up from \$3.5m (\$0.07 per share) a year ago but cut from \$8.5m (\$0.15 per share) last quarter. Nevertheless, full-year net loss has risen from \$6.4m (\$0.14 per share) in fiscal 2022 to \$24.6m (\$0.44 per share) for fiscal 2023.

Driven by the lower revenue due to the delay in securing the new government contract with National Security Technology Accelerator (NSTXL) plus increased days sales outstanding (DSO), quarterly cash burn has increased. Cash, cash equivalents and restricted cash have hence more than halved during the quarter, from \$34m to \$16m.

After the end of the quarter, in early April, Transphorm raised \$9.3m through the exercise of existing warrants and a private placement of common stock. Also,

in mid-June, it announced a rights offering for up to \$15m of common stock, in which certain key stockholders have indicated their interest in participating.

Also in April, Transphorm fully repaid its \$12m loan from Nexperia, and ended its exclusivity for Nexperia in the four-wheeler electric vehicle segment.

Business highlights during the quarter are listed as:

- The strong five-year pipeline opportunity now stands at over \$440m, up 7% from the previous update in February.
- Increased design-ins and opportunities nearing or in production are currently expected to result in sequential product revenue growth resuming in fiscal second-quarter 2024.
- A contract worth up to \$15m was secured from NSTXL to manufacture GaN epiwafers under the ECLIPSE project.

High-power segment update

- Total design-ins for higher power (300W–4kW) grew by 25% from the previous update (in February) to over 60 (with 30 in production).
- Transphorm is the only GaN company with a proven ramp in the micro-inverter segment, with several hundred thousand devices in the field (800W, 1500W inverters) and a targeted ramp to over \$1m annual revenue over the next 12 months with the largest customer. Other key design-ins are ongoing.
- A low-cost driver solution for SuperGaN FETs was launched, strengthening Transphorm's value proposition in segments such as LED lighting, charging, micro-inverters,

Driven by the lower revenue due to the delay in securing the new government contract with NSTXL plus increased DSO, quarterly cash burn has increased

uninterruptible power supplies (UPS) and gaming computers.

● Transphorm launched the first 1200V FET simulation model and preliminary datasheet, a 1200V GaN-on-sapphire power semiconductor backing the firm's ability to support future automotive power systems and compete with 1200V SiC devices.

● The firm launched its third high-power GaN design tool using a digital signal controller from Microchip Technology, featuring a 3.0kW DC-to-AC non-isolated full-bridge inverter evaluation board.

Low-power segment update

● Transphorm increased its total design-ins for power adapters and fast chargers (<300W) to over 90 (with over 25 in production), an increase of 10% from the previous update in February.

● Fabless firm Weltrend Semiconductor Inc of Hsinchu Science Park, Taiwan — which specializes in the design, testing, application development and distribution of mixed-signal/digital ICs in power supplies, motor controls and image processing — released an integrated GaN system-in-package (SiP) for 65W fast-charging applications, in collaboration with Transphorm.

● In a recent tear-down study of the 280W Razer gaming power supply, Transphorm's drop-in SuperGaN out-performed different e-mode devices (including leading foundry-made GaN) with a device temperature reduction of 20–50%, higher efficiency, and expected reliability.

● Six surface-mount devices were launched, available in industry-standard PQFN 5x6 and 8x8 packages (for both low- and high-power segments).

"We continue to see strong fundamental growth trends driven primarily by increased design wins for both the high-power and low-power market segments," says president, CEO & co-founder Primit Parikh.

"These trends point to the company

resuming sequential product revenue growth beginning in the second quarter of fiscal 2024," he adds.

"Our differentiated GaN semiconductors lead the industry in performance and reliability, carrying the only reported broad power spectrum reliability ratings for GaN power and over 175 billion hours in the field," he claims. "Our increased design-ins, the end-customer momentum in ramping GaN, and the recent broad market excitement in GaN power is driving our desire to commence a strategic review of various opportunities to enhance shareholder value."

"The past quarter and fiscal year have been extremely important toward positioning us strategically for future growth," Parikh believes. "We expect our recently announced rights offering and the asset-based debt financing initiatives we are

pursuing will significantly improve our cash position and put us in a strong position to pursue the increased opportunity funnel and allow us to focus on product innovation, operational capabilities and collaborative opportunities," says

Our recently announced rights offering and the asset-based debt financing initiatives we are pursuing will significantly improve our cash position and put us in a strong position to pursue the increased opportunity funnel and allow us to focus on product innovation, operational capabilities and collaborative opportunities

chief financial officer Cameron McAulay.

During fiscal first-quarter 2024 (to end-June 2023), Transphorm was awarded the NSTXL contract, resulting in revenue being recognized commencing that quarter, and DSOs improved to historical levels. Consequently, for fiscal Q1/2024 Transphorm expects revenue of \$5.8–6.2m, GAAP gross margin of 30–34%, and GAAP net loss per share of \$0.10–0.13.

Transphorm forecasts it will have cash runway into the second half of September 2023, not including the rights offering, asset-based debt or any other financings. If the rights offering is fully subscribed and the firm completes the asset-based debt financing that it is pursuing, it would have cash runway well into fiscal 2025.

www.transphormusa.com

Transphorm's rights offering raises \$7.94m Firm to begin review of strategic opportunities, including strategic partnerships, licensing in the USA and Asia, and M&A

Transphorm says that its rights offering (announced on 16 June), which entitled eligible stockholders to purchase 0.07655623 of a share of common stock for every right held at a subscription price of \$3.30 per whole share, has resulted in the sale of 2,404,758 shares, generating about \$7.94m in gross proceeds. After giving effect to the rights offering, the firm has about 61.8 million shares of common stock issued and outstanding.

KKR Phorm Investors L.P. — which beneficially owned about

38.52% of the common stock outstanding as of the record date — exercised in full its basic subscription rights in the rights offering. In addition, all executive officers and certain directors of the company — who together beneficially owned about 2.55% of the common stock outstanding as of the record date — each acquired shares in the offering. Updated positions of their shares held will be disclosed via Form 4 filings with the US Securities and Exchange Commission (SEC).

Transphorm intends to use the

net proceeds for working capital and other general corporate purposes.

"With the completion of the rights offering, Transphorm is now well positioned to begin a review of strategic opportunities and alternatives for enhancing and maximizing stockholder value including, but not be limited to, strategic partnerships, licensing opportunities in the USA and Asia, and potential M&A opportunities," says Transphorm's president, CEO & co-founder Primit Parikh.

www.transphormusa.com

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Finwave appoints Pierre-Yves Lesaicherre as CEO Co-founder & former CEO Dr Bin Lu becomes chief technology officer

Finwave Semiconductor Inc of Waltham, MA, USA says that Dr Pierre-Yves Lesaicherre has joined it as CEO. Described as a semiconductor industry veteran with decades of experience leading technology companies into accelerated growth and increased profitability, Lesaicherre will be instrumental in driving the adoption of Finwave's technology and bringing it to the broader market.

Co-founder & former CEO Dr Bin Lu is now taking on the role of chief technology officer, maintaining his commitment to driving technology development and innovation within the company.

Founded in 2012 by researchers at Massachusetts Institute of Technology (MIT) as Cambridge Electronics before being rebranded in June 2022 as Finwave Semiconductor (with offices in San Diego, CA and the Bay Area), the early-stage technology company targets 5G communications with its 3DGaN technology, which features a 3D fin gallium nitride transistor (GaN FinFET) structure.

"With his extensive leadership experience in the semiconductor industry, profound expertise in technology, science and global business, and a remarkable track record of transforming businesses into resounding successes, Pierre-Yves is ideally positioned to guide the company forward as we con-



CEO Dr Pierre-Yves Lesaicherre.

tinue to push the boundaries of GaN semiconductor technology," believes Lu. "I eagerly anticipate the positive impact he will undoubtedly make, as we strive to revolutionize

energy-efficient 5G/6G communications, data centers, automotive power, the IoT and more."

Finwave says its 3DGaN FinFET technology delivers advances in linearity and power efficiency for 5G communications. Also, it claims that its pioneering enhancement-mode (E-mode) RF technology opens up possibilities for high-performance power amplifiers in mobile handsets. By capitalizing on high-volume 8" silicon CMOS manufacturing, Finwave says that its GaN-on-Si platform enables substantial cost reductions compared with traditional 6" GaN-on-SiC and GaAs technologies, while embracing the scalability principles akin to 'Moore's Law' for GaN.

"Finwave has introduced a new era of innovation and progress and is on the cusp of bringing the true potential of GaN to some of today's most important enabling markets — including 5G, AI and the IoT," says Lesaicherre. "The company's

technology has already demonstrated its ability to deliver extremely high performance in higher-frequency applications."

Before joining Finwave, Lesaicherre was president, CEO and a director of Nanometrics Inc, a provider of advanced process control metrology and software analytics. He was also CEO of Lumileds, an integrated manufacturer of LED components and automotive lighting lamps, from 2012 to 2017. Lesaicherre previously held senior executive positions at NXP and Philips Semiconductors, and served as chairman of the board of Silvaco Group Inc, a supplier of TCAD, EDA software and design IP. Lesaicherre currently serves on the board of InterDigital, a technology company that develops and licenses mobile and video technologies that are at the core of devices, networks and services worldwide.

Lesaignerre holds an MBA with a focus on International Business and Strategy from INSEAD, and has an M.S. degree and a Ph.D. degree in Material Science from the Grenoble Institute of Technology (Grenoble INP). He is a board leadership fellow, governance fellow and director certified for NACD (National Association of Corporate Directors) and an active member of NACD and SVDX (Silicon Valley Director's Exchange).

www.finwavesemi.com

Gallium Semiconductor showcases new products at IMS

At the IEEE's International Microwave Symposium (IMS 2023) in San Diego, CA, USA (13–15 June), Singapore-based Gallium Semiconductor showcased its RF gallium nitride (GaN) products targeting 5G telecoms, aerospace & security, and multi-market applications.

Specifically, the firm is highlighting its most recent GaN technology breakthroughs and new product

introductions including:

- dual-path, asymmetric Doherty power amplifiers for 5G MIMO and Macro applications in sub-6GHz cellular bands;
- a full suite of transistors in bare die form and packaged in leadless plastic, air-cavity plastic and air-cavity ceramic packages for industrial, scientific & medical (ISM) and multi-market applications; and
- transistors designed for pulsed

radar systems across aviation, air-traffic control, weather services, and satellite communications.

Gallium Semi says that, as a global company delivering a broad portfolio of RF GaN solutions, it has established partnerships with customers worldwide to quickly deliver high-performance and high-efficiency systems for various applications.

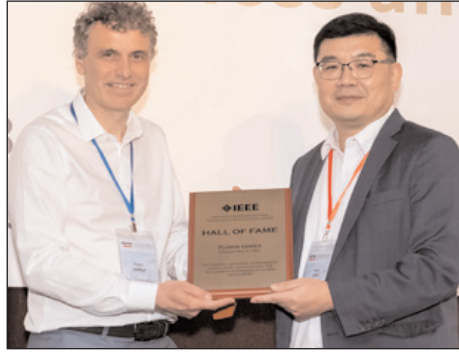
www.ims-ieee.org/ims2023

www.galliumsemi.com

CGD's CTO Udrea inducted into IEEE ISPSD Hall of Fame

Cambridge GaN Devices Ltd (CGD) — which was spun out of the University of Cambridge Department of Engineering's Electrical Power and Energy Conversion group in 2016 and designs, develops and commercializes power transistors and ICs that use GaN-on-silicon substrates — says that its co-founder & chief technology officer professor Florin Udrea was recently inducted into the IEEE ISPSD (35th International Symposium on Power Semiconductor Devices and ICs) Hall of Fame, which honours individuals who have made high-impact contributions in advancing power semiconductor technology and/or sustaining the success of ISPSD. His citation reads: "For inspiring a generation of engineers to excel in power semiconductors and his numerous contributions to the field and to ISPSD".

Besides the Hall of Fame induction at the ISPSD 2023 in Hong Kong (28 May–1 June), Udrea was also given the awards for 'Best Paper' and 'Best Poster' for his contributions at ISPSD 2022 in Canada — the first time in the 35-year history of ISPSD when these two awards have been given to the same person.



CGD's co-founder & CTO Florin Udrea.

"I am proud to join such an august and select group of illustrious and pioneering colleagues," comments Udrea. "It is my privilege and also good fortune to be active at a time when the subject of 'power' has never been more relevant. By working with new WBG materials such as GaN, we can all improve efficiency and reduce our carbon footprint," he adds.

"CGD is fortunate to have some-one of his experience with power materials of many different types — silicon, silicon carbide, diamond as well as gallium nitride — as CTO, and we still benefit from the research that results from the efforts made by HVMS, the High Voltage Microelectronics and Sensors group

at Cambridge University, which Florin still leads," comments co-founder & CEO Giorgia Longobardi.

Udrea has published over 600 papers in journals and international conferences and is an inventor of 200 patents in power semiconductor devices and sensors. In 2015 he was elected a Fellow of the Royal Academy of Engineering. His Best Poster award at the ISPSD 2023 conference was given for the presentation 'The Smart ICeGaN Platform with Sensing and Protection Functions for Both Enhanced Ease of Use and Gate Reliability.' CGD's 650V ICeGaN GaN HEMT family is claimed to deliver industry-leading robustness, ease-of-use and maximized efficiency. ICeGaN can be used as platform technology for a wide spectrum of application ranging from power supplies in the consumer sector to converters and inverters in the industrial sector. Udrea's Best Paper award was given for work on vertical silicon carbide (SiC) FinFET devices undertaken at the University of Cambridge, in collaboration with Japan-based Misrise Technologies and University of Kyoto.

www.ispsd2023.com

CGD signs global distribution deal with DigiKey DigiKey to hold stocks of ICeGaN HEMTs and related products

Cambridge GaN Devices has signed a global distribution deal with DigiKey of Thief River Falls, MN, USA. DigiKey will hold substantial stocks of CGD's ICeGaN gallium nitride high-electron-mobility transistors (HEMTs) and related products.

"This agreement is a significant step for CGD as we are scaling-up the business and building a GaN ecosystem that will help engineers explore and utilize the benefits of ICeGaN for high-voltage power conversion," says chief commercial officer Andrea Bricconi. "DigiKey is very well respected and a trusted brand, and we are sure that this deal will enable CGD to penetrate

and support new markets worldwide," he adds.

"We are pleased to add Cambridge GaN Devices (CGD) to our Fulfilled by DigiKey program," says Missy Hall, VP new market development at DigiKey. "By including CGD's ICeGaN series transistors in our portfolio, DigiKey is delivering even more energy-efficient options for our customers to choose from."

Recently, CGD launched its 650V H2 Series ICeGaN gallium nitride HEMT family. The new parts reduce design complexity as they can be driven using commercially available industry gate drivers. In terms of efficiency, ICeGaN HEMTs

feature a QG that is 10x lower than silicon parts, and QOSS is 5x less. This reduces switching losses, enabling what is claimed to be industry-leading efficiency performance that result in reductions in system size, weight and cost. H2 Series ICeGaN HEMTs also address reliability and ruggedness concerns by employing CGD's smart gate interface that is said to virtually eliminate typical enhancement-mode GaN weaknesses. Devices feature improved over-voltage robustness, higher noise-immune threshold, dV/dt suppression and ESD protection.

www.digikey.com

Aehr added to Russell 3000 Index

Semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has been added to the Russell 3000 Index as part of the 2023 Russell index annual reconstitution "highlighting the financial and operating growth we have achieved and further enhancing our visibility and reach within the investment community," says president & CEO Gayn Erickson.

"We look forward to continuing our strong momentum in the semiconductor wafer-level test and burn-in market and driving increased value for shareholders."

The annual reconstitution of the Russell indexes captures the 4000 largest US stocks as of 28 April, ranking them by total market capitalization. Membership in the US all-cap Russell 3000 Index, which remains in place for one year,

means automatic inclusion in the large-cap Russell 1000 Index or small-cap Russell 2000 Index as well as the appropriate growth and value style indexes. FTSE Russell determines membership for its Russell indexes primarily by objective, market-capitalization rankings, and style attributes.

www.ftserussell.com/resources/russell-reconstitution
www.aehr.com

Aehr receives \$13.7m follow-on orders from its lead silicon carbide test & burn-in customer

Aehr has received \$13.7m in orders from its lead silicon carbide test & burn-in customer for WaferPak full-wafer Contactors to meet their increased production capacity needs for silicon carbide power semiconductors for the electric vehicle (EV) market. This customer is "a leading Fortune 500 supplier of semiconductor devices with a significant customer base in the automotive semiconductor market".

"We continue to be excited about this customer's incredible growth and production ramp to meet capacity increases from their current customers, as well as to meet new design wins using our wafer-level test & burn-in systems and WaferPaks," says president & CEO Gayn Erickson. "These orders for a large number of WaferPaks include both current design capacity increases and several new designs that are expected to ramp to volume production after their customer qualification is completed. These WaferPaks are scheduled to be delivered over the next six months," he adds.

"This customer has a significant installed base of our FOX-XP wafer-level test & burn-in systems that is growing as we continue to ship systems to them monthly. Each of the 18-wafer FOX-XP systems requires 18 WaferPaks

that each make contact with 100% of the die on the wafers with parametric measurement and monitoring that allows us to provide 100% traceability of test coverage and results to them on every die on every wafer. This is incredibly important to them, as well as other companies that supply devices to mission-critical applications such as the traction inverters used to power electric vehicle motors," he adds.

"FOX-XP system orders are required to increase general manufacturing capacity, while our proprietary WaferPak Contactors are unique to each device design. As our customers win new designs from their customers, Aehr secures orders for new WaferPak Contactors to fulfill these new wins. Over time, we expect to see our follow-on WaferPak business grow both in absolute dollars and as a percent of our overall revenue."

"These WaferPak full-wafer Contactors are also shipping in a configuration that utilizes new patented features that allow optimized alignment accuracy and alignment speed and throughput using our new fully automated FOX WaferPak Aligners that began shipping this last month," Erickson continues. "The new FOX WaferPak Aligner comes in both standalone and integrated configurations.

In a standalone configuration, each FOX WaferPak Aligner can service multiple 18-wafer FOX-XP systems in batch mode, while the integrated configuration of our Aligner docks directly to the front of the 18-wafer FOX-XP system and allows continuous flow of WaferPak alignment and testing in the FOX-XP without the need for any operator handling. The integrated FOX-XP and WaferPak Aligner allow the ability to support a lights-out operation with full factory automation using automated mobile robot transport or full overhead material movement of wafer transport cases (SMIF pods or FOUPs) carrying 150mm, 200mm or 300mm wafers."

The FOX-XP system, available with multiple WaferPak Contactors (full-wafer test) or multiple DiePak Carriers (singulated die/module test) configurations, is capable of functional test & burn-in/cycling of integrated devices such as silicon carbide (SiC) power devices, silicon photonics as well as other optical devices, 2D and 3D sensors, flash memories, gallium nitride (GaN), magnetic sensors, microcontrollers, and other leading-edge ICs in either wafer form factor, before they are assembled into single- or multi-die stacked packages, or in singulated die or module form factor.

New silicon carbide customer and initial order for Aehr's FOX-XP multi-wafer test and burn-in

Long-term supply agreement covers FOX-XP systems, WaferPaks, WaferPak Aligners and support for high-volume SiC MOSFET production

Semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has announced a new silicon carbide customer and initial order for a FOX-XP multi-wafer test and burn-in system, multiple WaferPak Contactors, a WaferPak Aligner, and a high-volume production support kit for volume production of silicon carbide MOSFETs for electric vehicles, trucks and train traction inverter modules. The turnkey system including the FOX-XP, WaferPak Contactors and WaferPak Aligner is expected to ship within the next two quarters.

In addition, Aehr has also signed a long-term supply agreement with this new customer covering FOX-XP systems, WaferPaks, WaferPak Aligners, and support. This new customer is a multinational industrial conglomerate and manufacturer of semiconductors, including power semiconductors.

"After conducting an evaluation of technical and commercial requirements, this new customer has decided to move very quickly to purchasing our production FOX-XP solution to accelerate their time to market," notes president & CEO Gayn Erickson. "This evaluation included cost of ownership, customer device module yield improvement, system capacity and throughput, and device test, burn-in and stabilization coverage. They see the enormous opportunity in the silicon carbide market, particularly for the traction inverters used in electric vehicles including trucks, and in electric commuter trains where they believe they can provide a superior product of long-term reliability and useful life. Importantly, these new applications represent new market drivers for our system. This customer is forecasting to grow their silicon carbide

business significantly, which we believe will drive incremental capacity for our FOX systems as well as WaferPak Contactor purchases for capacity and new designs," he adds.

"Our momentum with this newest customer reflects the acceleration in customer benchmarks and evaluations we are seeing, including shifting from on-wafer evaluations and moving straight to placing orders for our systems and WaferPaks," Erickson continues.

"Several companies are describing an even stronger and broader shift to multi-die modules for the electric vehicle market, particularly for the main traction inverters used on each electric engine or drive unit. The reduction in size and cost of implementing traction inverters using multi-die modules becomes more critical in achieving cost reductions in electric vehicles that are smaller and that have multiple drive units per vehicle. Unlike traditional internal combustion vehicles with only one engine per vehicle, it is becoming more and more typical to see electric vehicles that come standard or have the option of more than one motor or drive unit in them," he adds.

"Wafer-level burn-in is critically important to remove infant mortality or early failures of devices before they are put into modules, where the failure of any device would cause the entire module to fail and be scrapped. A single module for use in large traction inverters such as commuter trains might include up to 10, 12 or even 32 devices. Our FOX-XP wafer-level system can test and burn-in up to 18 wafers at a time and enables contact to 100% of the die in a single touch-down up to several thousand die per wafer, with 100% confidence of test burn-in of each device. This is key to companies wanting to put

these devices in electric vehicle applications, where up to 1% or more of the die would fail in the field if not burned in," Erickson says.

"In addition, beyond screening out weak devices or early failures before they are put into a module, there is a need to stabilize the inherent early life drift of threshold voltages of devices that is critical to the module reliability. Silicon carbide devices have voltage thresholds, which is effectively the voltage at which each individual device turns on and will drift during the first use, or during burn-in stress conditions under thermal loads. This can cause individual die in a multi-die module to turn on prematurely relative to the other die in parallel, which can create a disproportional stress on the die, leading to its early failure. This in turn will lead to the failure of the entire module. This failure must be screened out to prevent a 'walk-home event' whereupon, with the failure of the traction inverter module, the drive unit will fail, leading to the driver and all the passengers having to get out of the electric vehicle and walk home."

The FOX-XP system, available with multiple WaferPak Contactors (full-wafer test) or multiple DiePak Carriers (singulated die/module test) configurations, is capable of functional test and burn-in/cycling of integrated devices such as silicon carbide power devices, silicon photonics as well as other optical devices, 2D and 3D sensors, flash memories, gallium nitride (GaN), magnetic sensors, micro-controllers, and other leading-edge ICs in either wafer form factor, before they are assembled into single- or multi-die stacked packages, or in singulated die or module form factor.

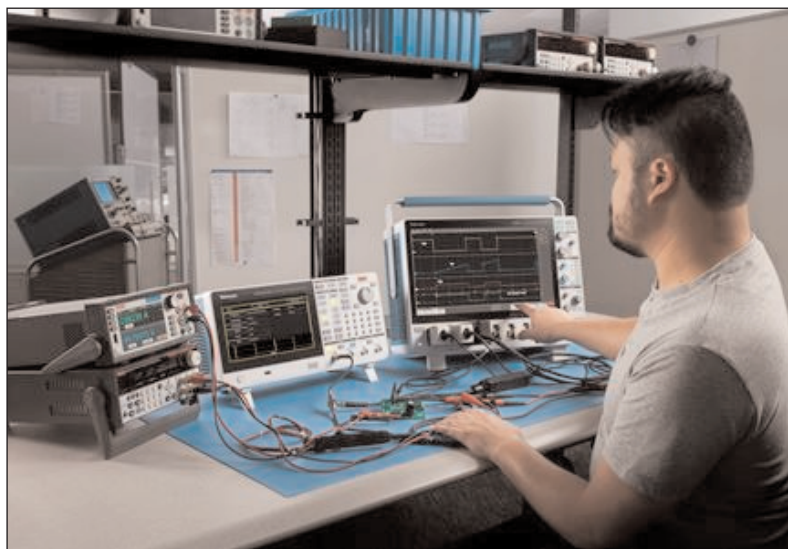
www.aehr.com

Tektronix releases oscilloscope-based Double Pulse Test Speeding up validation time for SiC and GaN MOSFETs

Test, measurement and monitoring solutions supplier Tektronix Inc of Beaverton, OR, USA has announced a new release of its Double Pulse Test (WBG-DPT) solution (available now for global customers). With new wide-bandgap switching devices enabling significant advances in electric vehicles, solar energy and industrial controls, the WBG-DPT solution has the ability to provide automated, repeatable and accurate measurements on wide-bandgap devices such as silicon carbide (SiC) and gallium nitride (GaN) MOSFETs, says the firm.

Designers of next-generation power converters can now be able to quickly utilize the WBG-DPT solution to optimize their designs. With the ability to run on Tektronix 4, 5 and 6 Series MSO oscilloscopes, integrating seamlessly into the measurement system of the oscilloscopes, the WBG-DPT solution is claimed to have several industry-first measurement capabilities, such as an automatic WBG de-skew technique, and reverse recovery timing plots, making it easier for engineers to see reverse recovery details for multiple pulses overlaid on a single display. Measurements are also designed to align with JEDEC and IEC standards for double pulse testing and diode reverse recovery.

"Tektronix customers are the designers of the next generation of cutting-edge power electronics technology, and their designs must be optimized to balance efficiency, size and reliability," says Daryl Ellis, mainstream portfolio general manager. "The design of the Tektronix WBG-DPT solution will allow for simplified debugging, repeatable measurements (per JEDEC and IEC standards) and a faster learning curve. Test automation reduces test times and re-testing errors, ensuring our customers meet their project timelines and time-to-market plans," he adds.



Double pulse testing software on the Tektronix 5 Series MSO automates key validation measurements on GaN and SiC power converters.

"The WBG-DPT software provides instantaneous measurements of key parameters, like EON, EOFF and QRR when performing double-pulse tests," comments Masashi Nogawa, staff systems engineer at Qorvo. "The software makes the power waveform and markers showing the integration ranges used to calculate the energy losses immediately visible. This is an excellent alternative to exporting waveform data into Excel spreadsheets for processing."

To achieve meaningful energy loss measurements, designers must correct for delays introduced by test fixtures and probes. The traditional technique for aligning drain-to-source voltage (V_{DS}) and drain current (I_D) measurements requires re-wiring the test setup and careful pre-test measurements.

Key features of WBG-DPT solution

The WBG-DPT solution's industry-first WBG de-skew technique eliminates the need for re-wiring and may even be performed after double pulse measurements have been taken. To simulate the effects of delays in the test setup, the software generates an alignment waveform. The engineer adjusts a

few settings to match the alignment waveform with the measured waveform, as the software corrects any differences in delays. This new process reduces the de-skew time from an hour or more to just 5–10 minutes.

Since power converters must operate over a wide range of temperature conditions, there is a growing need to measure output charge (Q_{OSS}) at different junction temperatures. The WBG-DPT solution makes fast and accurate Q_{OSS} measurements, providing important insight into the effects of device output capacitance.

With the WBG-DPT solution, industry-first reverse recovery timing plots make it easy for engineers to see reverse recovery details for multiple pulses overlaid on a single display. Measurements are made per JEDEC and IEC standards, and users can configure measurements in WBG solution to query results on every first or second pulse, or all pulses of a double pulse set. This unique approach to reverse recovery plotting allows for multiple double pulse sets and provides visual and measurement results on each set. The measurement provides the ability to easily zoom in on the reverse recovery region and even debug reverse recovery parameters of the system.

www.tek.com/en/datasheet/wide-bandgap-double-pulse-test-analysis-455b6b-series-mso-option-4wbgdpt5wbgdpt6wbgdpt

Keysight introduces PathWave ADS 2024 EDA software

New mmWave and sub-THz capabilities accelerate 5G product design and pioneer 6G development

Keysight Technologies Inc of Santa Rosa, CA, USA has introduced PathWave Advanced Design System (ADS) 2024, an electronic design automation (EDA) software suite giving chip designers new millimeter-wave (mmWave) and subterahertz (sub-THz) frequency capabilities that accelerate 5G mmWave product design and anticipate requirements for 6G wireless communications development.

Developers of 5G and non-terrestrial network components are creating next-generation radio front-end modules using mmWave frequency bands that present significant design and simulation challenges. These frequencies are prone to signal loss due to propagation characteristics, atmospheric attenuation, complex packaging issues, and noise and dynamic range problems. Designing for 6G poses even greater challenges with sub-THz signals operating at higher frequencies.

Monolithic microwave integrated circuits (MMIC) and module designers are combining multiple semiconductor and III-V processes at mmWave frequencies, which requires multiple die assembly, module-level interconnection, and power considerations. mmWave power amplifiers are built separately from the rest of the design to mitigate heat, yield and semiconductor performance issues. In addition, power amplifiers developed in gallium nitride (GaN) processes handle higher current densities than silicon.

New semiconductor packaging techniques, such as flip-chip bonding, achieve higher densities and performance. These packages also require co-design across multiple technologies and processes because they concentrate challenges with internal crosstalk, electromagnetic interference (EMI), stability, and operating temperature.

Keysight says that the latest version of its radio frequency and microwave (RF/_W) design software suite addresses these development pain points with algorithm, layout, electro-thermal, and workflow automation enhancements.

Specifically, new PathWave ADS 2024 design capabilities include:

- Faster second-generation 3D-EM and 3D-Planar meshing and solvers – Delivers algorithm enhancements taking superior advantage of domain knowledge about microwave structures and processes. Mesh optimization and layout and connectivity improvements reduce problem sizes for faster simulations. Solver enhancements also speed simulation by up to 10 times and require less specialized user expertise over a wider range of problems, including mmWave design at automotive radar frequencies of 79GHz. Open workflows save database management and reduce overhead from iterative, manual setup.
- Advanced layout and verification features – Enables design sign-off directly from ADS for LVS, LVL, DRC and ERC for MMICs, as well as streamline productivity for module and multi-technology assembly. Wavetek is the latest foundry to fully support ADS for an end-to-end workflow.
- Electrothermal enhancements accelerate validation – Drives higher reliability and higher operating performance with validation of dynamic device operating temperatures under different bias and waveform conditions. Supports high-performance compute acceleration and up to 100 times transient speed-up using W3051E Electrothermal Dynamic Re-use, enabling higher test plan coverage and earlier insights in the design phase.
- Custom workflow support with expanded Python APIs – Increases flexibility and scalability. A load-pull

data import utility, ANN modeling, and Python automation scripting for 5G power amplifier designers unlock new application potential to create targeted personalities of ADS.

“We use PathWave ADS for our mmWave power amplifier designs because it is a complete integrated solution that gives us simulation models, layout tools, and the accuracy we need to ensure first-pass success,” comments Doug Jorgensen, VP of applications at Marki Microwave. “ADS has a unique Winslow Probe stability analysis capability that enables us to optimize our amplifier designs with confidence. Our simulations closely match our lab measurements, so we avoid expensive prototype re-spins on our designs. ADS is our preferred tool for power amplifier design,” he adds.

“Traditional RF/ μ W EDA workflows involve a variety of specialized solvers that require database transfers, deep domain knowledge, and familiarity with multiple environments,” says Joe Civello, Keysight’s PathWave ADS product manager. “We’ve added more speed and performance to ADS electromagnetic (EM) meshing and solving algorithms to improve sweeping coverage through parameters like process variations and layout effects. RFPro in PathWave ADS 2024 streamlines workflows into a unified circuit-EM co-design cockpit where circuit designers can now perform EM simulation to tune and optimize designs early in the development cycle,” he adds. “ADS supports multi-technology design and analysis of thermal, EM and layout parasitics on circuits and signal modulation. It enables rapid assembly of circuits, MMICs, packaging, interconnects and module layouts to significantly improve mmWave engineering productivity.”

www.keysight.com

Axcelis ships Purion H200 SiC Power Series ion implanter to Wolfspeed Evaluation system to support production of silicon carbide power devices for electric vehicles

Ion implantation system maker Axcelis Technologies Inc of Beverly, MA, USA has shipped a Purion H200 SiC ion implant system to Wolfspeed Inc of Durham, NC, USA, which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF devices. The evaluation system will be used to support the production of power devices for electric vehicle (EV) applications.

"The power device market continues to grow rapidly and is a key driver of our growth globally," notes Axcelis' president & CEO Dr Russell Low. "We are pleased to continue to support Wolfspeed's fab capacity expansion and are also excited

about the potential of this new opportunity focused on high-current implant applications in silicon carbide power devices," he adds.

"The popularity of electric vehicles is only steepening, and Wolfspeed is focused on scaling our capacity to meet the surge in demand for our silicon carbide devices," says Missy Stigall, Wolfspeed's senior VP of global fab operations. "We partnered with Axcelis due to their expertise, highly differentiated features, and process control capabilities that are essential for power device applications," she adds.

"Together, we will work to ease supply chain constraints as more and more EVs utilizing Wolfspeed's

silicon carbide technology are introduced to the market."

Wolfspeed is currently engaged in a \$6.5bn capacity expansion effort to dramatically increase production. This includes the John Palmour Manufacturing Center for Silicon Carbide, the world's largest silicon carbide crystal growth facility, currently under construction in North Carolina, and the final build-out of the company's Mohawk Valley Fab in New York. In February, Wolfspeed also announced its plans to build a highly automated 200mm wafer fabrication plant in Saarland, Germany.

www.wolfspeed.com

www.axcelis.com

SK Powertech adopts Silvaco's Victory TCAD solution Technology computer-aided design accelerates silicon carbide power device development

Silvaco Group Inc of Santa Clara, CA, USA (which provides electronic design automation software and semiconductor design IP for process and device development) says South Korea's SK Powertech (which was founded in 2017, and became a part of SK Group in May 2022) has adopted its Victory TCAD (technology computer-aided design) solution for power devices to accelerate R&D of its silicon carbide (SiC) power devices. The Victory TCAD solution is said to enable SK Powertech to achieve significant improvements in its power management technology.

SK Powertech provides compact silicon carbide power devices for high-voltage/high-temperature applications serving growing end markets such as electric vehicles, railways, and alternative energy. The firm's products are claimed to be optimal for smaller, light-weight packages with high-voltage/

high-temperature requirements.

"To achieve significant advances in SiC power semiconductor performance, we sought a partner who could assist us in implementing our next-generation SiC power technology," says Dr Changheon Yang, director of R&D center at SK Powertech. "Through our collaboration with Silvaco's technical team and the utilization of their Victory TCAD solution for power devices, we successfully transformed conceptual ideas into actual working devices. The combination of the advanced feature set in Victory TCAD solution and Silvaco's depth of technical capabilities enables us to deliver the best products and to meet our end-market requirements," he adds.

"The expanding markets for power management in solar, automotive, industrial applications and embedded computers are driving the growing adoption of SiC power

devices," says Silvaco Group CEO Dr Babak Taheri. "The success of SK Powertech demonstrates the benefits of using Silvaco Victory TCAD solution for power devices. This solution enables the development of cutting-edge semiconductor products that drive innovation and advancement in the field," he adds.

"Our Victory TCAD solution is recognized in the semiconductor industry for its simulation and analyses capabilities and is widely adopted in the SiC power devices market," states Eric Guichard, senior VP & general manager of Silvaco's TCAD business unit. "With Silvaco's TCAD solution, SK Powertech is well positioned to make significant advancements in SiC power device technology and to contribute to the adoption of its SiC devices in various industries."

www.silvaco.com

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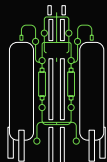
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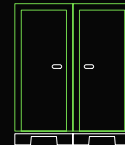
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Kulicke & Soffa launches high-power-interconnect capabilities for power devices

HPI capabilities introduced across wedge bonder portfolio

Singapore-based Kulicke & Soffa Industries Inc (K&S) — which designs and makes semiconductor, LED and electronic assembly equipment — has launched several new systems and capabilities serving high-volume semiconductor and fast-growing power-semiconductor applications.

POWERCOMM and POWERNEXX are said to represent the next evolution in wire bonding systems and are designed with a new generation of intuitive advanced process capabilities that deliver maximum levels of performance, efficiency and productivity. Also, both systems deliver enhanced mean-time-between-assists (MTBA), with automated recovery features that improve the machine-to-operator ratio and better support localization of semiconductor assembly.

The POWERCOMM wire bonding solution is designed to support high-volume discrete and low-pin-count devices commonly used in applications such as data centers, automotive, industrial automation, smartphones, wearables and connected devices.

The POWERNEXX wire bonding solution is optimized for higher-density QFN packages with widths of up to 100mm. The improved illumination design on POWERNEXX allows faster alignment time through its Pattern Recognition System (PRS). Faster alignment and advanced process capabilities deliver what is claimed to be industry-leading UPH (units per hour) and the lowest cost-of-ownership.

In addition to the new POWERCOMM and POWERNEXX systems, for wedge bond applications K&S has introduced new high-power-interconnect (HPI) capabilities addressing the emerging needs of power devices. HPI capabilities are becoming increasingly necessary to assemble applications such as inverters, battery assembly, and charging infrastructure that supports the growth and increasing efficiency requirements of sustainable energy and electric vehicle (EV) applications. The need for more efficient and higher-current applications is driving rapid changes to the power semiconductor market by increasing demand in

emerging compound semiconductors, such as silicon carbide (SiC) and gallium nitride (GaN), but are also demanding new capabilities to support next-generation battery assembly and are accelerating the transition from aluminium wire and ribbon to copper wire and ribbon. Next-generation HPI capabilities are now being introduced across Kulicke & Soffa's wedge bonder portfolio.

"Our rich history of innovation and ongoing development priorities are enabling us to provide additional value to the increasingly critical assembly process," says Shawn Sarbacker, VP of the Ball Bonder business unit. "This recent set of new wire bonding systems and capabilities will better enable customers to optimize productivity, improve material handling capabilities and significantly lower cost-of-ownership."

Both the POWERCOMM and POWERNEXX solutions, along with K&S's full suite of solutions, were debuted at the SEMICON China 2023 trade show in Shanghai (29 June–1 July). www.kns.com

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IQE appoints senior VP, Communications Infrastructure and Security

Rabbeni to lead expansion in communications infrastructure, data center, and aerospace and security markets

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has appointed Peter Rabbeni as senior VP, Communications Infrastructure and Security business unit, leading the firm's expansion within the communications infrastructure, data center, and aerospace and security markets.

Rabbeni has decades of experience in the semiconductor industry, including significant executive experience in business development and sales across the wireless industry, underpinned by a background in product design and engineering.

Rabbeni joins IQE after over a decade in executive roles at GlobalFoundries Inc (GF), where he was most recently responsible for foundry sales partnerships and business development, leading the regional strategy for growing foundry sales partnerships and business development as well as



Peter Rabbeni.

Before joining GF, Rabbeni held various leadership roles at IBM, as well as multiple RF systems and circuit design engineering positions at Ericsson, Raytheon and the US Army Millimeter Wave Lab.

Rabbeni received his BSEE degree from the Stevens Institute of Technology in 1986 and an MSEE with a concentration in RF systems design from the University of Massachusetts in 1991. He is an alumnus of the IBM Executive Management program and the Executive Program for

restructuring the Aerospace and Defence segment. Before that, he was VP of the Wireless Infrastructure and Satellite Communications business unit.

Growing Companies at Stanford University. Rabbeni is also a member of the IEEE.

"Peter is an industry expert with a solid track record of success across global businesses including GlobalFoundries, IBM and Raytheon," comments CEO Americo Lemos. "He brings a wealth of knowledge of the semiconductor ecosystem and deep customer relationships to IQE. His vast experience will help drive value creation and value capture for IQE, and enable us to deliver our strategic goals."

"Compound semiconductors are a tremendously exciting technology with huge growth potential across multiple applications," says Rabbeni. "I look forward to partnering with IQE's customers and industry-leading experts to deliver innovation and success."

www.iqep.com

IQE expects first-half 2023 revenue of at least £52m

Pre-close update within May's £50–56m guidance, though down from first-half 2022's £86.2m

In an unaudited pre-close update for first-half 2023, IQE says that trading was in line with management expectations. Revenue is expected to be at least £52m, in line with market guidance and

within the firm's £50–56m guidance provided on 17 May. This compares with revenue in first-half 2022 of £86.2m.

IQE says that it is continuing to effectively navigate the challeng-

ing macroeconomic environment, by managing costs and implementing its diversification strategy.

IQE will report full (unaudited) interim results for first-half 2023 on 8 September.

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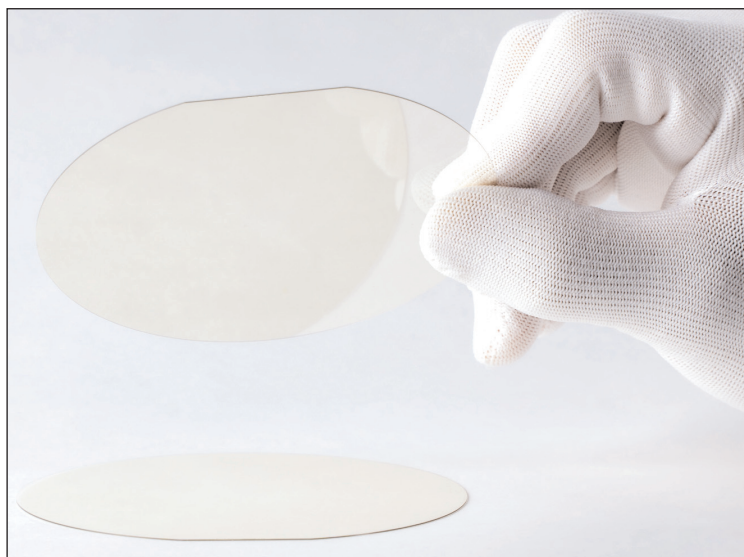
DISCO unveils KABRA process optimized for GaN wafer production

Process developed for silicon carbide now available for gallium nitride

Tokyo-based DISCO Corp – which makes semiconductor manufacturing equipment including chemical mechanical polishing (CMP) systems and laser-based ingot slicing equipment and processes – says that, using its KABRA (Key Amorphous-Black Repetitive Absorption) laser-based ingot slicing method, it has developed a process optimized for the production of gallium nitride (GaN) wafers that can simultaneously increase the number of GaN wafers produced and decrease the production time.

GaN requires time for crystal growth, and is a very delicate material as the ingots produced are small in diameter and thin. Conventionally, the mainstream method for slicing GaN ingots into wafers was to use a diamond wire saw. However, there were several problems when slicing with a wire saw, such as the processing time, material loss at the sliced sections that is thicker than the thickness of the wire used, and the low number of wafers produced due to material loss from the lapping process which is done after slicing to planarize the surface. These led to the wafers being expensive, and has hindered the spread of GaN power devices, reckons DISCO.

DISCO says that, since the KABRA process was developed for the



4-inch GaN wafer after separation and grinding.

production of silicon carbide (SiC) wafers, it has been receiving requests from many manufacturers to apply this process to GaN as well. DISCO has hence been putting effort into R&D to realize a KABRA process optimized for GaN, and is now announcing its readiness for mass production.

KABRA process flow for GaN wafer mass production

1. The laser irradiates inside the ingot and a KABRA layer is formed;
2. The ingot is separated into a wafer;
3. The wafer is ground to the specified thickness;
4. The ingot's upper surface is ground for the next laser irradiation.

as there are no undulations after slicing.

High throughput

- Development of a special optical system and processing method optimized for GaN;
- Efficient creation of the KABRA layer (the processing mark and cleaved area are created by focusing the laser within the material) due to a short stage scanning distance.

High yield

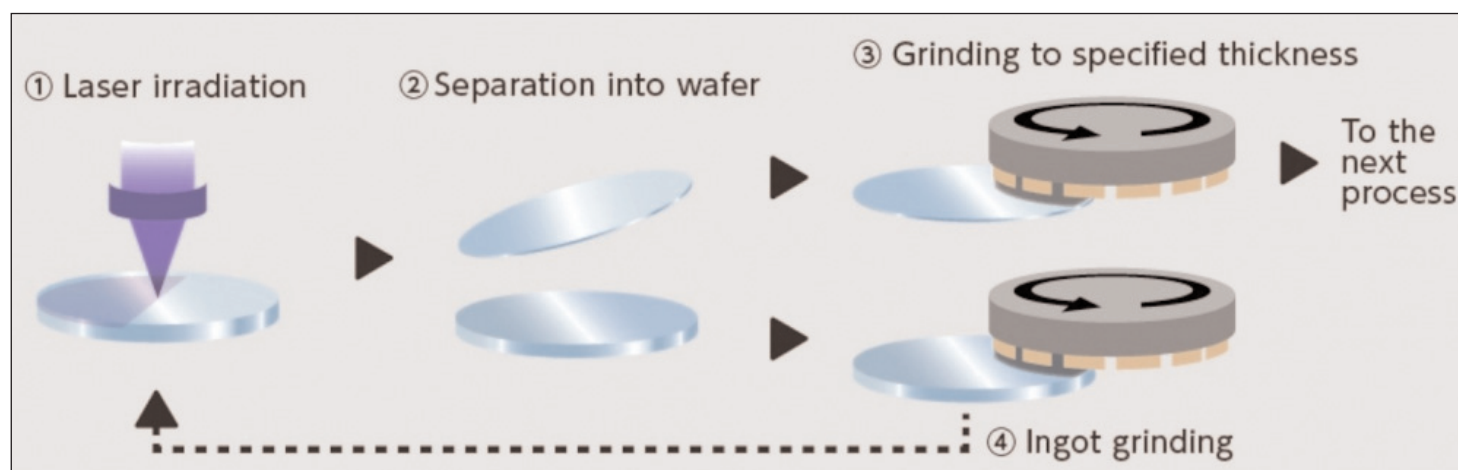
- Efficient discharge of the nitrogen produced within the material and prevention of wafer breakage by also creating a uniform KABRA layer near the edge of the ingot.

www.disco.co.jp/eg/news/corp/kabra_gan.html

Properties of the new process are listed as:

Low material loss

- By controlling the position of the laser's focal point in real time, slicing without thickness variation is possible;
- Unlike the wire saw, lapping is unnecessary,



Inseto supplies equipment to Cardiff's Institute for Compound Semiconductors

Fabrication line scaled up from 150mm to 200mm wafers in new cleanroom at Translational Research Hub

Inseto (UK) Ltd of Andover, UK (a distributor of equipment and materials to the semiconductor, microelectronic & advanced technology sectors) has supplied Cardiff University's Institute for Compound Semiconductors (ICS) with a variety of semiconductor manufacturing equipment for its new 16,150ft² cleanroom adjacent to its Translational Research Hub (TRH), which opened for business in May.

The TRH is a 129,000ft² facility with a mix of flexible laboratory and office space where industry and experts can come together to solve complex global challenges. The ICS's new 200mm fabrication line is being used by researchers in the ICS and commercial partners to trial, develop and scale up new

compound semiconductor devices.

The equipment supplied by Inseto includes an MCS8 manual resist coating system, an MA8 Gen4 mask aligner, SD12 and AD12 wet processing systems, and an HMxSquare 9 photomask cleaner (all from SUSS MicroTec), a PlasmaEtch PE-75 plasma treatment system and an ADT 7900 wafer dicing saw. In addition, Inseto's engineering team managed the equipment installation and operator training.

"Inseto was able to offer us a range of state-of-the-art equipment that has enabled us to scale up our fabrication line from 150mm to 200mm – something that was at the heart of our move to the new cleanroom," notes ICS operations director Dr Angela Sobiesierski.

"The post-delivery support from Inseto has also been great, working closely with our team and the OEM engineers involved to ensure that installation and commissioning proceeded smoothly," she adds.

The ICS was a founding member and key partner in the development of Europe's first compound semiconductor cluster, CSconnected, in South Wales, UK. The institute provides small- to medium-scale fabrication capacity to complement activity at other cluster partners, with the expertise and capability to translate academic excellence through to practical, manufacturable devices and integrated subsystems.

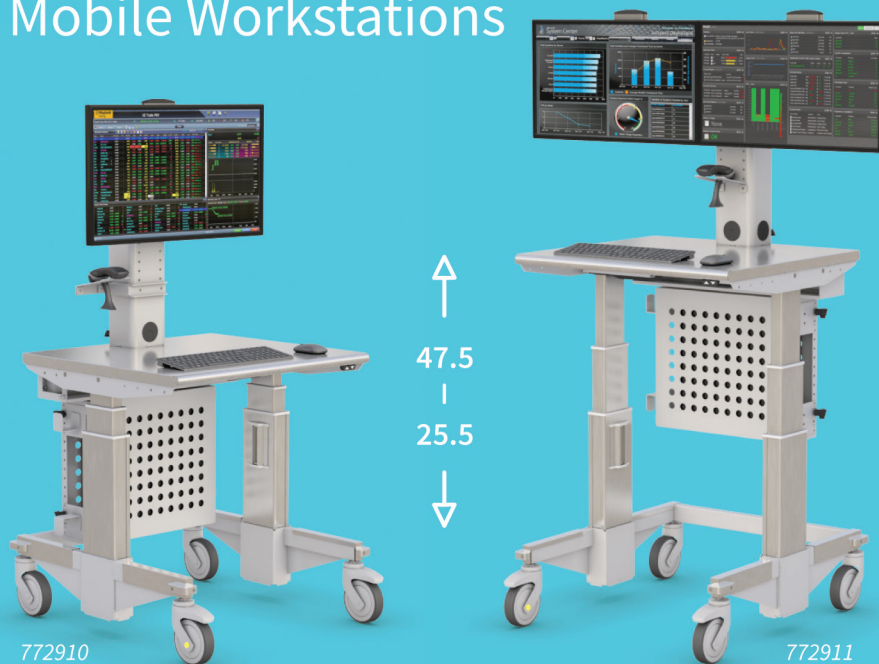
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Taiyo Nippon Sanso launches UR26K-CCD MOCVD system for GaN mass production

Production efficiency improved by 2x compared with conventional systems

Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan has launched the UR26K-CCD metal-organic chemical vapor deposition (MOCVD) system for the mass production of gallium nitride (GaN).

As its flagship production-scale MOCVD model, with fully automated handling of wafers and parts cleaning, it is reckoned that the UR26K-CCD can increase production efficiency by about 2x compared with conventional systems.

Compared with the existing UR26K commercial production GaN MOCVD system, to boost productivity the new UR26K-CCD is an improved model offering an upgraded 'Cassette-to-Cassette Wafer Handling System' automated transfer mechanism and an 'Integrated Dry-Cleaning System' for dry-cleaning reactor parts.

These features allow fully automated transfer of wafers inside the unit. Additionally, since the used parts inside the reactor are transferred within the system by the transfer robot to the separately installed dry-cleaning chamber and returned to the reactor after cleaning, the entire epitaxial growth process is handled with clean parts. This automated cycle eliminates the need to interrupt the operation of the growth chamber for the cleaning process, which increases production efficiency by about 2x compared with conventional system.

Growing GaN-on-silicon wafers can pose significant challenges to achieving reproducible results, a



Taiyo Nippon Sanso's new UR26K-CCD MOCVD system.

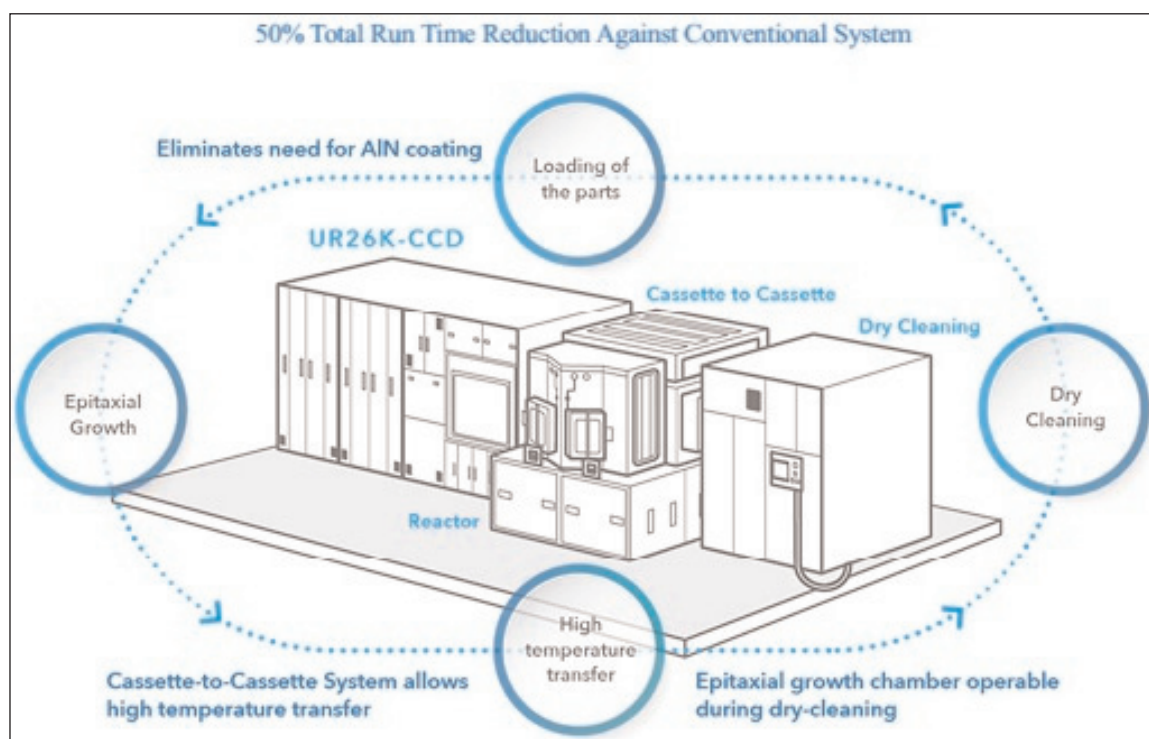
difficulty attributed to the contamination of wafers due to foreign material and wafer warping. Integrating the cleaning unit and maintaining the consistency of the reactor environment should result in improved reproducibility and higher yield ratios, i.e. lower total cost of ownership, says Taiyo Nippon Sanso.

Accommodating 10x6" or 6x8" wafer sizes, the reactor configuration (face up, rotation & revolution) is the same as the conventional UR26K, which employs the firm's proprietary three laminar flow horizontal gas nozzles, gear-driven wafer rotation mechanism, and a 6-zone resistance heater for uniform film growth.

Sources include TMGa, TEGa, TMAI, TMIIn, NH₃, Cp₂Mg, and SiH₄. The growth pressure is 13–100kPa. Applications include power devices, high-frequency devices, and micro-LEDs.

www.tn-sanso.co.jp/en

www.tnsc-innovation.com/innovations/ur26k-ccd-gan-mocvd



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IntelliEPI and Riber MBE 8000 joint development program shows high thickness and doping uniformities across 8x6" or 4x8" wafer runs

Final qualification expected by fourth-quarter 2023 for high-volume optoelectronic and microelectronic applications

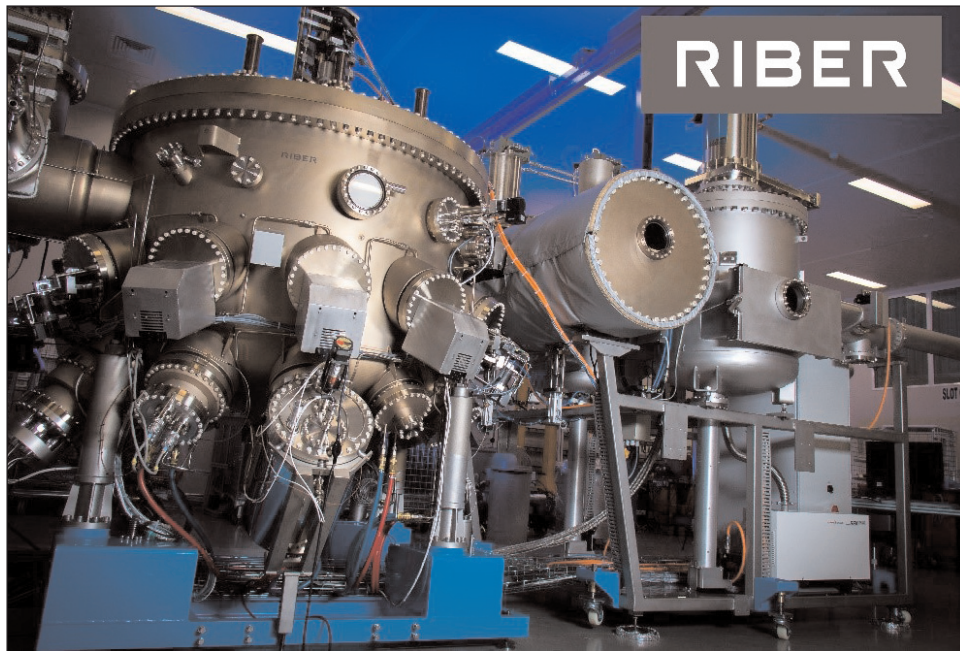
Milestones have been announced in the joint development program between Intelligent Epitaxy Technology Inc (IntelliEPI) of Richardson, TX, USA — which manufactures MBE-grown epitaxial wafers — and Riber S.A. of Bezons, France — which makes molecular beam epitaxy (MBE) systems as well as evaporation sources — regarding qualification of the latter's new MBE 8000 production platform.

As Riber's new flagship, the MBE 8000 is reckoned to be the highest-capacity MBE production tool available on the market, able to handle batches of eight 150mm (6-inch) or four 200mm (8-inch) wafers. The design benefits from over 20 years' experience in production MBE systems running daily around the world, enabling what is claimed to be outstanding process performances and stability, and thus reducing cost of ownership.

Following the delivery of the first MBE 8000 platform and thorough qualification work in close cooperation with IntelliEPI, results have exceeded expectations for such technology, particularly in terms of uniformities, defect densities, increasing yield, and interface abruptness, which is key for superlattice structures to achieve high-performance lasers.

The performance, combined with a high level of run-to-run repeatability control in large-scale production, will enable a new generation of lasers, particularly for the fast-growing vertical-cavity surface-emitting laser (VCSEL) sector, with significant market opportunities in the field of smartphone under-display facial recognition.

In its latest report on VCSELs, market research firm Yole Group states: a "major change expected



Riber's new MBE 8000 production system.

is a shift in wavelength from 940nm to 1380nm... to achieve an integration of the VCSELs behind organic light-emitting diode (OLED) displays, which are transparent at this wavelength. The first application could be the proximity sensor being placed under the display..."

In addition to the VCSEL market, the precise control of doping uniformity and the processes stability offered by the MBE 8000 platform can also enhance microelectronic device performances, such as conductivity, says Riber.

Over the past few months, as results were disclosed to several industrial customers, interest in the machine has grown quickly, leading to discussions for potential purchase, Riber adds.

"From the initial evaluation so far, this Riber MBE 8000 has shown very impressive performance in terms of being able to produce high-quality epi materials over such a large substrate platen area, with excellent composition and thick-

ness uniformity across the 8x6" platen," comments IntelliEPI's president & CEO Yung-Chung Kao. "With this improvement, the MBE 8000 platform offers a solution to make large-scale production MBE technology more competitive, especially for high-performance and high-throughput market opportunities," he adds.

"Thanks to the efforts of Riber and IntelliEPI teams, we have reached a major step for MBE 8000 qualification. The results provided by the machine exceed our initial objectives," states Riber's CEO Christian Dupont. "With an optimum cost of ownership and large capacity, the MBE 8000 equipment has strong commercial prospects," he believes. "In addition, our milestone in this joint development program with IntelliEPI demonstrates the capability to bring MBE technology in high-volume semiconductor industry."

www.intelliepi.com

www.riber.com

Oxford Instruments launches high-rate ALD research tool PlasmaPro ASP targets quantum technology and advanced R&D

UK-based Oxford Instruments has launched the PlasmaPro ASP, a high-rate atomic layer deposition (ALD) research system within its Atomfab product range.

The PlasmaPro ASP benefits from a new patented remote-plasma source design, optimized chamber geometry and wafer stage bias for ion energy control. These features combine to deliver three times faster ALD rate, low resistivity and high T_c superconducting nitride films for quantum technology, the initial application focus for the launch. The plasma source design involved a partnership with Eindhoven University of Technology (TU/e), which received a development module to study the plasma parameter space and confirm the high-rate low-damage source characteristics. The research paper published following the joint development work with TU/e was awarded best paper at the American Vacuum Society's 22nd International Conference on Atomic Layer Deposition (AVS

ALD/ALE 2022) conference.

Oxford Instruments' collaboration with TU/e has continued through to process development, where TU/e has been serving as a PlasmaPro ASP application development accelerator for quantum and additional applications for the past year.

"This system is an excellent addition to our existing ALD tool set from Oxford Instruments, as it distinguishes itself in terms of productivity and plasma capability," comments professor Erwin Kessels, chair of Plasma & Materials Processing (PMP) group at TU/e.

"Hence it provides some unique opportunities for our research in the field of electronics, photonics and quantum technology," he adds.

"We have experienced high pre-launch interest from the market for the PlasmaPro ASP for superconducting quantum materials. The PlasmaPro ASP is designed to address key quantum challenges with an innovative high-rate source design and high machine up-time, as well as an intuitive software user

interface called PTIQ," says Dr Russ Renzas, Quantum Technologies market manager, Oxford Instruments Plasma Technology, Americas.

"With the source design derived from our Atomfab ALD production product, the PlasmaPro ASP retains process speed and robustness, with the inclusion of additional hardware to increase flexibility, which offers a unique solution to the quantum market to speed up development cycles."

Oxford Instruments attended the American Vacuum Society's 23rd International Conference on Atomic Layer Deposition (AVS ALD/ALE 2023) in Bellevue (East Seattle), WA, USA (23–26 July). The Oxford Instruments Plasma Technology team were available at the company's booth to talk about the PlasmaPro ASP and share its latest atomic-scale processing solutions for quantum and other developing technologies.

www.ald2023.avs.org
<https://plasma.oxinst.com/products/ald/plasmapro-asp>

OIPT ships plasma processing tools to Indian Institute of Science's GaN Ecosystem Enabling Centre and Incubator

Oxford Instruments Plasma Technology (OIPT) of Yatton, near Bristol, UK has shipped a suite of gallium nitride (GaN) plasma processing equipment to the GaN Ecosystem Enabling Centre and Incubator (GEECI) at the Centre for Nano Science and Engineering (CeNSE), Indian Institute of Science (IISc), in Bengaluru (formally Bangalore).

To be installed in a pilot-production line, the shipment includes atomic layer etch (ALE) equipment, two variants of inductively coupled plasma (ICP) etch modules, and plasma-enhanced chemical vapor deposition (PECVD) technology. The equipment will be used to develop GaN-on-Si and

GaN-on-SiC high-power and high-frequency power electronics and RF devices, says the firm.

"The equipment, ongoing process and service support, and technical collaboration with Oxford Instruments Plasma Technology is crucial to our GaN device development program," says professor Srinivasan Raghavan (Vasu), who is in charge of setting up GEECI. The new GaN pilot-production line will support the next generation of GaN startups and spin outs, which are "critical to accelerate India's flourishing semiconductor ecosystem", he adds. "We look forward to developing new process recipes to enable GaN power and RF electronics," adds process expert professor

Shankar Kumar Selvaraja.

"We have recently experienced a surge in interest for our solutions in India, which points toward a shift in the technology landscape for that region with momentum generated through government funding," says Ian Wright, OIPT's VP of sales & business development, Asia. "We have invested in an ambitious and expanding program of service and support for India, and are uniquely positioned in the region, to play an integral role in encouraging transformational semiconductor technology development and industry growth," he adds.

www.geeci.in/about
www.iisc.ac.in

Applied Materials and Fraunhofer IPMS to create European metrology technology hub

Collaboration to accelerate learning, develop novel methods and prove new metrology equipment, methods, algorithms and software

Process equipment maker Applied Materials Inc of Santa Clara, CA, USA and the Fraunhofer Institute for Photonic Microsystems (FhG IPMS) in Dresden, Germany are collaborating to create what is reckoned will be Europe's largest technology hub for semiconductor metrology and process analysis, aiming to accelerate research and enhance development projects with chipmakers and ecosystem partners across Europe, particularly in the ICAPS (Internet of things, Communications, Automotive, Power and Sensors) market segments.

To be located at Fraunhofer IPMS' Center Nanoelectronic Technologies (CNT) — which offers applied research on 300mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners — the technology hub is situated in the heart of Silicon Saxony, Europe's largest semiconductor cluster. The hub will be equipped



Applied Materials' eBeam metrology equipment in the cleanroom at Fraunhofer IPMS.

with Applied Materials' eBeam metrology equipment, including its VeritySEM CD-SEM (critical dimension scanning electron microscope) systems, and staffed by Applied engineers and R&D experts.

"Fraunhofer IPMS and its partners will benefit from access to Applied's industry-leading eBeam metrology systems," comments Dr Benjamin

Uhlig-Lilienthal, head of Fraunhofer IPMS' Next Generation Computing business unit. "The new technology hub will offer advanced wafer-level metrology in our industrial CMOS environment with Fraunhofer IPMS's unique ability to loop wafers directly with semiconductor manufacturers," he adds.

"Our collaborative metrology hub will accelerate learning cycles and the development of new applications for the Fraunhofer Institute, Applied Materials and our customers and partners in Europe," says James Robson, corporate VP for Applied Materials Europe.

"This unique technology hub will have the capability to test and qualify processes on a variety of substrate materials and wafer thicknesses critical to applications across the diverse European semiconductor landscape."

www.appliedmaterials.com
www.ipms.fraunhofer.de

KLA appoints Agilent's president & CEO to board Michael R. McMullen also joins Compensation and Talent Committee

Process control and inspection systems provider KLA Corp of Milpitas, CA, USA has appointed Michael R. McMullen to its board of directors and Compensation and Talent Committee.

McMullen was named president of

Agilent Technologies in 2014 and CEO in 2015 and has been with the company and its predecessor, Hewlett-Packard, for more than 30 years.

"Mike's extensive experience in driving growth at a global scale in

complex multi-national equipment businesses makes him an ideal fit for KLA's board as we execute our long-term growth strategies," believes Robert M. Calderoni, chair of the board of KLA.

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Cree LED moves into new HQ in Research Triangle Park New R&D-focused facility includes components pilot production line

Cree LED Inc of Durham, NC, USA (a company of SMART Global Holdings of Milpitas, CA) has officially moved into its new headquarters at the Park Point campus in Research Triangle Park, NC. The new location will focus on R&D and provide an environment for collaboration and innovation capabilities.

The new facility at 4001 E. Hwy. 54, Suite 2000, Durham NC 27709, offers a total footprint of 85,866ft², with 42,000ft² dedicated to new laboratory space. A key feature of the facility is a components pilot production line that supports a wide range of products, from video applications to high-power lighting.

"The added space at this new location will play a critical role in the continued development of new leading LED solutions, pushing the boundaries of LED technology," says president Joe Clark.

In addition to the expanded new



Cree LED's new HQ at the Park Point campus in Research Triangle Park, NC.

product development capabilities, the new facility provides a work environment for employees that includes amenities such as a fitness

center, onsite café, walking trails, sports courts and recreational fields.

www.cree-led.com

Cree LED unveils fourth-generation XLamp XP-G family Maximum drive current of 3000mA boosts output by 41% to 1130lm

Cree LED has unveiled the fourth generation of its XLamp XP-G product family.

With more than 2 billion XP-G LEDs shipped to date, the XP-G4 incorporates the latest advances in high-power LED technology for improved optical performance while delivering what is claimed to be leading efficacy. The XP-G4 also has a maximum drive current of 3000mA, which is a first for the XP-G family of LEDs.

The fourth generation of XP-G products introduces an optimized optical profile designed to maximize on-axis light output and yield substantial improvements over the previous XP-G3 LEDs. These enhancements include a smaller light-emitting surface (LES) and up to 69% higher intensity, resulting in tighter beam angles and higher candela. The XP-G4 delivers

what is claimed to be exceptional color-over-angle performance and a 70° cutoff which dramatically improves coupling efficiency with secondary optics compared with all competing high-power LEDs, the firm adds.

"This fourth generation offers a remarkable 41% increase in maximum light output compared to XP-G3 Standard, reaching a maximum of 1130 lumens," says president Joe Clark. "This notable performance, combined with the latest optical system, delivers a 'no compromise' solution for both new and existing systems alike," he adds.

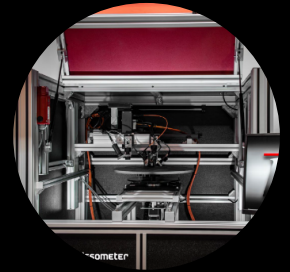
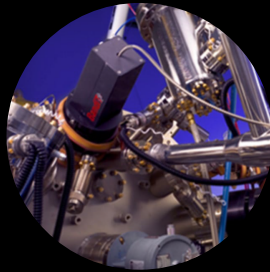
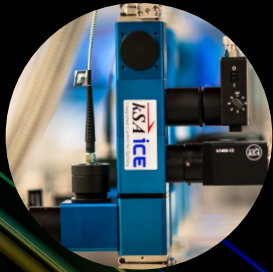
"COAST has a 100+ year history of product innovation. As we design our next generation of portable lighting products, we will use Cree LED's new XP-G4 LED based on its clear product advan-

tages," says Todd Ernst, VP product at Cree LED customer COAST Products. "This new LED family offers both higher intensity and higher maximum current in the familiar XP-G footprint, allowing us to improve the performance of our products."

The latest generation of XP-G products is optimized for a wide range of both indoor and outdoor directional lighting applications requiring precise light control, good color over angle and long-term reliability. The new XP-G generation is available in correlated color temperatures (CCTs) ranging from 1800K to 6500K and color rendering index (CRI), including 70, 80 and 90 CRI. Additionally, broadcast color options featuring Television Lighting Consistency Index (TLCI) will also be offered.

www.cree-led.com/xp-g4

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Mojo powers highest-density red micro-LED micro-display

Vibrant 1.37 μ m-diameter, 1.87 μ m-pitch red micro-LEDs target full-color requirements for AR/XR markets

Mojo Vision Inc of Saratoga, CA, USA — which is developing and commercializing micro-LED display technology for consumer, enterprise and government applications — claims that it has made an important step in overcoming challenges of delivering high-performance and reliable full-color micro-LED displays by powering the world's highest-density (14K ppi) red micro-LED micro-display.

Mojo Vision used its proprietary quantum dot (QD) process to display visually vibrant red micro-LEDs measuring 1.37 μ m in diameter and set on a 1.87 μ m pitch. The visual quality and efficiency at this size are critical in meeting the full-color requirements for augmented reality (AR) and extended reality (XR) markets.

A primary challenge with existing display technologies, such as organic light-emitting diodes (OLED), in today's AR/VR headsets is the ability to deliver optimal brightness and contrast dynamically as environmental light conditions change. When micro-LEDs are commercially available, the displays will be able to provide rich device functionality in all ambient conditions for AR and XR emerging products. Mojo Vision's high-density red micro-LED is claimed to be the industry's first to overcome wavelength and visual challenges with ultra-high pixel density, brightness, contrast, color gamut and energy efficiency.

"The ability to make very small red, green and blue micro-LEDs on the same substrate is critical to achieving vibrant and effective

full-color micro-displays," says CEO Dr Nikhil Balram. "Powering a true red display, rather than leaning toward orange as others do, at this size and specification puts us a big step closer to producing a micro-LED display that will meet or exceed the current performance and form-factor requirements for AR and XR products."

While it is typically easier to deliver high-quality micro-LEDs at larger sizes (>5 μ m), the industry has struggled with smaller micro-LEDs, particularly those using color conversion materials. Mojo Vision claims that its latest development sets a new benchmark for micro-LED manufacturers by achieving true red vibrancy at a record-small pitch, exceeding past records for red wavelengths of 620nm or more that are required by major color standards used in broadcast and consumer displays.

"Addressing all three comfort pillars — wearable, visual and social — in all-day-use smart glasses is critical for wide consumer adoption," says Dr Bernard Kress, president of the International Society for Optics and Photonics (SPIE). "The display sub-system is at the core of this problem. Emissive display panels are preferred to traditional liquid crystal on silicon (LCOS) or digital light processing (DLP) panels that require larger volumes and higher drive power. Although micro-OLED panels can be effectively matched to bulky birdbath combiners, micro-LED panels are best suited for thin waveguide combiners due to their higher brightness," he adds.

"Monolithic RGB micro-LED panels have been the industry's holy grail for many years now but are still struggling to produce efficient pixels with pitches below 4 μ m, with challenges ranging from using InGaN instead of more mature AlInGaP, efficiency in red, reliability and thermal issues, and lack of 300mm wafer-scale fab," Kress continues. "Mojo's proprietary red and green QD conversion of mature blue GaN micro-LED panel technology at pixel pitches below 2 μ m can be a great alternative and provide effective solutions for today's smart glasses."

Mojo Vision says that its new prototype will support a more advanced display in lightweight glasses form factor. In May, the firm announced a partnership with DigiLens to advance display capabilities in AR/XR markets. The partnership closely followed Mojo Vision's successful light-up of the first-ever 300mm blue GaN-on-silicon micro-LED array wafer.

"Full-color micro-LED micro-displays are going to start emerging in the market in the coming years," notes Dr Guillaume Chansin, director of display research at Display Supply Chain Consultants (DSCC). "Mojo Vision's prototype stands out as a new milestone, by demonstrating red color conversion with a sub-2 μ m pixel pitch," he comments. "This development is significant for the micro-LED industry and shows the potential of Mojo Vision's approach towards full-color, high-resolution micro-displays."

www.mojo.vision

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SemiLEDs revenue rebounds from last quarter's dip ...but losses rise, and revenue forecast to fall back next quarter

For its fiscal third-quarter 2023 (to end-May), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue rebounding to \$1.679m, up on \$1.152m last quarter and roughly level with the prior quarter's \$1.695m. However, this is still down on \$1.784m a year ago.

Gross margin fell further, from

23% last quarter to 14%, down on 19% a year ago.

Operating expenses have risen from \$0.964m to \$1.222m, above the \$1.11m a year ago. Despite this, operating margin rebounded slightly from -61% last quarter to -58%.

Net loss has risen further, from \$541,000 (\$0.11 per diluted share) to \$756,000 (\$0.15 per diluted

share), although this is less than the \$916,000 (\$0.20 per diluted share) a year ago.

During the quarter, cash and cash equivalents fell further, from \$3.859m to \$3.041m.

For fiscal fourth-quarter 2023 (to end-August), SemiLEDs expects revenue to fall back, to \$1.4m+/-10%.

SemiLEDs receives Nasdaq non-compliance notice Director Roger Lee resigns

On 11 July, SemiLEDs received a notice from The NASDAQ Stock Market indicating that it no longer complies with the audit committee requirements as set forth in Listing Rule 5605 and confirming its opportunity to regain compliance within the cure period provided in Listing Rule 5605(c)(4), which is the earlier of the firm's next annual meeting of stockholders or 10 July 2024. Alternatively, if the next annual stockholders' meeting is held before 8 January 2024,

then the firm must evidence compliance no later than that date.

Also on 11 July, SemiLEDs received a separate notice from The NASDAQ Stock Market indicating that the firm does not meet the minimum of \$2.5m in stockholders' equity required by Listing Rule 5550(b)(1) for continued listing. The firm also does not meet the alternatives of market value of listed securities or net income from continuing operations. Under the listing rule, SemiLEDs has 45

calendar days to submit a plan to regain compliance. If the plan is accepted by The NASDAQ Stock Market, an extension of up to 180 calendar days from 11 July will be granted.

On 10 July, Roger Lee resigned as a director of SemiLEDs effective immediately due to personal reason. His decision was not the result of any disagreement with the company regarding its operations, policies or practices, says the firm.

www.semileds.com

ROHM launches RGB chip LED for automotive interiors

Japan's ROHM Semiconductor has launched a new RGB chip LED (SMLVN6RGBFU) suitable for automotive interiors, such as function/status indicators in instrument clusters, CID (Center Information Displays), car audio/navigation, heater control etc, and automotive ambient/accent lighting (footwells, roof, handles, cup holders, etc).

In recent years, more driver assistance functions (i.e. automatic speed control, vehicle distance/white line detection) have been introduced as vehicles become progressively electronic and sophisticated. As such, the demand for RGB chip LEDs capable of expressing a range of colors to indicate operational status in instrument panels and meter clusters is rising. In addition, there is an increasing

need to create a comfortable and luxurious cabin space with decorative lighting using RGB chip LEDs.

In response, ROHM has developed an RGB chip LED that further minimizes color variation by precisely controlling the luminous characteristics of the RGB elements and improving color mixing through in-house device technology.

Generally, developing RGB chip LEDs that emit light at the specified color requires precise control of the wavelength and brightness of the mounted red, green and blue (RGB) elements individually and methods to enhance color-mixing capability. ROHM says that it has minimized element color variation over general products by utilizing a vertically integrated production system from the element fabrication

stage — claimed to be one of ROHM's strengths.

At the same time, original element color mixing control technology reduces color variations caused by color mixing that tends to occur in RGB chip LEDs, resulting in the accurate color expression required in automotive interiors. ROHM also supports detailed color matching tailored to user specifications with the chromaticity simulation system.

Chromaticity simulation system

The SMLVN6RGBFU sets adjustment coefficients for each chromaticity rank while providing calibration support to bring the color closer to the desired target. The new RGB chip LED and high-accuracy chromaticity simulation allows precise color matching, says ROHM.

www.rohm.com

ams OSRAM launches third generation of OSLO Compact PL LEDs

Single-chip brightness boosted by 8% from 405lm to 440lm, increasing efficiency for vehicle headlamps and daytime running lamps

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has introduced the third generation of its OSLO Compact PL family of automotive LEDs, boosting brightness by 8% from the second generation. By producing the luminous output required by safety specifications with fewer LEDs, the new LEDs are said to offer manufacturers of automotive forward lighting greater value and new design options.

As compact LEDs housed in a robust ceramic package, the OSLO Compact PL products are a common component of forward lighting assemblies across all segments of the automotive market, from budget to premium. ams OSRAM has supplied about 100 billion LEDs in vehicles since 1990. OSLO Compact PL products are said to provide reliable, standards-compliant light output for high- and low-beam headlamps and for daytime running lamps.

Since 2017, ams OSRAM has increased the luminous efficacy of the OSLO Compact PL product family by 33% (24.6lm/W). The increasing efficacy enables car makers to reduce the climate impact of operating vehicle lighting systems. The higher brightness of the new OSLO Compact PL also gives lighting equipment designers a wider set of options for the choice of components in the optical assembly, such as light guides.

"Higher optical power output from the same footprint means that automotive OEMs can now do more with less," notes product marketing manager Florian Fink.

Multiple variants give design flexibility

The AEC-Q102-qualified OSLO Compact PL is based on ams OSRAM's UX.3 chip. It is certified for corrosion robustness to Class 3A.



OSLO Compact PL LEDs, as used in automotive forward lighting applications such as high- and low-beam headlamps and for daytime running lamps.

The single-chip variant produces a typical luminous output of 440lm, compared with the second generation's 405lm. The OSLO Compact PL is also available in 2-, 3- and 4-chip variants, and with a light-emitting surface area of up to $(1150\mu\text{m})^2$.

Two package options are available. The three-pad version includes one isolated thermal pad for increased heat dissipation. The two-pad version has larger pads to provide a

more stable bond with a low-cost aluminium PCB.

The six products in the third-generation Compact PL series are:

- KW CWLPM3.TK – single $1150\mu\text{m}$ chip, two-pad LED, typical 455lm output;
- KW CELNM3.TK – single $1030\mu\text{m}$ chip, three-pad LED, typical 440lm output;
- KW CWLNM3.TK – single $1030\mu\text{m}$ chip, two-pad LED, typical 440lm output;
- KW2 CFLNM3.TK – dual $1030\mu\text{m}$ chip, four-pad LED, typical 880lm output;
- KW3 CGLNM3.TK – triple $1030\mu\text{m}$ chip, four-pad LED, typical 1320lm output;
- KW4 CHLNM3.TK – quad $1030\mu\text{m}$ chip, four-pad LED, typical 1760lm output.

The OSLO Compact PL is available to order now for volume production.

www.ams-osram.com/products/product-families/oslon-compact-pl#automotive-mobility



ams OSRAM's OSLO Compact PL LED.

ams OSRAM adds 640nm Red to OSOLON Optimal horticultural LED Series

Broader spectral coverage for better growth of common plant types under artificial lighting

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has extended its OSOLON Optimal family of horticultural lighting LEDs with a new 640nm Red LED, which enables indoor farmers to produce faster and healthier plant growth.

Providing broader coverage of the red portion of the spectrum, the new 640nm Red LED (which can be ordered now in production volumes, using part number GR CSS-RML.24) joins the 660nm Hyper Red and 730nm Far Red in the OSOLON Optimal family, which also includes a 450nm Deep Blue LED and a horti white LED.

It has been common practice in horticulture to illuminate crops with a mix of 660nm, 450nm and 730nm, or 660nm and white LEDs for plants that require full-spectrum light. Initial research conducted by Wageningen University on behalf of ams OSRAM shows that a double red peak (640nm and 660nm) in combination with horti white increases the dried biomass level in indoor growing environments.

In addition, the use of the OSOLON Optimal Red helps to prevent photo bleaching in some plant varieties. Experience shows that it can also prevent the incidence of fungal and bacterial infection in leafy greens such as basil.

The firm reckons that the new OSOLON Optimal Red product can play an important role in raising energy efficiency and reducing the



cost of electric power in all horticultural lighting applications, including greenhouse top-lighting and inter-lighting, and vertical farming. Producing 3.53 $\mu\text{mol}/\text{J}$, it achieves very high wall-plug efficiency of 66.3%. The LED's radiant flux is 485mW, and photon flux is 2.58 $\mu\text{mol}/\text{s}$. Peak wavelength is 640nm and the dominant wavelength is 630nm.

"The discovery of new recipes that include a double red peak of Hyper Red and Red is helping growers produce more biomass and maintain superior plant health," says marketing manager Thomas Grebner. "With the introduction of the OSOLON Optimal Red LED, horticultural lighting equipment manufacturers can achieve very high levels of efficiency and reliability."

Robust ceramic package for high reliability

The OSOLON Optimal LEDs are high-power ceramic packages based on a 1mm² die and a standard 3030 footprint with a Lambertian emission profile. Based on the latest ams OSRAM 1mm² chip technology, the OSOLON Optimal portfolio of products provides very stable light output over a wide temperature range, as well as very low thermal resistance and long lifetime.

The new Red product is suitable for horticultural purposes as well as for use in general lighting applications such as archtainment and signal lighting.

www.ams-osram.com/applications/lighting/agriculture-horticulture

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ams OSRAM launches new generation of blue and green lasers with higher beam quality and tighter tolerances

New PLT3 and PLT5 products launched at LASER World of Photonics

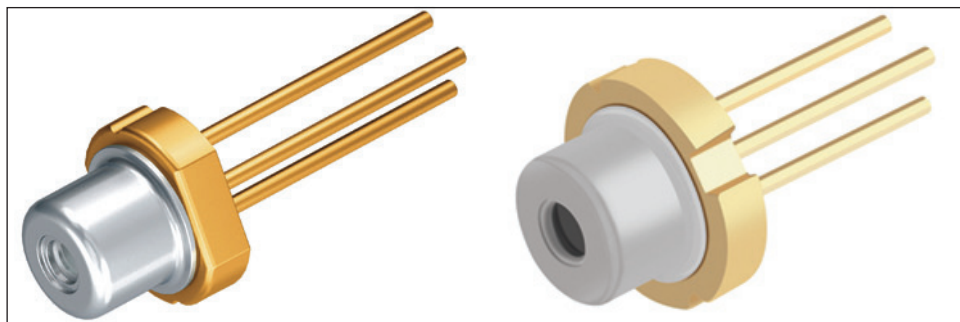
ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has introduced improved blue and green lasers based on a new generation of its diode emitter chip. The chip's performance enables manufacturers to increase the value of laser modules and devices aimed at applications such as leveling and scanning. Enhancements enabled by the new lasers include a smaller power supply, a more homogeneous beam, and more efficient coupling to optical fiber.

The improved PLT3 products are available in a TO38 metal can package, and the PLT5 products in a TO56 package. Optical power output is 100mW for the blue lasers, and 10-50mW for the green lasers.

Optical power output, wavelength options and beam shape are maintained from the previous generation of PLT3 and PLT5 products, but the new versions offer improved beam quality and a narrower distribution across production units of values for key operating parameters.

"By choosing the latest versions of the popular PLT family of laser diodes, customers benefit from excellent beam quality and tight tolerances, making it easier for them to produce better laser module devices," says Martin Wittmann, senior director product marketing for Visualization & Sensing.

The new chip improvement in beam quality means that laser module manufacturers gain coupling efficiency when light is coupled into a waveguide or glass fiber, giving greater flexibility in the specification of the required output power from the laser source. In addition, the new PLT3 and PLT5 lasers have a more homogeneous beam, improving a laser module's ability to illuminate a surface or object uniformly.



PLT3 single-mode laser (TO38 package) on the left and PLT5 single-mode laser (TO56 package) on the right. Image: ams OSRAM.

Tighter tolerances reduce maximum power requirement

ams OSRAM has enhanced its laser diode fabrication technology to narrow the distribution of values for key operating parameters across the population of production units. This makes it easier for laser module makers to maintain the required tolerance in the driver circuits.

In addition, the new lasers feature lower maximum operating current and voltage, as well as threshold current. For example, the maximum threshold current for the PLT5 518FB_P 30mW green laser has been reduced by about 25% from 60mA to 45mA in the latest generation of PLT5 products.

The tighter tolerances, and the lower operating current, mean that the power supply to the laser can be shrunk. The space and power savings enabled by use of the new PLT laser diodes is an important benefit for portable battery-powered devices in particular, says the firm.

Scanning applications enhanced by use of high-performance green lasers

A typical application that can benefit from the new chip is barcode scanning with green lasers. Large warehouses or open-air storage units suffer problems with the use of traditional red laser scanners, because the red dot is difficult to see over a long distance or in bright daylight. This increases the risk that an operator scans the wrong item.

The human eye is much more sensitive to green light than to red, however, so green laser scanners are less affected by interference from ambient light and hence becoming increasingly popular in laser leveling and scanning applications. Many laser scanners are mobile, battery-powered products: they will benefit substantially from the reduced maximum operating current drawn by the new PLT family of green laser diodes, extending run-time between battery charges.

ams OSRAM showcased the new PLT3 and PLT5 laser diodes at the LASER World of Photonics 2023 exhibition in Munich, Germany (27–30 June). Its display included a mobile computer with an integrated barcode scanner featuring the new PLT5 520EB_Q 20mW green laser diode.

New product availability

The PLT3 and PLT5 single-mode lasers based on the new diode chip have a typical peak wavelength of 450nm (blue) or 520nm (green). The products available at launch are the blue laser with optical power output of 100mW and green lasers in 10mW, 20mW, 30mW and 50mW output options. They can be ordered now in production volumes and will replace the existing blue and green single-mode laser products. A new 110mW green laser diode will be introduced at a later date.

www.photonics-congress.com

www.ams-osram.com

ams OSRAM shows latest laser and optical sensing technologies at LASER World of Photonics 2023

EEL, VCSEL and high-power multi-LED light-emitting technologies for industrial, robotics, medical and wearable applications

At the LASER World of Photonics 2023 exhibition in Munich (27–30 June), ams OSRAM GmbH of Premstätten, Austria and Munich, Germany showcased how it uses its photonics technologies to develop edge-emitting lasers (EELs), vertical-cavity surface-emitting lasers (VCSELs) and light-emitting diodes (LEDs) for industrial, robotics, medical and wearables applications in settings as diverse as large warehouses, industrial manufacturing plants, and biomedical laboratories.

“Under the theme of ‘Laser and Sensing Innovation on Point’ at LASER World of Photonics 2023, we will showcase how our ecosystem is using our industry-leading laser diodes to stay ahead of the curve,” says Jörg Heerlein, head of product marketing EMEA for Visualization & Sensing.

Demonstrations include:

Making next-generation 3D sensing and machine vision solutions a reality

- Small solid-state 3D LiDAR sensor — a 905nm high-power laser diode

in a compact SMT package provides the optical power and suitable beam shape for this small and lightweight LiDAR sensor offering a wide field of view and a long detection range;

- Time-of-flight camera — precise 3D imaging with VGA resolution in real time thanks to a powerful and flood illuminator consisting of a highly efficient 940nm VCSEL in a small SMT package.

Lasers and sensing — a combination for industrial applications

- Handheld laser marking with blue lasers — the 5W blue laser diode in a TO90 package, PLPT9 450LB_E, is at the heart of this small laser engraving machine;
- Mobile computer with integrated barcode scanner — a green laser diode with 20mW optical power serves as an efficient and highly visible light source, enables targeting at barcodes even at long distances and in bright daylight. The exhibit features the new generation of visible laser chips from ams OSRAM;

- Fixed barcode reader — this fully integrated vision system uses a 10mW green laser diode for targeting barcodes and a powerful R/G/B/W Ostar Stage LED, LE RTDUWS2WN, to illuminate the targeted area with the appropriate color when detecting with an image sensor.

Smart solutions for wearables and medical analysis

- Optical module for augmented reality glasses — a compact and powerful R/G/B/W projection LED with cutting-edge chip technology allows for small near-to-eye projection units enabling light-weight AR glasses;
- Laser spectroscopy for DNA sequencing — the PLT5 488 laser diode was developed specifically for biomedical applications. It features high brightness, very narrow wavelength binning and ams OSRAM’s Brilliant Beam technology, which suppresses unwanted side lobes in the laser beam.

www.photonics-congress.com
www.ams-osram.com

TRUMPF Photonic Components gains Thomas Dobbertin as new managing director

Berthold Schmidt to become CTO and managing board member

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets — is to have a new managing director as of 17 July. Dr Thomas Dobbertin will take over the role from Dr Berthold Schmidt, who will serve as chief technology officer (CTO) and member of the managing board for TRUMPF SE +



TRUMPF Photonic Components’ new managing director Thomas Dobbertin.

manufacturer ams AG in Singapore and was responsible for the laser

Co KG as of 1 July.

Previously, Dobbertin, who has a PhD in Electrical Engineering, served as general manager for the optical sensor technology business units at semiconductor

components business at OSRAM Opto Semiconductor GmbH in Germany. Most recently, he worked for Nanofilm Technology International, a Singapore-based provider of nanotechnology solutions.

In his role as managing director of TRUMPF Photonic Components, Dobbertin is expected to further expand the VCSEL and photonics business and the technological know-how of this TRUMPF subsidiary.

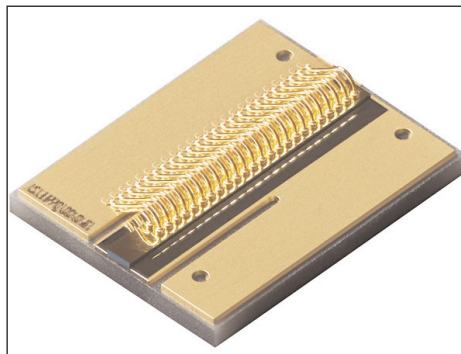
www.trumpf.com/s/VCSEL-solutions

Coherent launches record 65W pump laser diode

Record raised from 50W diode launched at Photonics West in January

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA (formerly II-VI Inc before it acquired Coherent in July 2022) has introduced its next-generation pump laser diode, with 65W output power for fiber lasers in industrial and consumer applications.

Handheld fiber laser welding is increasingly replacing arc welding as the technology of choice, driving strong demand for components that enable cost-efficient designs. The new laser diode reliably achieves a record 65W output power, 30% more than that of the existing products, yet with lower operating current. These unique features, combined with the diode's compatibility with existing submounts, enable a wide range of extremely low-cost fiber laser design architectures.



"This is the first commercially available pump laser diode in the industry to achieve 65W of output power, surpassing our previous-record 50W diode that we introduced at Photonics West in January," believes Dr Karlheinz Gulden, senior VP, Laser Components and Subsystems business unit. "While the conventional wisdom is that, at these power levels, more expensive ceramic submounts are required, this is not the case with our laser

design because we were able to lower the operating current even as we increased the output power," he adds. "This, in addition to the record-breaking output power, is what makes it such a unique and compelling product."

The 65W laser diodes are based on a vertically integrated 6-inch gallium arsenide (GaAs) technology platform with decades of field-proven reliability. They are available at 915nm and 975nm wavelengths as bare dies or chips on ceramic submounts to meet customer requirements. The chips include Coherent's proprietary E2 front-mirror passivation that prevents catastrophic damage to the laser, even at extremely high output powers. The 65W laser diodes will be available in fall 2023.

www.coherent.com

TRUMPF showcases new TruHeat VCSEL modules

at LASER World of Photonics 2023

Live demonstrations of speed and distance measurement and particulate matter sensing

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, data-coms, industrial sensing & heat treatment and automotive markets — showcased the latest product developments in its TruHeat VCSEL series as well as live applications of optical sensing at the LASER World of Photonics 2023 event in Munich, Germany (25–29 June).

The VCSEL-based heating systems offer direct and homogeneous heat treatment for processes such as drying, sealing or softening. At the LASER World of Photonics show, TRUMPF is demonstrating two new heating solutions for e-mobility. "One example is our

next-generation TruHeat VCSEL systems for battery foil drying, offering even higher efficiency and lower power consumption," says Ralph Gudde, VP marketing & sales. "A small footprint, high process quality, fast processing and lower CO₂ emissions are the benefits customers get, when processing using TruHeat VCSEL systems," he adds.

Live demonstrations: highly precise sensing with VCSELs

Production control and quality management is supported by smart optical sensing solutions to measure speed, distance and position of various materials. Single-mode VCSEL solutions with polarization control are the key enabler for demanding non-contact processing sensor applications due to their superior optical characteristics.

A live demonstration highlights the variety of applications that the VCSEL light sources can cover.

In addition to VCSEL components, TRUMPF offers integrated packages for easy and robust handling and the option to customize by integrating optics or electronics. In a second live demo, TRUMPF is showing the real-time measurement of air quality. In cooperation, Bosch Sensortec and TRUMPF developed what is claimed to be the world's smallest, most highly accurate particulate matter sensor based on a VCSEL with integrated photodiode. The VCSEL solution is a compact, reliable laser source that is maintenance free and insensitive to sunlight.

www.photonics-congress.com

www.trumpf.com

BluGlass showcases enhanced GaN laser products at LASER World of Photonics 2023

Vertical integration into Silicon Valley fab nearing completion

At the LASER World of Photonics 2023 event in Munich, Germany (27–30 June), BluGlass Ltd of Silverwater, Australia — which manufactures gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — is showcasing enhanced GaN laser products featuring significant performance improvements in light emission, power conversion efficiencies, and voltage. Specifically, the firm's blue 450nm single-mode and multi-mode devices feature increases in power conversion efficiency of more than 55% and 42%, respectively, from those launched at Photonics West 2023 in San Francisco at the end of January, enabling their use in more demanding customer applications such as quantum computing, robotics and biotechnology.

Customers can inspect BluGlass' enhanced performance data at Laser World across the 405nm, 420nm and 450nm wavelengths in single-mode and multi-mode devices. The firm is also using the conference to launch a new 397nm ultraviolet single-mode alpha product on the market. UV lasers are increasingly being sought after for quantum sensing applications, advanced disinfection technologies, water and surface purification applications, and medical devices.

BluGlass' product suite now includes six commercial and three prototype products, available in a range of form factors including TO cans of various sizes, and chip-on-submounts.

DFB update

Together with its collaboration partner University of California Santa Barbara (UCSB), BluGlass has made significant improvements to its GaN distributed feedback laser (DFB) demonstrations using its proprietary RPCVD technology for longer-wavelength devices. The firm has improved DFB side-mode suppression ratio by more than 50% since Photonics West, delivering advanced single-frequency performance at 450nm and demonstrating longer-wavelength DFB lasers up to 478nm.

DFB single-frequency lasers are commonly utilized in non-visible wavelengths to enable devices that require narrow spectral width and high spectral purity, such as quantum applications. GaN-based DFB lasers are currently not commercially available in visible wavelengths. BluGlass is releasing an updated GaN DFB white paper at Laser World.

Vertical integration

BluGlass is nearing the completion of vertical integration, with production moved from four out of five contract manufacturers (CMs) into its Silicon Valley fab. The firm is

now in advanced stages of completing the integration of the final back-side contract manufacturer.

Since acquiring its laser diode fabrication facility in Silicon Valley and commencing operations in July 2022, BluGlass has accelerated development and production, mitigated reliability challenges to launch a suite of GaN lasers, advanced long-term roadmaps, and begun shipping products to customers.

"Our enhanced GaN laser products are shifting our market position from an emerging alternative supplier to an agile player that is focused on providing high-quality and competitive GaN lasers," says CEO Jim Haden. "As a dedicated GaN laser supplier, we are focused on launching innovative products that address gaps in the market whilst also improving the baseline performance of our existing lasers... This strategy broadens our target customer base," he adds. "Performance improvements are a direct result of greater operational control, and we are nearing completion of vertical integration of our front-end contract manufacturers. Given our aggressive improvement curve, we remain confident in our ability to gain market share in a rapidly growing category with very few players and high barriers to entry."

www.photonics-congress.com

www.bluglass.com.au

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NUBURU's latest private placement boosts June capital raise from about \$8m to \$9.2m

NUBURU Inc of Centennial, CO, USA — which conducts research, development, design and manufacturing of high-power, high-brightness industrial blue lasers — says that, subsequent to the purchase agreement announced on 12 June that raised \$7.925m, on 16 June it entered into an additional note and warrant purchase agreement with certain investors including existing investors, for the sale of (i) convertible promissory notes worth a total of \$1.3m, and (ii) warrants to purchase up to 1,889,535 shares of common stock, par value \$0.0001 per share.

The total amount of the cash infusion raised from these two purchase agreements (prior to deducting transaction and issuance costs) is about \$9.2m.

The shares underlying the convertible notes and the warrants are subject to a one-year lock up and are expected to be registered for resale on a registration statement on Form S-3 after 6 February 2024.

"Our ability to attract both existing and new investors to complete a second funding transaction this month provides further indication that our next-generation technology and market opportunity are

resonating with the financial community," believes CEO & co-founder Dr Mark Zediker. "This additional capital will help us continue our commercialization and execute our product development roadmap and deliver dramatically improved manufacturing capabilities to our customers in our primary markets: welding, metal additive 3D printing and consumer electronics."

The convertible notes are senior, unsecured obligations of the company and bear interest at the rate of 7% per year and are payable on the earlier of 23 June 2026, or the occurrence of an event of default, as defined in the convertible notes. They may be converted at any time following 23 June 2023, prior to the payment in full of the principal amount of the convertible notes at the investor's option. In the event of the sale of the company, the outstanding principal amount of each convertible note, plus all accrued and unpaid interest not otherwise converted into equity securities pursuant to the terms of the convertible notes, shall:

(i) if the investor so elects, be converted into equity securities pursuant to the terms of the convertible notes (the conversion

shares) at a price equal to \$0.688 (subject to appropriate adjustment from time to time for any stock dividend, stock split, combination of shares, reorganization, recapitalization, reclassification or other similar event), or (ii) be due and payable immediately prior to the closing of such sale of the company, together with a premium equal to 150% of the principal amount to be prepaid. Subsequent to the effectiveness of a registration statement registering the registrable securities, NUBURU may elect to pay interest in kind through the issuance of shares of common stock at the conversion price, in lieu of payments in cash (the interest shares).

The warrants issued pursuant to the purchase agreement entitle the relevant investor to purchase that number of fully paid and non-assessable shares of common stock (the warrant shares) determined by dividing the principal amount of each convertible note by the conversion price. The warrants have an exercise price equal to \$1.03, which represent a 50% premium over the exercise price, and expire on 23 June 2028.

www.nuburu.net

BL blue laser product line boosted from 250W to 1kW

NUBURU has increased the power of its BL product line from 250W to 1000W by introducing its next-generation BL-1000-F. The extra power enables higher-speed, micron-level precision and repeatable high-quality welds, all of which are critical attributes for the needs of large commercial markets including electric vehicle (EV) battery welding and 3D printing.

"Our customer feedback has indicated that our BL-1000-F will provide a compelling solution that combines both speed and weld quality which will dramatically

improve the manufacturing capabilities of our customers in our primary markets: welding, metal additive 3D printing and consumer electronics," says CEO & co-founder Dr Mark Zediker.

NUBURU says that the BL-1000-F can deliver these next-generation capabilities due to its ability to harness the intrinsically higher absorption of metals to blue light. When combined with a scanner, the BL-1000-F enables critical benefits such as high-speed and conduction-mode weld precision with the quality and process stabil-

ity requirements that are critical to customers while lowering their total cost of ownership. The higher power delivered by the BL-1000-F enables a higher-quality laser beam. This allows the BL-1000-F to more efficiently weld and process metals that are highly reflective for traditional infrared (IR) lasers as well as other metals that are used extensively in the manufacturing of EV batteries and 3D metal printing.

NUBURU introduced the BL-500-F and the BL-1000-F on 27 June at the Laser World of Photonics 2023 trade fair in Munich, Germany.

Sivers Photonics receives \$1m order from Ayar Labs DFB laser array light source technology to support in-package optical I/O

IC and integrated module supplier Sivers Semiconductors AB of Kista, Sweden says that its subsidiary Sivers Photonics of Glasgow, Scotland, UK has received a new order worth \$1m (about SEK11m) from silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA for the development of laser arrays that support applications including high-performance computing (HPC), artificial intelligence (AI), machine learning (ML). The order deepens Sivers' strategic collaboration with Ayar Labs, which is working on scaling its in-package optical I/O solution for volume production.

With this order the companies enter the next phase of their partnership with a focus on the continued development and commercialization of Sivers' distributed feedback (DFB) laser arrays supporting Ayar Labs' optical I/O solution, which is currently enabling 4Tb/s bidirectional chip-to-chip optical connectivity. The order will be delivered across 2023 and 2024 and includes agreed commercial terms for volume pricing in anticipation of future manufacturing by Sivers at larger volumes.

Sivers Photonics says that its DFB laser arrays provide the high-quality light source for Ayar Labs'

SuperNova remote optical source product as they scale to volume production across a broad range of applications including AI/ML interconnects, disaggregated data centers, 6G networks, and phased-array sensor systems.

In May, Ayar Labs closed a second round of Series C funding, raising it to \$155m. The additional C round was led by Capital TEN and included VentureTech Alliance and participation by previous investors Boardman Bay Capital Management, IAG Capital Partners, NVIDIA, and Tyche Partners. Other Series C existing strategic and financial investors include Applied Ventures, GlobalFoundries, Hewlett Packard Pathfinder, Intel Capital and Lockheed Martin Ventures.

"We are excited to continue our strong relationship with Ayar Labs after our successful joint demos at both ECOC 2022 and OFC 2023," says Sivers Photonics' interim managing director & chief technology officer Dr Andrew McKee. "Utilizing our proven technology, Ayar Labs can confidently deliver to their customers at scale, all whilst leveraging the continued growth of the CW-WDM MSA ecosystem for high-bandwidth and channel-count laser solutions," he adds.

"We value Sivers as an essential part of our thriving ecosystem, as they have consistently proven to be a responsive and reliable supplier in meeting our SuperNova product commitments," comments Ayar Labs' CEO Charlie Wuischpard.

"The ability to deliver high-quality remote light sources at volume and maintain an aggressive development roadmap are important to commercializing our optical I/O solutions," he adds.

"Ayar Labs is revolutionizing the way CPUs and GPUs will communicate within next-generation HPC and AI/ML architectures," comments Sivers Semiconductors' group CEO Anders Storm.

"By enabling the switch to optical interconnect technology versus traditional electrical links, Ayar's solution, leveraging Sivers technology, will provide a dramatic step-change in the required bandwidth, power and latency improvements necessary for these complex systems to scale and meet the exploding demand for AI/ML clusters. With the massive growth of generative AI, we believe this is just the beginning and are excited to support our customers in enabling the AI revolution."

www.ayarlabs.com

Sivers Photonics receives \$1.3m order from US Follow-on order includes development, qualification and supply of InP100-based custom devices

Sivers Photonics has received a new order worth \$1.3m (SEK14m) from a US-based customer for the qualification and supply of photonic devices for optical sensing applications.

As the next step in an ongoing partnership where Sivers received the first order in December 2021, the latest order includes the development, qualification and supply of custom photonic devices manufactured on Sivers' InP100

technology platform and forms an essential part of the customer's advanced sensor product range.

"We're excited to continue our relationship with this customer, supplying custom devices designed and manufactured on our InP100 platform, on which we support many customers across several applications," says Dr Andrew McKee, interim managing director & chief technology officer at Sivers Photonics. "Our technol-

ogy is playing a critical role in allowing this customer to move closer to volume production," he adds.

"This order strengthens our relationship with this important US customer, and this market is definitely one of the major megatrends that Sivers Photonics offers a strong portfolio towards," comments Sivers Semiconductors' group CEO Anders Storm.

www.sivers-semiconductors.com

X-FAB leads EU-funded photonixFAB project to industrialize European silicon photonics value chain

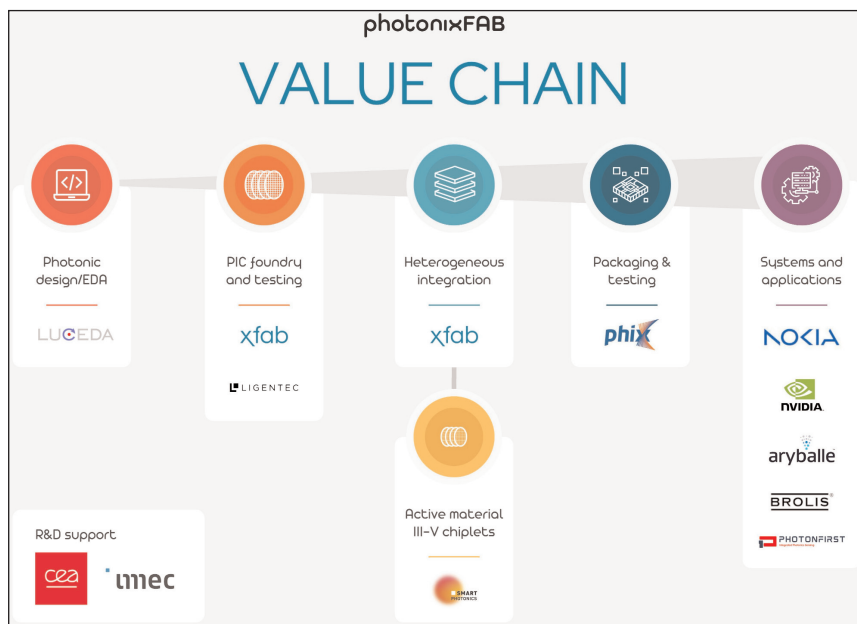
Consortium to enable photonics product innovation and commercialization with path to high-volume manufacturing

Analog/digital (mixed-signal) integrated circuit, micro-electro-mechanical system (MEMS) and specialty semiconductor foundry X-FAB Silicon Foundries SE of Tessenderlo, Belgium is spearheading a strategic initiative aiming to enable the European semiconductor and photonics industries to gain greater sovereignty, strengthening the continent's manufacturing capabilities in key emerging areas. The photonixFAB project aims to empower photonics innovation by small- and medium-sized enterprises (SMEs) and large entities by providing low-barrier access to both low-loss silicon nitride (SiN)- and silicon-on-insulator (SOI)-based photonics platforms with indium phosphide (InP) and lithium niobate-on-insulator (LNO) heterogeneous integration capabilities.

The photonixFAB consortium consists of major public and private enterprises, plus research institutes — all focusing on the development and production of next-generation silicon photonics. The partners include technology and manufacturing service providers LIGENTEC, SMART Photonics, PHIX Photonics Assembly and Luceda Photonics plus application developers Nokia, NVIDIA, Aryballe, Brolis Sensor Technology and PhotonFirst, as well as the research organizations CEA-Leti and IMEC.

The objective is to establish a European photonics device value chain and initial industrial manufacturing capabilities, providing a path to scalable high-volume manufacturing for innovative product developers.

The photonixFAB consortium will span a comprehensive set of photonics foundry and assembly capabilities, including:



- industry-scale silicon photonics manufacturing services with low entry barriers and fast turn-around times for both low-loss SiN- and SOI-based photonic integrated circuits (PICs);
- enablement of micro-transfer printing and direct bonding technologies for InP, LNO and germanium-based active and passive component heterogeneous integration on SiN- and SOI-based PIC platforms.
- development of scalable packaging and testing solutions in alignment with the (heterogeneous) PIC platform developments.
- process design kit (PDK)-based design automation enablement for the photonic platforms.

As a part of the project, six demonstrators are being built to validate the implemented photonics value chains. These include applications such as datacom and optical switches, a coherent optical transceiver, an infrared (IR) spectrometer for sensing, a digital olfaction sensor for consumer healthcare and a health monitoring demonstrator.

Prospective opportunities for photonic devices fabricated via

detection and ranging).

"Seeing huge potential emerging there, traditional semiconductor vendors, OEMs and start-ups are all now exploring photonic-enabled applications," says X-FAB's CEO Rudi De Winter. "Consequently, this is the right time for companies to work together on building an extensive Europe-centric silicon photonics ecosystem that will help drive the continent's competitiveness in this exciting new market."

The project is being supported by the Key Digital Technologies Joint Undertaking (KDT JU), with funding from the European Union (EU), under grant agreement no. 101111896, plus top-up funding from national authorities in Belgium, Germany, France, Israel, Italy, The Netherlands and Switzerland. The combination of this funding plus direct investment from each of the consortium members totals €47.6m. A major part of the work of this 3.5-year project will be conducted at X-FAB's foundry operation in Corbeil-Essonnes, France, with additional activities also undertaken at the numerous other partners' sites across Europe.

www.xfab.com

the photonixFAB project have already been identified, including data communications, telecoms, biomedical sensors/detectors, quantum computing and vehicle LiDAR (light

SMART Photonics secures €100m in extra funding round

Firm to extend manufacturing capabilities and speed development of photonic integrated circuit technology platforms and PDKs

The independent pure-play indium phosphide (InP) photonic integrated circuit (PIC) foundry SMART Photonics of Eindhoven, The Netherlands, has secured an additional round of funding of €100m from a group of strategic industry and financial Dutch players.

Among the group of new lenders are strategic players from the semiconductor industry (ASML, NXP and VDL Groep) as well as financial institutions (ING, BOP Impact Ventures and Deep Tech Fund, which is part of Invest-NL and partly funded by the ministry of Economic Affairs and Climate Policy). Previous investors, including Innovation Industries, BOM, PhotonDelta and KPN Ventures have joined in this funding round again. The government of the Netherlands will provide €60m public funding as part of the approved National Growth Fund project PhotonDelta as previously announced.

SMART Photonics will use the funds to extend its manufacturing capabilities and accelerate the development of its photonic integrated chip technology platforms and its process design kits (PDKs). "With this round of funding, we



receive strong support from the Dutch ecosystem including strategic lenders and financial institutions in our ambition to become the globally leading foundry for photonic integrated chips," says CEO Johan Feenstra.

"Financial support from the three fellow-Brainport region companies gives SMART Photonics the best opportunity to take the essential next steps to further mature the organization, strengthen technical capabilities and extend their manufacturing base," state ASML, NXP and VDL Groep jointly. "Our additional funding will help strengthen the Brainport and wider Dutch and European Photonics ecosystem.

SMART Photonics becoming a strong and versatile foundry can greatly benefit the growing number of fabless photonic chip design companies in the Brainport region," he adds.

"We believe in the Netherlands as a leading international hub for the development of the fast-growing integrated photonics

industry," says Micky Adriaansens, Netherlands' Minister of Economic Affairs and Climate Policy. "That's why we invest both through the National Growth Fund project PhotonDelta in the whole ecosystem and through our dedicated Deep Tech Fund with specific funding for start-ups and scale-ups who focus on innovative complex technology such as SMART Photonics. For the prosperity and economic growth of the future and to maintain our competitiveness, it is necessary that we develop innovative key technologies like integrated photonics within the European Union."

www.smartphotonics.nl

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POET announces alpha sample availability of Infinity chiplet and testing with two lead customers

POET Technologies Inc of Toronto, Ontario, Canada has announced alpha sample readiness of POET Infinity, a chiplet-based transmitter platform for 400G, 800G and 1.6T pluggable transceivers and co-packaged optics solutions. Two lead customers have agreed to partner with POET to test the alpha version.

The Infinity chiplet complements the POET 800G 2xFR4 Receiver optical engine that the firm announced in February, and completes the 800G chipset for 2xFR4 QSFP-DD or OSFP applications with two Infinity chiplets and one Receiver optical engine. Both customers intend to develop 800G 2xFR4 QSFP-DD and OSFP transceiver solutions using the POET Optical Engine chipsets.

The Infinity chiplet is said to be the industry's first implementation of directly modulated lasers (DMLs)

for 100G/lane applications. DMLs are power efficient, cost effective and become a highly scalable solution when paired with the POET Optical Interposer platform, the firm says. The chiplet incorporates 100G PAM4 DMLs, DML drivers and an integrated optical multiplexer for a complete 400GBASE-FR4 transmitter solution on a chip. The small size of the chiplet and a daisy-chain architecture enables side-by-side placement of multiple instances to achieve 800G and 1.6T speeds.

The Infinity product line carries forward the POET differentiation of all passive alignments and monolithically integrated waveguides, multiplexers and demultiplexers — said to translate to lower cost, lower power consumption and ease-of-assembly benefits for customers.

"Availability of a transmitter solution for 400G, 800G and 1.6T speeds

that is power efficient, cost effective and highly scalable for the data-center market is a major achievement," reckons chairman & CEO Dr Suresh Venkatesan. "Customers are excited to receive the samples and test them because it simplifies their transceiver design significantly and shortens the design cycle with POET optical engines that incorporate all of the required optical elements as well as the key electronic components, including laser drivers and trans-impedance amplifiers."

The development of a production version of the POET Infinity chiplet is on track and the firm expects to deliver beta samples by fourth-quarter 2023 and start production by first-half 2024. The Ethernet transceiver market for 400G-and-above data rates is projected by market research firm Lightcounting to exceed \$6bn by 2028.

Samples of 100G LR4 optical engines made available

POET has announced sample readiness of 100G LR4 Transmit and LR4 Receive optical engines that are part of its POET Legacy product family. Three lead customers have received samples and started product evaluation and two others have requested samples.

The LR4 Transmit and Receive optical engines are designed using POET's Optical Interposer technology and known good optical components, including high-speed directly modulated lasers (DMLs) and photodiodes. The engines meet the IEEE 100GBASE-LR4 standard for transmission up to 10km and are suitable for use in QSFP28, CFP, CFP2 and other high-density form factors. 100G LR4 transceivers are a mainstay of the telecom industry, providing key links from data centers to trunk lines.

"We have seen a strong interest in our 100G LR4 optical engines from a good mix of tier-1 and tier-2

customers that intend to cost reduce their transceivers to continue supporting the market for the next several years," says Raju Kankipati, senior VP & general manager of POET North America. "Our chip-on-board architecture and passive alignment process simplifies the module design to achieve a substantial cost reduction. 100G LR4 has a strong deployment base in both telecom and datacom networks, and we look forward to supplying our engines to our transceiver customers for the entire LR4 lifecycle."

The chip-on-board, non-hermetic architecture of POET's optical engines eliminates costly TOSA and ROSA that are prevalent in most existing 100G LR4 transceivers. The engines are assembled using a standard pick-and-place attach process without micro-optic lenses and isolators. No active alignment enables wafer-scale assembly and testing.

The small-size 100G LR4 Transmit optical engine is about 9mm by 4mm and incorporates four DML lasers operating at the LAN-WDM wavelengths as defined by the IEEE 802.3ba standards. The optical multiplexer, monitor photodiodes and an FAU (fiber array unit) are included on the engine. The Receive optical engine is 7.5mm by 4.5mm and includes high-speed photodiodes, a demultiplexer and FAU.

POET expects to complete the qualification of 100G LR4 Transmit and Receive optical engines and start volume production at its joint venture partner Super Photonics by first-quarter 2024. The Ethernet transceiver market for 100G LR4 is projected by market research firm LightCounting to sustain a steady run rate, with estimated cumulative sales of \$1.6bn over the 2024–2028 period.

www.poet-technologies.com

Lumentum upsizes convertible notes offering from \$500m to \$525m

Part of proceeds to be used to repurchase \$125m of common stock

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has announced the pricing of its offering of \$525m worth of convertible senior notes due 2029 in a private placement to qualified institutional buyers (pursuant to Rule 144A under the Securities Act of 1933, as amended).

The offering was increased from the previously announced \$500m (or \$575m if the initial purchasers exercise their option to purchase additional notes in full). Lumentum granted the initial purchasers of the notes a 13-day option to purchase up to an additional \$78.75m of the notes. The sale of the notes to the initial purchasers is expected to settle on 16 June (subject to customary closing conditions), and is expected to result in net proceeds of about \$520.1m (or \$598.2m, if the initial purchasers fully exercise their option to purchase additional notes) after deducting the initial purchasers' discount and estimated offering expenses payable by Lumentum.

The notes are senior, unsecured obligations of Lumentum, and will bear interest at a rate of 1.50% per year, payable semi-annually in arrears on 15 June and 15 December of each year, beginning on 15 December 2023. The notes will mature on 15 December 2029, unless earlier converted, redeemed or repurchased.

Lumentum intends to (i) use about \$132.8m of the net proceeds

to repurchase about \$125m of its 0.250% convertible senior notes due 2024, and (ii) purchase about \$125m of its common stock, in each case concurrently with the pricing of the offering in privately negotiated transactions effected through one of the initial purchasers of the notes or its affiliate, as its agent. Lumentum intends to use the remaining net proceeds for general corporate purposes, which may include the repayment or repurchase of its indebtedness, including any of its existing convertible notes, capital expenditures, working capital and potential acquisitions.

Holders of the 2024 notes that are repurchased in the concurrent repurchases may purchase shares of Lumentum's common stock in the open market to unwind any hedge positions they may have with respect to the 2024 notes. These activities may affect the trading price of Lumentum's common stock and the initial conversion price of the notes. Additionally, the concurrent repurchases of shares of common stock may result in the common stock trading at prices that are higher than would be the case in the absence of these repurchases.

The initial conversion rate for the notes is 14.3808 shares of Lumentum's common stock per \$1000 of notes (equivalent to an initial conversion price of about \$69.54 per share) and is subject to adjustment upon the occurrence of certain events. Prior to the close of business on the business day immedi-

ately preceding 15 September 2029, the notes will be convertible at the option of the noteholders upon satisfaction of specified conditions and during certain periods. Thereafter, until the close of business on the second scheduled trading day preceding the maturity date, the notes will be convertible at the option of the noteholders at any time regardless of these conditions. Conversions of the notes will be settled in cash, shares of common stock or a combination of cash and shares of common stock, with the form of consideration at Lumentum's election. The initial conversion price represents a premium of about 30% over the last reported sale price of Lumentum's common stock on 13 June of \$53.49 per share.

Lumentum may redeem for cash all or any portion of the notes, at its option (subject to certain limitations), on or after 22 June 2026, if the last reported sale price of its common stock has been at least 130% of the conversion price then in effect for at least 20 trading days (whether or not consecutive) during any 30 consecutive trading-day period (including the last trading day of such period) ending on, and including, the trading day immediately preceding the date on which Lumentum provides notice of redemption at a redemption price equal to 100% of the notes to be redeemed, plus accrued and unpaid interest to, but excluding, the redemption date. No sinking fund is provided for the notes.

www.lumentum.com

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NREL awards \$2m in contracts to support development of cheaper, more efficient CdTe solar cells

Six projects funded for Cadmium Telluride Accelerator Consortium

The US Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) has awarded \$2m to fund six projects to support the Cadmium Telluride Accelerator Consortium (CTAC).

Announced in August 2022, CTAC is a three-year consortium intended to accelerate the development of cadmium telluride (CdTe) technologies by lowering the cost and increasing the efficiency of these thin-film solar cells. NREL released the request for proposal notice for small projects in September 2022. The following projects were selected.

Topic Area 1:

High-Efficiency Devices

- *'Advanced Back Contacts and Surface Photovoltage (SPV)/SPV Spectroscopy (SPS)*

Characterization To Unlock Bifaciality, Open-Circuit Voltage (V_{oc}) >900mV, and Efficiency of 26% From CdTe-Based Cells'

The University of Utah will develop sputtered, doped wide-gap materials and bilayer stacks for back contacts to state-of-the-art CdSeTe/CdTe absorbers. It will focus on p-type materials that have energy level alignment predicting hole selectivity, are amenable to passivation, and have a wide gap to provide transparency for enhanced bifaciality or back mirror cell optics. It will obtain state-of-the-art absorber stacks from CTAC partners and fabricate sputtered back contacts. It will continue to develop its surface photovoltage and SPV spectroscopy techniques to characterize back-contact band structure, traps, and recombination activity.

- *'Advanced Activation and Contact Approaches for Cadmium Zinc Telluride (CdZnTe) Solar Cells'*

The University of Delaware will develop new approaches for processing $Cd_{1-x}Zn_xTe$ solar cells that overcome previously reported difficulties, such as ineffective

chloride activation and passivation, which prevented the realization of high performance with increased open-circuit voltage (V_{oc}) relative to CdTe. The approach will be based on two hypotheses: modification of film growth, including in-situ antimony incorporation, can form more equilibrated films with reduced defects and enhanced grain sizes, reducing the need for high-temperature activation; and alternative halide activation chemistries during post-deposition treatments can minimize the deleterious effects of cadmium chloride ($CdCl_2$) activation. A final goal of the project will be to confirm the viability of $Cd_{1-x}Zn_xTe$ by demonstration of a thin-film solar cell with $V_{oc} \geq 1.0V$.

- *'Toward High-Efficiency n-Cd(Se)Te Solar Cells'*

The University of South Florida will develop alternative device architectures based on n-type CdTe/CdSe_xTe_{1-x} (CST) thin-film absorbers to create opportunities to overcome the efficiency limitations associated with the current state-of-the-art p-type CdTe/CST solar cells. The project aims to build upon advances in n-CdTe/CST films that demonstrated group-III and group-VII n-type doping for CdTe films. It will focus on the development of p-type heterojunction partners for n-CdTe/CST absorbers.

Topic Area 2:

Tellurium (Te) Supply

- *'Selective and Efficient Recovery of Tellurium From Copper Processing Streams'*

The Missouri University of Science and Technology will enhance Te recovery from copper processing (CP) by optimizing the current operations to capture the Te, gold (Au) and silver (Ag) that are presently lost to tails. The scope of work involves: advanced mineralogical analysis of different processing streams of the flotation circuit of CP

ores to identify Te carriers and modes of occurrence (i.e. Te in the crystal lattice versus Te-rich inclusions in larger minerals); evaluation of different approaches and flow-sheet options for enhanced separation of Te, Ag and Au minerals from processing streams of CP ores; and techno-economic assessment to estimate the capital and operating costs of the developed flow sheets for successful implementation, which could increase the domestic production of Te from CP ores by at least 50%.

Topic Area 3:

Characterization, Modeling, and Simulation

- *'3D In Situ Correlative X-Ray Studies of Defect Chemistry, Structure, and Electrical Performance During Dopant Activation'*

Arizona State University will combine the power of hard x-ray microscopy (XRM) and soft x-ray and electron spectroscopies to probe arsenic (As)-doped CdSeTe absorbers and devices. XRM will probe the chemical distribution, atomic environment and current collection at the nanoscale for the As and selenium (Se) absorption edges. Electron and soft x-ray spectroscopies will enable an area-integrating determination of the electronic structure at surfaces (band edges, surface bandgap) and interfaces (band alignment), in addition to the chemical bonding environment of the sulfur (S), chlorine (Cl) and oxygen (O) in the device. The team is tackling two main questions. How do the chemical states of As (and neighboring atoms) evolve between initial deposition and post-activation? What stressors and processes enhance or prevent activation of As dopants?

- *'Microcontact Arrays Measuring Local Carrier Transport in CdTe Solar Cells'*

The University of Utah will assess

▶ the role of microstructures in advanced CdTe devices. The goal is to improve the limiting open-circuit voltage while retaining the maximum values of short-circuit current and fill factor of CdTe solar cells by developing a novel architecture built on a comprehensive understanding of local carrier dynamics. It will investigate the interfacial and microstructural characteristics of

advanced CdTe ($\text{CdSe}_{(1-x)}\text{Te}_x$) passivated emitter and rear contact (PERC) solar cells. A micro-contact array platform with tunable pattern geometry will enable measurements of global (patterned CdTe PERC) and local carrier transport, delineating the contribution of grain bulk and grain boundaries to overall photovoltaic performance. Using complementary electron/optical

microscopy, it will correlate the transport characteristics to the microstructural properties of each sample set (e.g. GrV-doped versus copper (Cu)-doped CdTe PERCs).

CTAC is funded by DOE's Solar Energy Technologies Office (SETO).

www.nrel.gov/pv/cadmium-telluride-photovoltaics-accelerator-consortium-solicitation.html

Energix to buy 5GW of First Solar modules, for delivery in 2026–2030

Framework agreement to see Energix operate over 7–9GW of First Solar technology by 2030

First Solar Inc of Tempe, AZ, USA says that Israel-based Energix Renewable Energy Ltd has agreed to procure 5GW_{DC} of its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules, for delivery in 2026–2030 for projects in Israel, Poland and the USA.

Energix will take delivery of modules on a free-carrier (FCA) basis from a location near the relevant First Solar factories. Also, Energix has the right to increase or decrease the total volume to be procured under the agreement by 200MW_{DC} each year during the five-year term (with any such increase subject to module availability).

Energix, which has a portfolio of more than 7GW of projects under development in Israel, Poland and the USA, has also contracted First Solar Recycling Services to manage end-of-life handling of decommissioned modules. Prior to this deal, the firm had placed over 3.5GW_{DC} of orders for First Solar technology since 2017.

"As we grow our pipeline, we want a trusted partner that will not compromise on quality, its commitments, or principles, and that partner is First Solar," says Energix's CEO Asa (Asi) Levinger. "This deal, our largest ever, strongly reflects the long-term strategic partnership we share with First Solar. It also constitutes a

significant milestone for Energix's long-term growth, as we rapidly expand our global pipeline, with an emphasis on the United States," he adds.

"This deal demonstrates once again the substantial place Energix takes as one of our biggest clients worldwide," says First Solar's chief commercial officer Georges Antoun. "This is another example of a large, sophisticated player choosing to de-risk its development portfolio by working with us," he adds. "They recognize that they do not simply get a high-quality, high-performance, responsibly produced PV module, but a trusted partner and long-term pricing and supply certainty, which are rarities in the solar industry."

First Solar claims to be the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics. End-of-life modules from Energix projects will be processed by First Solar's recycling program, which provides closed-loop semiconductor recovery for use in new modules while also recovering other materials including aluminium, glass and laminates.

First Solar says that its thin-film semiconductor, integrated manufacturing process and tightly

controlled supply chain helps to eliminate the risk of exposure to solar supply chains identified by the US Department of Labor's 2022 List of Goods Produced by Child Labor or Forced Labor as being tainted by forced labor. The firm is the only one of the world's ten largest solar manufacturers to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain. First Solar says that it has zero tolerance for forced labor in its manufacturing or its supply chains.

First Solar is investing about \$1.3bn in expanding its US manufacturing footprint from over 6.5GW_{DC} of annual nameplate capacity currently to about 10.9GW_{DC} by 2026. In addition to the \$1.1bn expected investment in a new 3.5GW_{DC} facility in Alabama, the firm has also embarked on a \$185m expansion of its existing manufacturing footprint in Ohio. First Solar, the largest solar manufacturer in the Western Hemisphere, also announced an investment of up to \$370m for a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

www.energix-group.com
www.firstsolar.com

First Solar to invest \$1.1bn in building fifth US manufacturing facility

Plant to boost firm's nameplate capacity in 2026 by 3.5GW, to 14GW in USA and 25GW globally

Cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA is to build a fifth manufacturing facility in the USA (in a yet-to-be-determined location), investing up to \$1.1bn in further expanding the country's capacity to produce its own solar modules. The planned fully vertically integrated facility is expected to grow the firm's nameplate manufacturing capacity by 3.5GW to about 14GW in the USA and 25GW globally in 2026.

To be completed and commissioned in first-half 2026 (contingent upon obtaining necessary permits and approvals), the new facility will produce First Solar's Series 7 modules, which are expected to be manufactured with 100% US-made components identified in the current domestic content guidance issued by the US Department of Treasury. First Solar expects that, once the new factory is completed and ramped, Series 7 modules will account for over two thirds of its annual domestic nameplate capacity. Series 7 modules currently produced at the firm's Ohio facility are already

manufactured with US-made glass and steel.

"This decision is underpinned by robust fundamentals, including an order backlog of approximately 78GW, the industry's strongest balance sheet, a repeatable vertically integrated manufacturing template, and a proven technology platform," notes CEO Mark Widmar. "With this investment, we continue to help deliver on the promise of the Inflation Reduction Act, which is to create enduring value for our country," he adds. "By expanding America's solar manufacturing base, and the value chains that support it, we are working to ensure that the US enters the next decade in a position of strength, fully capable of producing the technology it needs to complete its transition to a sustainable energy future."

Over the past year and including this announcement, First Solar has committed to over \$2.8bn in capital investment and 7.9GW of additional manufacturing capacity in the USA. The firm had previously announced an approximately \$1.3bn investment in a new 3.5GW

manufacturing facility in Alabama and a 0.9GW expansion of its existing manufacturing footprint in Ohio, both of which are expected to be completed at the end of 2024. As the largest fully vertically integrated solar manufacturer in the Western Hemisphere, with 6.3GW of operational capacity in the USA, First Solar also previously announced an investment of up to \$370m for a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

With more than 2500 staff across the USA, First Solar is already believed to be the largest employer in America's solar manufacturing sector. The firm estimates that the new facility will add over 700 new jobs which, when combined with the 850 new manufacturing jobs expected to be created in Alabama and Ohio and over 100 new R&D jobs planned in Ohio, takes its total number of direct jobs in the USA to more than 4000 people across the country by 2026.

www.firstsolar.com/en/Products/Series-7

First Solar secures \$1bn revolving credit facility

On 30 June First Solar entered into a five-year revolving credit and guarantee facility for \$1bn, including up to \$250m available for the issuance of letters of credit. J.P. Morgan Chase Bank acted as lead arranger and is administrative agent for the facility.

Other banks participating include joint lead arrangers Bank of America, Citibank, Credit Agricole CIB and PNC Bank, as well as participating lenders BNP Paribas, Goldman Sachs Bank USA, HSBC Bank USA, MUFG Bank, Standard Chartered Bank, and Truist Bank.

"This agreement underscores First Solar's bankability and is underpinned by the strong fundamentals that drive our business today," says CEO Mark Widmar. "We are focused on exiting this decade in a stronger position than we entered it and liquidity is a crucial differentiator that we intend to maintain. This revolving credit facility provides us the financial headroom and flexibility we need, while also balancing our ability to grow in response to demand."

First Solar will commission a new 3.4GW_{DC} manufacturing facility in

India in second-half 2023, add a new 3.5GW_{DC} factory in Alabama in late 2024 and expand its footprint in Ohio by 0.9GW_{DC} by 2026.

"J.P. Morgan is proud to support First Solar's efforts to accelerate the transition to a low-carbon economy," says Mike Lister, head of J.P. Morgan Energy Power & Renewables Corporate Banking. "We're focused on helping clients meet the world's need for secure, reliable and affordable energy, while advancing long-term clean energy solutions to reduce our global carbon footprint."



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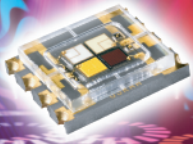


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First Solar announces limited production run of first bifacial thin-film PV module

Intersolar Europe sees debut of pre-commercial version of first alternative to bifacial crystalline silicon technology

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has announced a limited production run of what it says is the first bifacial solar panel utilizing a thin-film semiconductor. A fully functional pre-commercial Series 6 Plus Bifacial PV module made its industry debut at Intersolar Europe in Munich, Germany (14–17 June).

The module, which is undergoing field and laboratory testing, builds on the track record of First Solar's Series 6 monofacial module platform. It features a transparent back contact, pioneered by First Solar's R&D teams, which — in addition to enabling bifacial energy gain — allows infrared wavelengths of light to pass through rather than be absorbed as heat, and is expected to lower the operational temperature of the bifacial module and result in a higher specific energy yield.

"This module combines the quality, sustainability, reliability and

long-term performance of our Series 6 Plus platform with our first increment of bifaciality," says chief product officer Pat Buehler. "Once commercialized, we expect Series 6 Plus Bifacial to represent the first real alternative to crystalline silicon-based bifacial technology, effectively combining bifaciality with the industry's best warranted degradation rate, CdTe thin film's ability to deliver more energy per nameplate watt, best-in-class reliability and durability, and innovative module design."

Series 6 Plus monofacial module features what is claimed to be an industry-best 0.3% warranted degradation rate, superior temperature coefficient, spectral response and shading behavior, and an anti-reflective coating to enhance energy production. Moreover, unlike crystalline silicon (c-Si) panels, First Solar's Series 6 Plus module does not experience losses from light-induced degradation (LID) and light and elevated-temperature-

induced degradation (LeTID). The module is manufactured under one roof with 100% traceable quality assurance, exceeding International Electrotechnical Commission (IEC) standards in high temperature, high humidity and extreme desert and coastal applications.

In October 2022, First Solar announced that it would construct a new R&D innovation center in Perrysburg, Ohio. Representing an investment of about \$370m, the facility is believed to be the first of its scale in the Western Hemisphere and is expected to accelerate the development and production of thin-film PV. Scheduled to be completed in 2024, the new R&D center will be located near First Solar's existing Perrysburg manufacturing facility, covering an area of about 1.3 million square feet. It will feature a high-tech pilot manufacturing line, allowing for the production of full-sized prototypes of thin-film and tandem PV modules.

www.firstsolar.com

Tennessee Valley Authority secures 279MW of PV panels Alabama project in same county as First Solar's new US factory

The Tennessee Valley Authority (TVA) of Knoxville, TN, the USA's largest public power supplier (serving 10 million people across seven south-eastern states), has secured 279MW_{DC} of PV panels from First Solar for its planned Lawrence County Solar Project in Alabama, which is due to begin commercial operation in 2027. The project reflects TVA's growing emphasis on solar in the region which, by 2025, is also expected to become the home of one of the largest fully vertically integrated solar manufacturing facilities in the USA, when First Solar commissions its fourth American factory.

"Through our work with First Solar, TVA will continue to integrate more renewable generation into our overall portfolio with solar technology developed and manufactured in America," says Roger Waldrep, vice president, TVA Major Projects.

First Solar is investing about \$1.3bn in expanding its US manufacturing footprint from over 6.5GW_{DC} of annual nameplate capacity currently to about 10.9GW_{DC} by 2026. In addition to the \$1.1bn being invested in its new 3.5GW_{DC} panel manufacturing plant in Lawrence County, First Solar has also embarked on a \$185m expansion of its existing

manufacturing footprint in Ohio. The largest solar manufacturer in the Western Hemisphere has also announced an investment of up to \$370m for a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

"As we scale our manufacturing footprint and supply chains, it is vital that the communities we operate in benefit from our creation of jobs, economic value, and clean electricity produced by our solar technology," says First Solar's chief commercial officer Georges Antoun.

www.tva.com

Capital Power orders 1GW of First Solar PV modules Series 6 Plus modules to power US and Canada projects, with deliveries from 2026 to 2028

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA says that Capital Power Corp of Edmonton, Alberta, Canada — which builds, owns and operates 29 utility-scale generation facilities across North America including renewables and thermal — has secured its first order for about 1GW_{DC} of thin-film solar modules. For delivery between 2026 and 2028, the Series 6 Plus modules will support Capital Power's growing development portfolio.

"First Solar's longstanding investment in domestic supply chains ensures the use of high-quality American solar technology, including products made with significant amounts of domestically sourced content, to power our projects," comments Chris Kopecky, senior VP & chief legal, development and

commercial officer, Capital Power. "We look forward to building on this relationship."

First Solar says that its thin-film semiconductor, integrated manufacturing process and tightly controlled supply chain helps to eliminate the risk of exposure to solar supply chains identified by the US Department of Labor's 2022 List of Goods Produced by Child Labor or Forced Labor as being tainted by forced labor. The firm is the only one of the world's ten largest solar manufacturers to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain. First Solar is also the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment

Tool (EPEAT) global registry for sustainable electronics.

"Capital Power joins a growing group of project developers that partner with First Solar as a reliable module technology provider that can help de-risk their project pipelines by delivering long-term pricing and supply certainty," says First Solar's chief commercial officer Georges Antoun.

Committed to net zero by 2045, Capital Power's balanced approach to power generation includes a focused effort on solar energy growth across North America. With three solar facilities in operation, Capital Power aims to use its development and construction expertise to deliver projects against an active US solar pipeline totaling nearly 2.4GW_{DC}.

www.firstsolar.com

www.capitalpower.com

Matrix to procure 2.1GW of First Solar PV modules Framework agreement spans delivery in 2024–2027 in USA and Spain

First Solar has entered into a framework agreement for new customer Matrix Renewables of Madrid, Spain to procure about 2.1GW_{DC} of its cadmium telluride (CdTe) thin-film photovoltaic modules, for delivery in 2024–2027 for projects in the USA and Spain. Matrix Renewables was created and backed by global alternative asset manager TPG and its \$17bn investing platform TPG Rise.

Across the USA, Matrix owns more than 6GW of projects in various stages of development across four different regions (CAISO, MISO, ERCOT and WECC) and continues to expand its pipeline and team to capitalize on the large demand for renewable energy in the USA. Including Matrix's presence in Spain, Italy and Chile, Matrix's footprint has already surpassed 13GW of solar power,

battery storage and green hydrogen projects globally.

"As a purpose-driven company, and as part of our supply chain strategy of partnering with technology market leaders, we are thrilled to be working with First Solar to supply our projects in the US market, and a number of our Spanish projects, with responsibly produced ultra-low-carbon PV modules," says Matrix's president Luis Sabate. "With this deal, we're getting access to solar technology without compromising on competitiveness or performance."

"Matrix is the latest in a number of large IPPs [independent power producers], in the US and internationally, that are choosing to partner with First Solar not just on the strength of our technology and competitiveness but also because we share the same values," says

First Solar's chief commercial officer Georges Antoun. "This latest order underscores our belief that a growing number of developers are recognizing the value of Responsible Solar and of working with a partner that delivers on its commitments."

First Solar is investing about \$1.3bn in expanding its US manufacturing footprint from over 6.5GW_{DC} of annual nameplate capacity currently to about 10.9GW_{DC} by 2026. In addition to the \$1.1bn expected investment in a new 3.5GW_{DC} facility in Alabama, the firm has also embarked on a \$185m expansion of its existing manufacturing footprint in Ohio. First Solar has also announced an investment of up to \$370m for a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

www.matrixrenewables.com

All-MOCVD 980nm laser on (001) silicon

Continuous wave 980nm lasers grown on silicon by MOCVD show potential for application in optical fiber and IP network communication systems.

Hong Kong University of Science and Technology and the Chinese University of Hong Kong have reported continuous wave (CW) 980nm laser operation from structures grown on silicon (Si) by metal-organic chemical vapor deposition (MOCVD) [Qi Lin et al, Optics Express, v31, p15326, 2023]. The team used indium gallium arsenide phosphide (InGaAsP) layers for the quantum wells (QWs), and aluminium gallium arsenide (AlGaAs) for the barriers and cladding.

The researchers see the 980nm wavelength as having potential for optical fiber communication and internet protocol network systems. In particular, 980nm light can be used to pump erbium-doped fiber amplifiers (EDFAs).

The laser structure (Figure 1) was grown on (001) silicon, as used in mainstream complementary metal-oxide-semiconductor (CMOS) electronics manufacturing. The epitaxial growth was through MOCVD in

two reaction chambers for the GaAs template and for the laser structure.

The first growth was of the GaAs template layer, which included InGaAs/GaAs strained-layer superlattices (SLSs) to filter threading dislocations (TDs). Thermal cyclic annealing (TCA) was carried out before the SLS to improve the quality of the initial 1 μ m GaAs layer. The complete template layer was 2 μ m thick with the 2.8 $\times 10^7$ /cm² TD density.

The laser structure was grown in the second reaction chamber with strain-compensated InGaAs/GaAs/GaAsP quantum wells. The PL emission peak was at 956nm. A reference structure grown on GaAs substrate had a PL peak at the same wavelength.

The epitaxial material was fabricated into ridge-waveguide edge-emitting laser diodes (LDs). The n- and p-electrodes were titanium/platinum/gold and germanium/gold/nickel/gold, respectively. Passivation was provided by silicon dioxide. The material

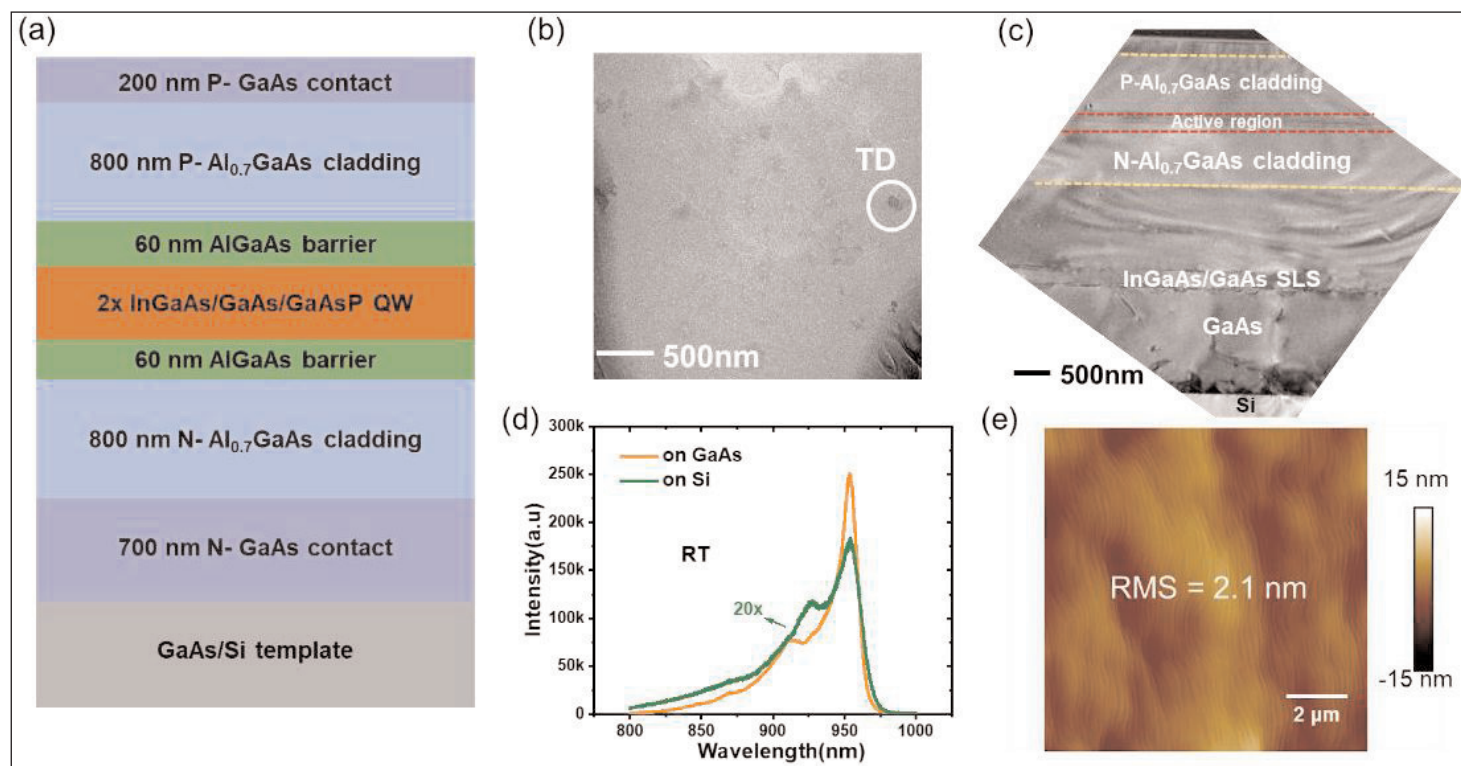


Figure 1. (a) Schematic of 980nm InGaAs/GaAs/GaAsP QW laser grown on GaAs/Si template; (b) Plan-view transmission electron microscope (TEM) images of 2 μ m-thick GaAs/Si template; (c) Global view cross-sectional TEM image of laser structure; (d) Room temperature (RT) μ -photoluminescence (PL) of structure; (e) Atomic force microscope image.

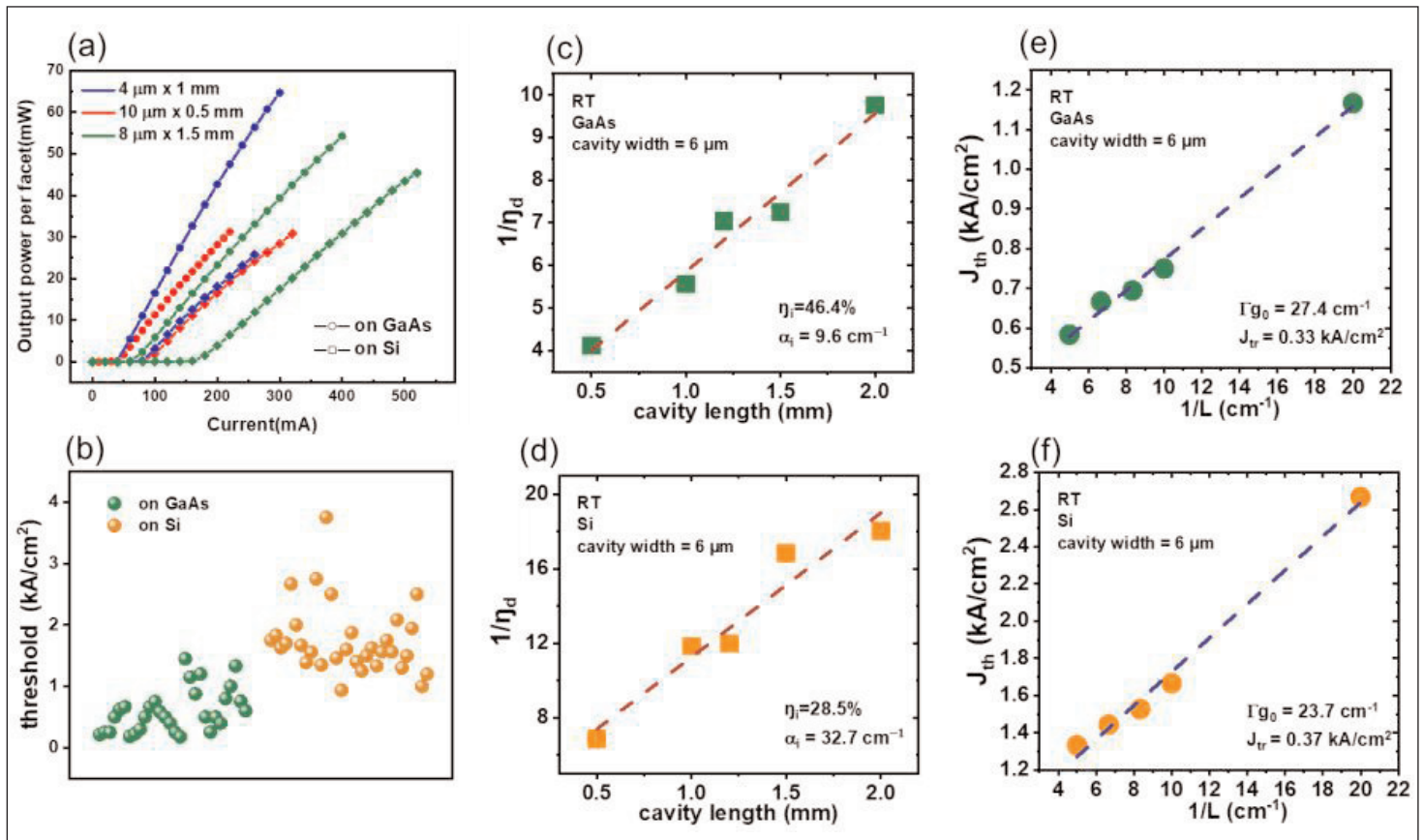


Figure 2. (a) Output power-current curves of InGaAs/GaAs/GaP QW lasers with various cavity size grown on GaAs and silicon; (b) threshold density distribution; extractions of (c) (d) internal quantum efficiency (IQE η_i), internal loss (α_i), (e) (f) modal gain (Γ_{g_0}) and transparency current density (J_{tr}), from cavity-length-dependent measurement.

was thinned to 100 μm and cleaved into laser bars without facet coatings. The CW measurements were made with the laser diodes mounted on temperature-controlled heatsinks.

The lowest lasing threshold current, 40 mA, was achieved on a 2 μm x 1 mm laser diode (Figure 2). The lowest threshold current density was 938 A/cm² on a 40 μm x 1.2 mm laser diode. This compares with a reference 70 μm x 2 mm device on GaAs that demonstrated a lower 179 A/cm² threshold.

The CW threshold on silicon is a little higher than the 867 A/cm² reported last year (see Semiconductor Today news, 2022) for a 980 nm laser diode on silicon grown by MOCVD (GaAs template) and molecular beam epitaxy (laser) at Beijing University of Posts and Telecommunications. The Beijing device was pretty short-lived at 12 minutes. The Hong Kong team does not report on the endurance of its laser diodes, although the Beijing life-time is considered “unacceptably short”.

The team comments: “Initial results show that the average threshold current density of the ridge-waveguide lasers on silicon (~1.91 kA/cm²), is approximately five times higher than devices on the native GaAs substrate (~410 A/cm²).”

The single-facet output power reached 46.4 mW on silicon, compared with 65 mW on GaAs substrate.

The greater spread in threshold current density and other laser diode performance limitations on silicon are tentatively attributed to the poorer quality of the GaAs template layer in comparison with what is achievable on native GaAs substrates. The poorer-quality template layer affects the QW uniformity, for example.

The researchers comment: “Based on the investigation of the internal parameters, a better laser performance with lower non-radiative losses can be achieved by further reducing the defects density of the GaAs film grown on silicon substrate via additional dislocation reduction approaches. In addition, laser performance improvement could also be achieved by enhancing the quality of QWs through optimization of parameters including the QW thickness and indium composition.”

The laser diodes on silicon were capable of lasing beyond the 95 °C limit of the measurement equipment. The characteristic temperature (T_0) scale for the shift to higher thresholds was 71.8 K, average. The T_0 for the reference devices on native GaAs was 139.1 K. The maximum values were 157 K (10 μm x 0.5 mm) and 84 K (2 μm x 1.5 mm) for laser diodes on GaAs and silicon, respectively. ■

<https://doi.org/10.1364/OE.484831>

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Author: Mike Cooke

InAs quantum dot lasers butt-coupled to SOI waveguides

Researchers claim the first monolithic epitaxial growth on SOI templates.

Researchers based in China claim the first demonstration of indium arsenide (InAs) quantum dot lasers epitaxially grown on trenched silicon-on-insulator (SOI) templates with butt-coupled silicon (Si) waveguides (WGs). [Wen-Qi Wei et al. *Light: Science & Applications*, v12, p84, 2023].

The team from Institute of Physics, Songshan Lake Materials Laboratory, Shanghai Jiao Tong University, and University of Chinese Academy of Sciences, comments: "Our results demonstrate that monolithic integration of III-V laser with silicon photonic components will no longer be a design-level hypothesis."

Efficient integration of a laser structure with low-cost silicon photonics is highly desirable for a wide range of advanced applications for on-chip optical interconnect and communications, along with integrated optical ranging, for system deployment in artificial intelligence, hyper-scale data centers, high-performance computing, LIDAR and microwave photonics.

The SOI wafer consisted of 220nm silicon on 3µm buried silicon dioxide (SiO₂). The wafer was patterned with a series of silicon waveguides with fork-shaped couplings to improve light energy transfer between the lasers and waveguides. The structures were covered

with 3µm plasma-enhanced chemical vapor deposition (PECVD) SiO₂ top cladding. A series of 16mmx16mm trenches for the lasers were then etched through to the substrate silicon with a 16% fill factor. The base of the lasers was also patterned with a grating.

The laser structures were grown (Figure 1) using a dual-chamber solid-source molecular beam-epitaxy (MBE) system to enable controlled growth of both silicon (group IV of the periodic table) and III-V materials.

The silicon growth created V-groove structures with (111) crystal facets on which the aluminium gallium arsenide (AlGaAs) III-V materials could be grown (Figure 2), avoiding defects such as anti-phase domains (APDs), threading dislocations (TDDs), and thermal-mismatch-induced thermal cracks. Further measures to reduce the effect of defects were applied in the buffer layer growth by including quantum well dislocation filters (DLFs) and superlattice (SL) layers.

After the MBE growth processes, the poly-crystalline residues outside the laser trench were removed with wet etching to enable accurate laser-waveguide alignment. The poly removal also partially etched the laser output facet, whose formation was completed with focused ion-beam (FIB) milling in two steps to give a

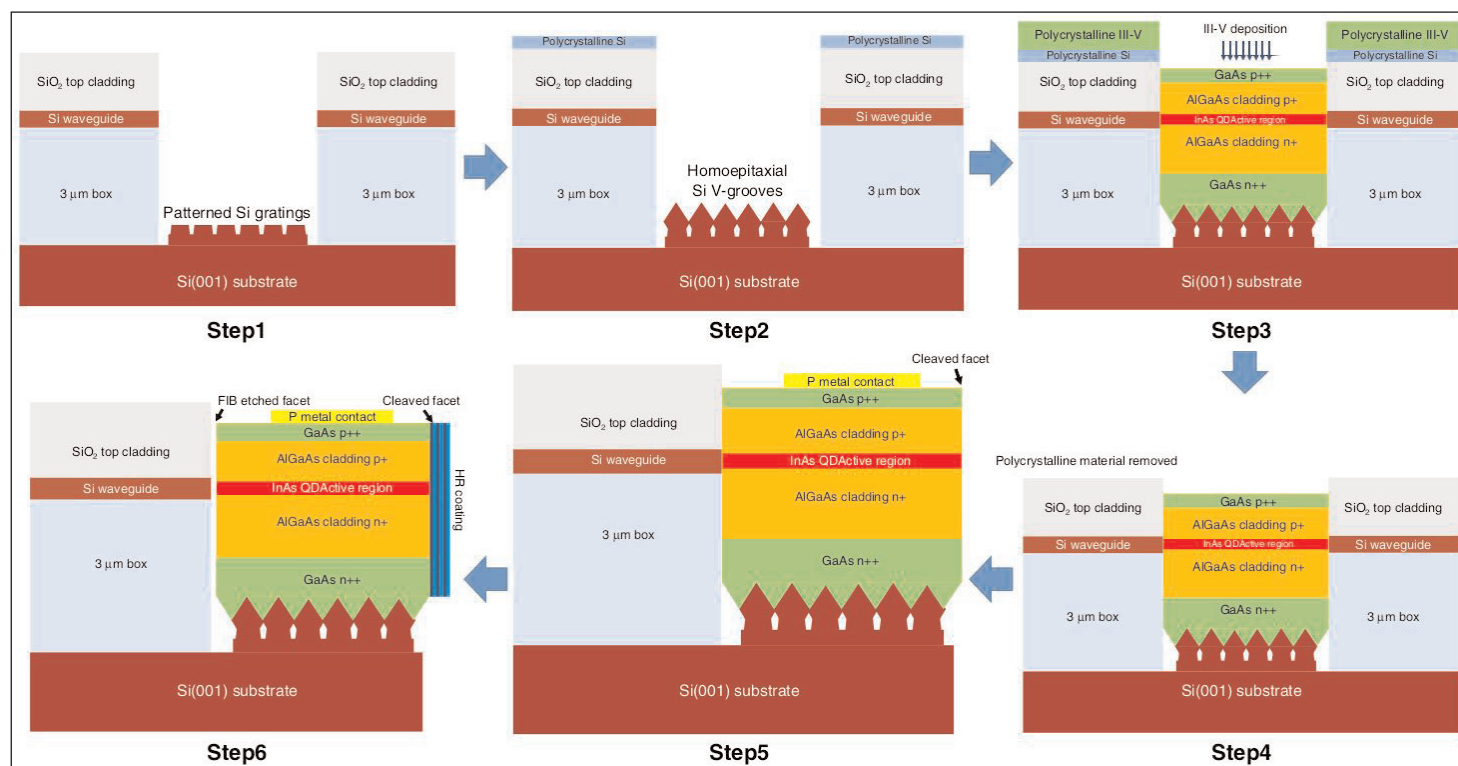
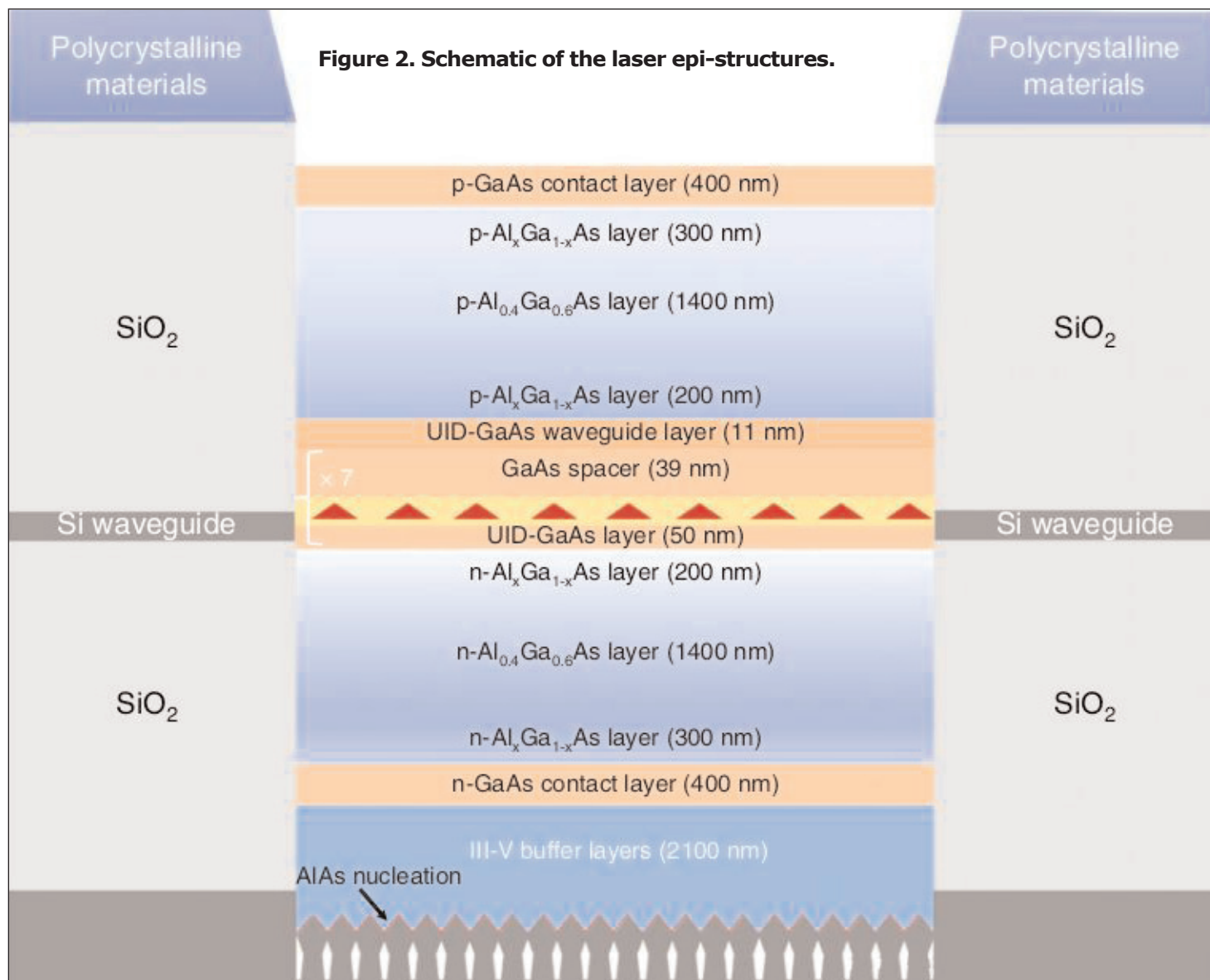


Figure 1. Schematic diagram of embedded laser process on trenched SOI.



very smooth surface. The coupling gap between the facets and waveguides was about 5 μ m.

The back facet was formed by wafer cleaving and application of a 95% high-reflection (HR) coating, consisting of 8 pairs of 145nm/228nm SiO₂/niobium pentoxide (Nb₂O₅) layers.

Photoluminescence experiments on the structure gave an O-band emission peak with 33nm full-width at half-maximum (FWHM). The researchers report that a similar structure grown on gallium arsenide (GaAs) substrate had a surprisingly wider 42nm FWHM. The peak intensity was "almost the same". The peak wavelengths for the trench template and GaAs substrate were 1293nm and 1278nm, respectively. The longer wavelength resulted from a 20°C lower growth temperature for the seven InAs quantum dot layer active light-generating region, relative to that for the structure on GaAs substrate.

The material was fabricated into 3mmx3 μ m ridge lasers. A reference device formed by cleaving the front and back facets achieved continuous wave (CW) lasing up to 95°C (Figure 3). At room temperature, the

threshold current was 50mA, and the maximum output power 37mW at 250mA. The slope efficiency was 0.148W/A.

Lasers coupled to the silicon waveguides had a higher CW threshold current of 65mA, and the maximum operating temperature was reduced to 85°C. The 20°C slope efficiency was 0.025W/A.

The researchers comment: "The relatively higher threshold current and lower maximum operation temperature are attributed to increased thermal accumulation inside the laser trench with surrounding BOX layer."

One effect of not polishing the output facet with FIB milling was to increase the threshold to 92mA. Also, the out-coupled optical power through the silicon waveguide was reduced to 5.3mW at 210mA, compared with 6.8mW for the FIB-milled lasers at the same injection.

The overall insertion loss of the laser coupling to the waveguide is estimated at -7.35dB, including 0.3dB from two 90° bends in, and 0.62dB from attenuation over the 814 μ m length of the waveguide. For pulse-mode operation, the loss was -7.6dB.

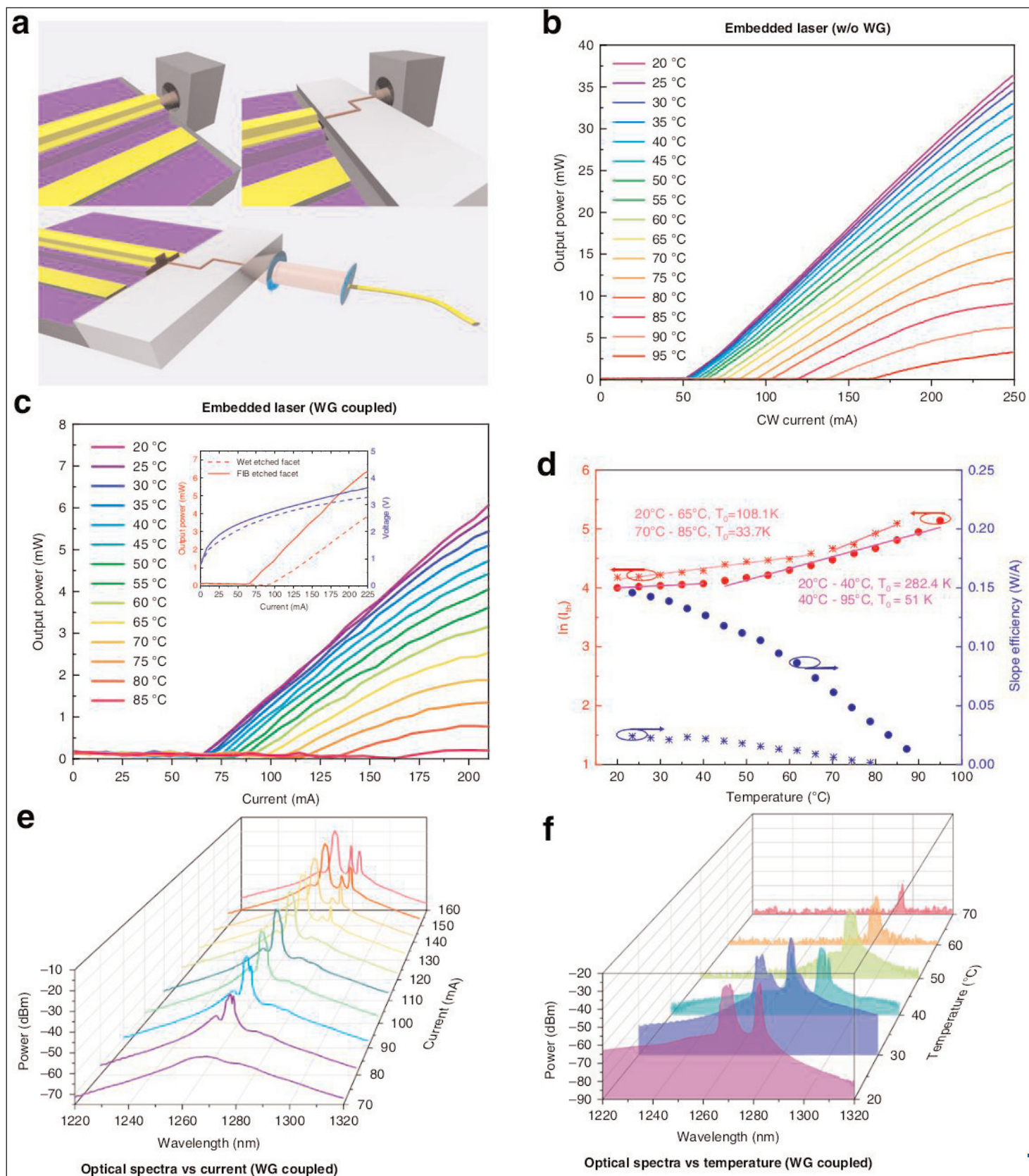


Figure 3. CW characterizations of embedded InAs QD laser on SOI with and without coupling into Si waveguide. a. Measurement schemes. b,c. Light output power vs CW current with and without waveguide coupling. d. Threshold current and slope efficiency vs temperature. e,f. Variations in spectra vs current and temperature.

The characteristic temperature for the increase in threshold current (T_0) of the reference device was 282K in the 20–40°C range, and 51K in the 45–95°C range. Coupled to the waveguides, T_0 reduced to 108K and

34K for 20–65°C and 70–85°C, respectively. ■ <https://doi.org/10.1038/s41377-023-01128-z>
 Author: Mike Cooke

InAs quantum dot lasers on silicon carbide substrate

Laser diodes show enhanced thermal stability with 221K characteristic temperature.

University of California Santa Barbara in the USA and King Abdullah University of Science and Technology in Saudi Arabia have reported enhanced thermal performance from an indium arsenide (InAs) quantum dot (QD) laser flip-chip bonded on silicon carbide (SiC), compared with silicon or other heterogeneous substrates [Roselyn Koscica, et al, Optics Letters, v48, p2539, 2023]. The laser diodes take advantage of the higher 4.9W/cm-K thermal conductivity of SiC at 300K, relieving thermal accumulation in the devices. Native gallium arsenide (GaAs) has a thermal conductivity of 0.55W/cm-K, and silicon has a thermal conductivity of 1.3W/cm-K.

Added interest comes from recent work on non-linear and quantum photonics on the SiC platform. The researchers point in particular to work suggesting that distributed feedback (DFB) could lead to direct on-chip

control over spin-defect quantum bits (qubits) in SiC-based quantum computers. The team comments: "With an optimized bonding procedure, the SiC platform will enable integration of III-V light sources with more technology-specific applications, such as DFB or comb lasers for telecommunications."

The team also points to advantages of enhanced thermal management for high-power-density optoelectronic systems combining lasers with high-performance application-specific integrated circuits (ASICs) consuming up to 200W. Laser performance tends to degrade at high temperature, with the threshold current increasing and eventually failing to lase at all.

The researchers used molecular beam epitaxy of varying layers of indium aluminium gallium arsenide (InAlGaAs) on (001) GaAs substrate for the III-V laser material targeting emissions from the center of the

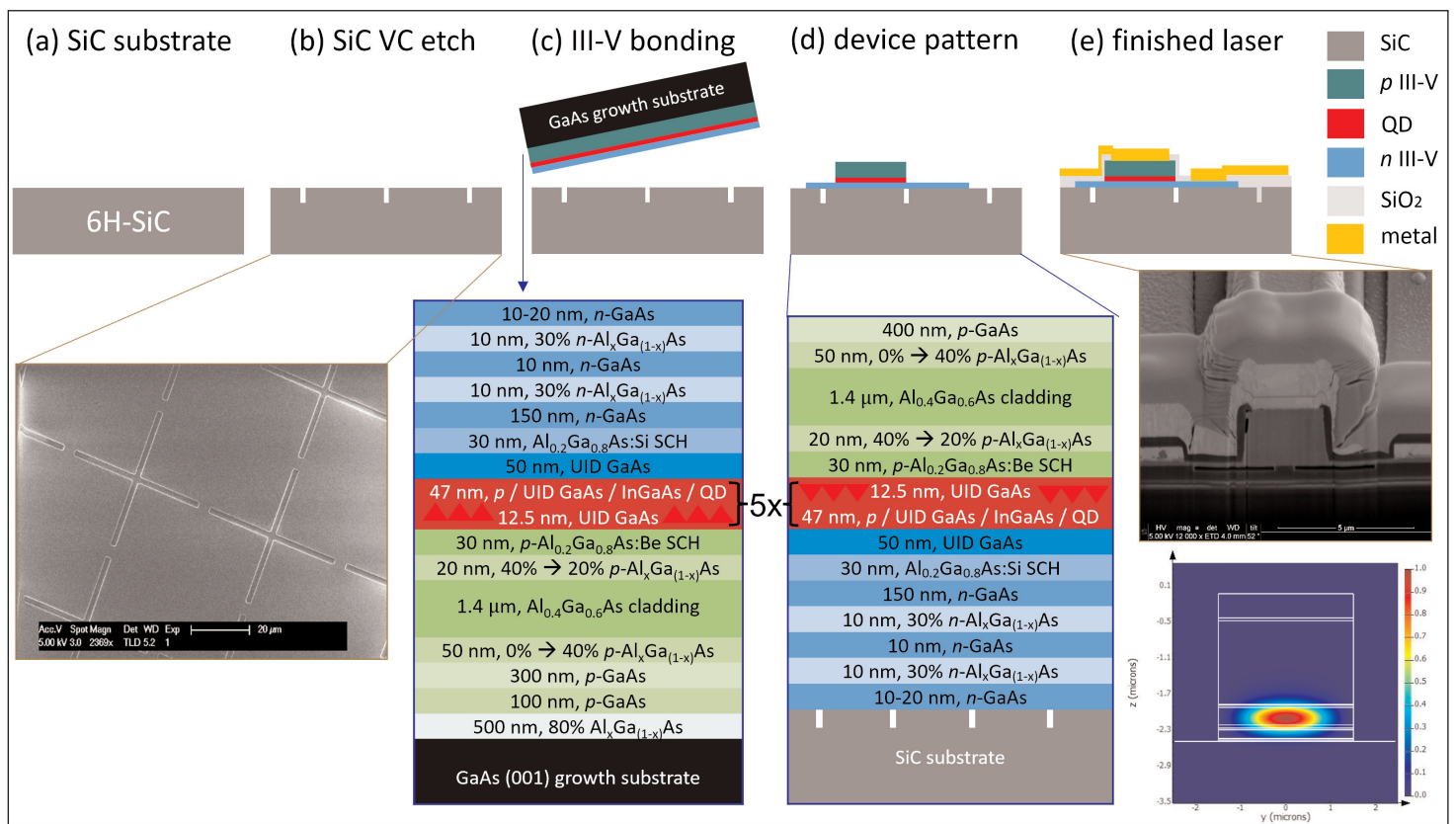


Figure 1. Device processing steps. (a) SiC substrate. (b) Substrate etched with vertical channels (VCs) before bonding, and scanning electron microscopy top view. (c) III-V laser stack epitaxially grown on native GaAs bonded to SiC substrate. (d) Device mesas defined and etched. (e) Cross-sectional schematic, scanning electron micrograph, and simulated normalized intensity profile of optical mode.

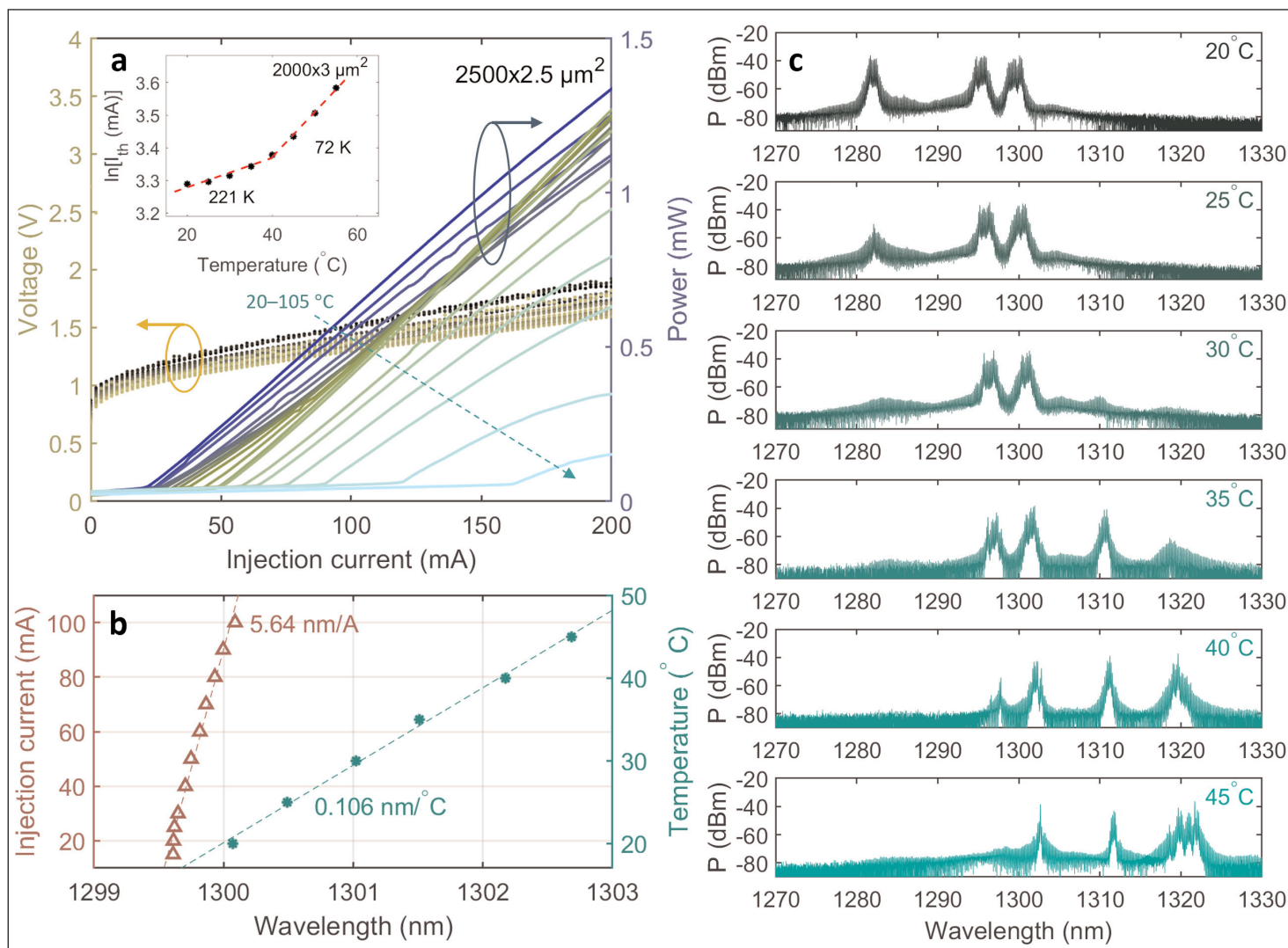


Figure 2. (a) Light-current-voltage (LIV) CW characteristics at stage temperatures from 20°C to 105°C. Inset: determination of 221K T_0 characteristic temperature from thermal increase in threshold current between 20°C and 40°C. (b) Thermal and injection current induced spectrum red-shift of ground-state peak in 1500µm x 3µm device held at either 20°C constant temperature or 100mA constant injection current. (c) Spectra under varied temperature for device in (b) under 100mA injection.

O-band (1260–1360nm), i.e. around 1300nm wavelength (Figure 1).

The device was fabricated on commercial 2-inch semi-insulating SiC. The substrate was vanadium-doped, giving a resistivity specification of more than $10^5\Omega\cdot\text{cm}$. The substrate was subjected to reactive-ion etching to create a perpendicular grid of vertical channels at 50µm pitch.

The laser material was flip-chip bonded onto the SiC substrate with a 3nm silicon dioxide interlayer. The structure was annealed at 100°C for 18–24 hours to relieve residual bonding stresses. The resulting III–V laser structure was tensile stressed at room temperature. Gases generated as a result of the bonding process could escape through the VC grid. The GaAs growth substrate and AlGaAs buffer were removed by polishing.

The device mesa fabrication resulted in p- and n-mesas from two dry-etch steps. The n-electrode metals were

palladium/germanium/gold/titanium; and for the p-contact was palladium/titanium/gold/palladium/titanium. The n-electrode was passivated with sputtered silicon dioxide before application of the p-contact. The structure was then rapid-thermal annealed at 300°C for a minute before application of another passivation layer, plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide. Titanium/gold was used for the probe contacts. The maximum temperature during device fabrication was 300°C, avoiding thermally induced strain or cracking of the bonded material.

Variouly sized Fabry–Perot laser bars were diced and polished from the fabricated material. The emission facets were as-etched with no coatings applied. The lowest threshold current density under continuous wave (CW) operation at 20°C was 233A/cm². The maximum output power reached 20mW.

A 2500µm x 3µm device achieved a wall-plug efficiency of 0.4% at 200mA injection (Figure 2). Above 105°C

the lasing mode disappeared. InAs QD lasers on native GaAs substrate have reached 220°C laser operation and 170K characteristic temperature.

The researchers comment: "Although the SiC laser maximum temperature is lower, owing to limited optical gain, the higher T_0 of 221K indicates reduction in temperature sensitivity compared with native GaAs and non-native silicon substrates."

For InAs QD lasers on silicon substrates the maximum temperature has reached 110°C and T_0 167K. The team expects future work to enhance the performance

on SiC substrates, as has been seen in work on silicon substrates.

Spectral analysis showed a ground-state laser peak around 1300nm, and a first excited state around 1295nm. The peaks shifted according to current injection and temperature. At 100mA injection, the thermal red-shift was 0.106nm/°C. At 20°C, the current red-shift was 5.64nm/A. ■

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Record sub-micron LED red emission efficiency

Device external quantum efficiency reaches 8.3% at 1A/cm² injection.

University of Michigan in the USA claims record efficiencies from red-emitting sub-micrometer light-emitting diodes (LEDs) [Ayush Pandey et al, Appl. Phys. Lett., v122, p151103, 2023]. Some of the intellectual property arising from the work has been licensed to NS Nanotech Inc, co-founded by one of the paper's authors, Zetian Mi. The company has in return funded some of the research.

Micron-scale LEDs are of particular interest for more efficient and versatile display technologies. The red sector of the visible part of the spectrum has been a particular roadblock, with conventional devices suffering poor performance in micron-scale form factors.

Although millimeter-scale III-nitride LEDs based on indium gallium nitride (InGaN) LEDs have very poor performance for red emission, the impact of scaling to the micron-scale is less marked, and in some respects offers enhanced operation compared with conventional devices.

The team reports (Figure 1): "By optimizing the p-type doping, a peak external quantum efficiency (EQE) of ~8.3% was measured for a sub-micrometer LED with an area of ~750x750nm², which is the highest value reported for a red-emitting LED with lateral dimensions around 1µm, or less to our knowledge."

The nanowires were formed by selective area growth (SAG) on N-polar GaN-on-sapphire templates, using a titanium mask (Figure 2). The team comments on the use of nanowire structuring: "The use of nanostructures offers several critical advantages, including significantly enhanced Mg dopant incorporation due to the efficient strain relaxation and the use of N-rich epitaxy conditions to suppress the formation of N-vacancy related defects."

The initial ~500nm silicon-doped n-GaN layer was grown at 960°C. The strain-relaxer short-period superlattice (SPSL) consisted of four 8nm/8nm InGaN/GaN pairs, grown at a reduced temperature.

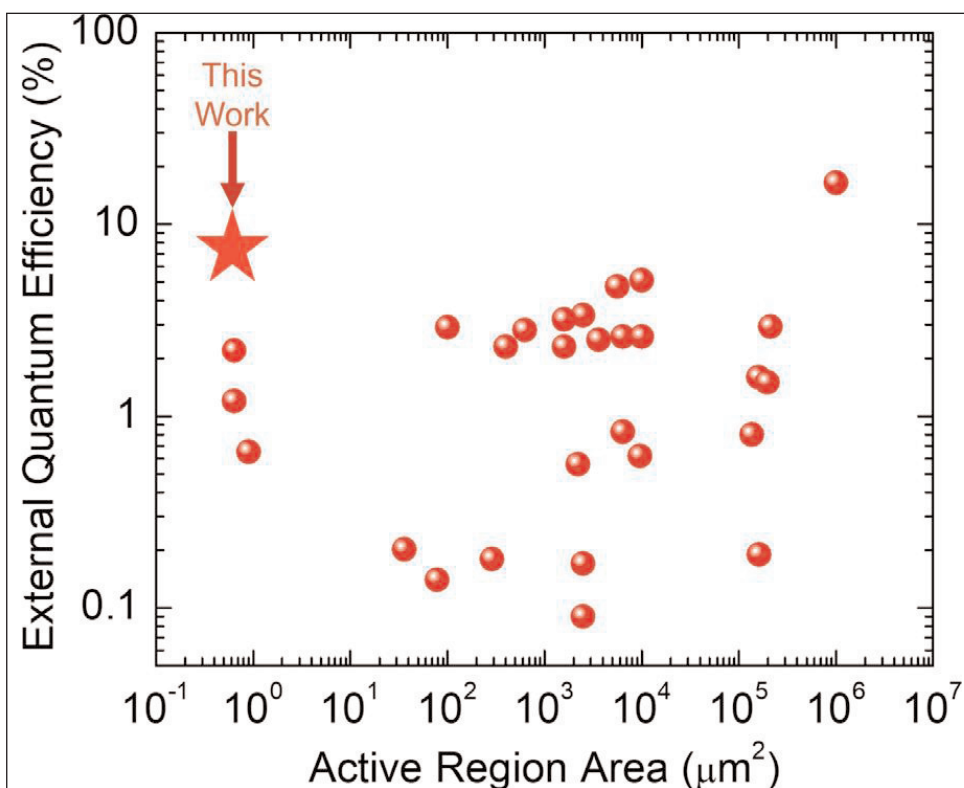


Figure 1. Variations of peak EQE with device active region area for reported red-emitting InGaN LEDs with emission peak more than 600nm.

The 15nm active region consisted of high-indium-content InGaN, grown at a lower temperature than the SPSL. The researchers comment: "We have previously shown that such an InGaN active region exhibits compositional inhomogeneity due to the effects of composition pulling and the diffusion of indium during the growth of high-temperature layers."

The final magnesium (Mg)-doped p-GaN layer was grown at a higher temperature than the active region. The tops of the nanowires were relatively flat, unlike in Ga-polar growth where the final p-GaN tends to have a rough surface, and other unwanted effects.

Red PL emission was achieved by adding an InGaN quantum dot section to the active region. The photoluminescence was multi-peaked due to indium content inhomogeneity and Fabry-Pérot interference effects between partially reflected light waves. Without the dot the dominant emission was in the green part of the visible spectrum.

Micro-LEDs were fabricated, beginning with 65nm

atomic layer deposition (ALD) aluminium oxide for passivation and surface repair. Plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide was added after etching back the passivation to expose the p-GaN of the nanowires. A 750nm x 750nm via was etched to give the micro-LED device area. The n-contact was titanium/gold. The p-contact consisted of nickel, gold and indium tin oxide (ITO) transparent conductor for current spreading.

The final step was application of a

reflection layer to increase light emission from the sapphire substrate side of the device. The reflector consisted of silver, titanium, aluminium, nickel and gold layers.

The researchers compared devices with different Mg concentrations in the p-GaN layer of the nanowires, as measured by the beam-equivalent pressure supplied to the growth process. A high Mg concentration was given by a pressure of 5×10^{-8} Torr, giving the material for device 'A'. A non-optimized, low-Mg-content device 'B' resulted from 5×10^{-9} Torr pressure. Higher Mg concentrations than that used for device A tended to give "degradation of nanowire morphology".

Device B showed its poorer performance in high

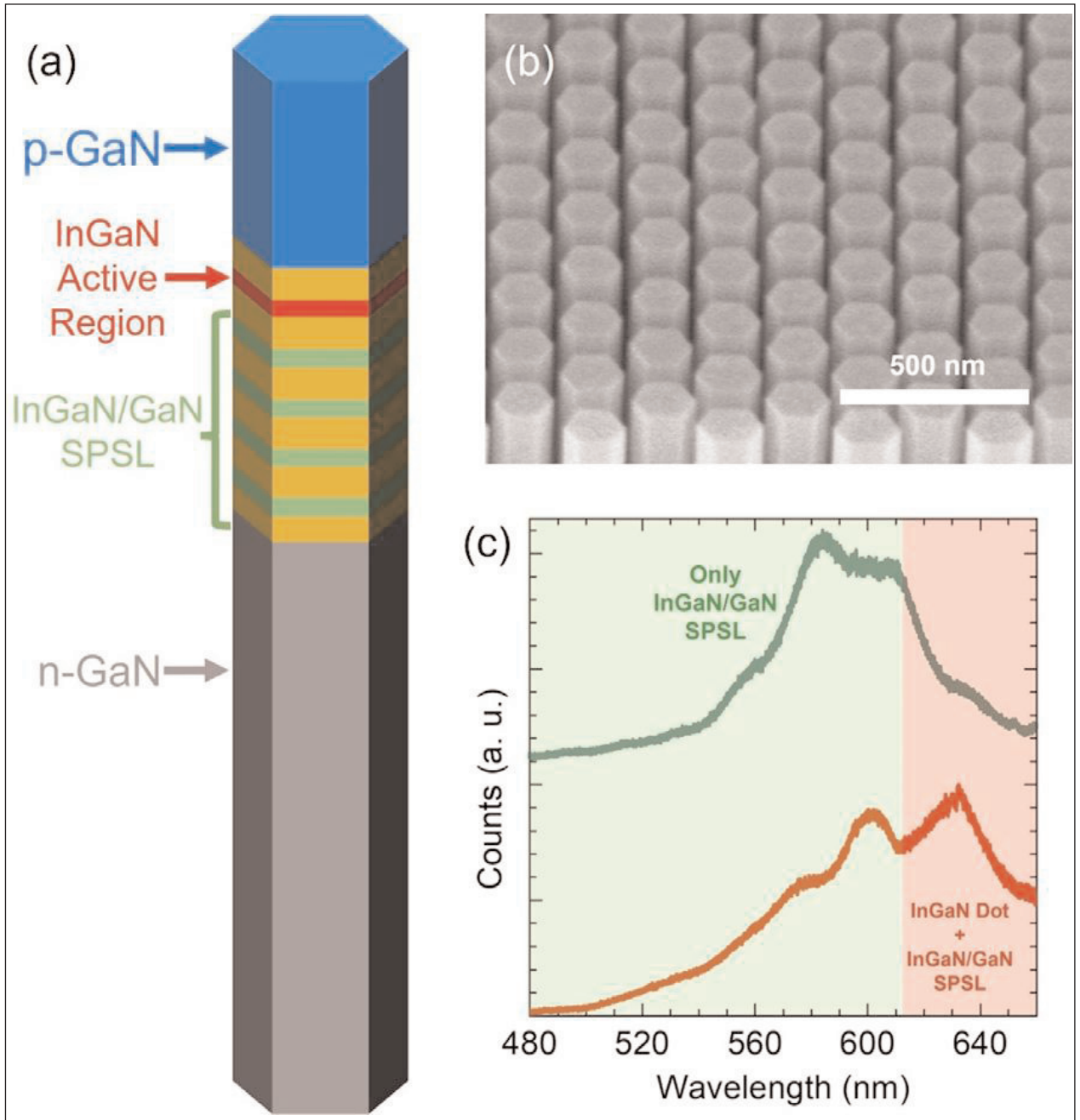


Figure 2. (a) Schematic of N-polar InGaN/GaN nanowire LED heterostructure. (b) Scanning electron microscope image of N-polar nanowire array. (c) Photoluminescence (PL) spectra of nanowires grown with and without InGaN dot, showing red emission from InGaN dot.

current leakage in both forward and reverse bias, and hence lower light output. Device A achieved a peak external quantum efficiency (EQE) of 8.3% when the current density was 1 A/cm^2 . The output power density at this point was 15 mW/cm^2 , sufficient for display applications, according to the team. The light detector was mounted on the micro-LED with an index-matching fluid.

The researchers comment: "Typical high-efficiency organic LEDs, which have been adopted in displays, reach their peak efficiency at lower currents (of the mA/cm^2 order), so the micro-LEDs described here would still have significantly improved brightness as compared to them."

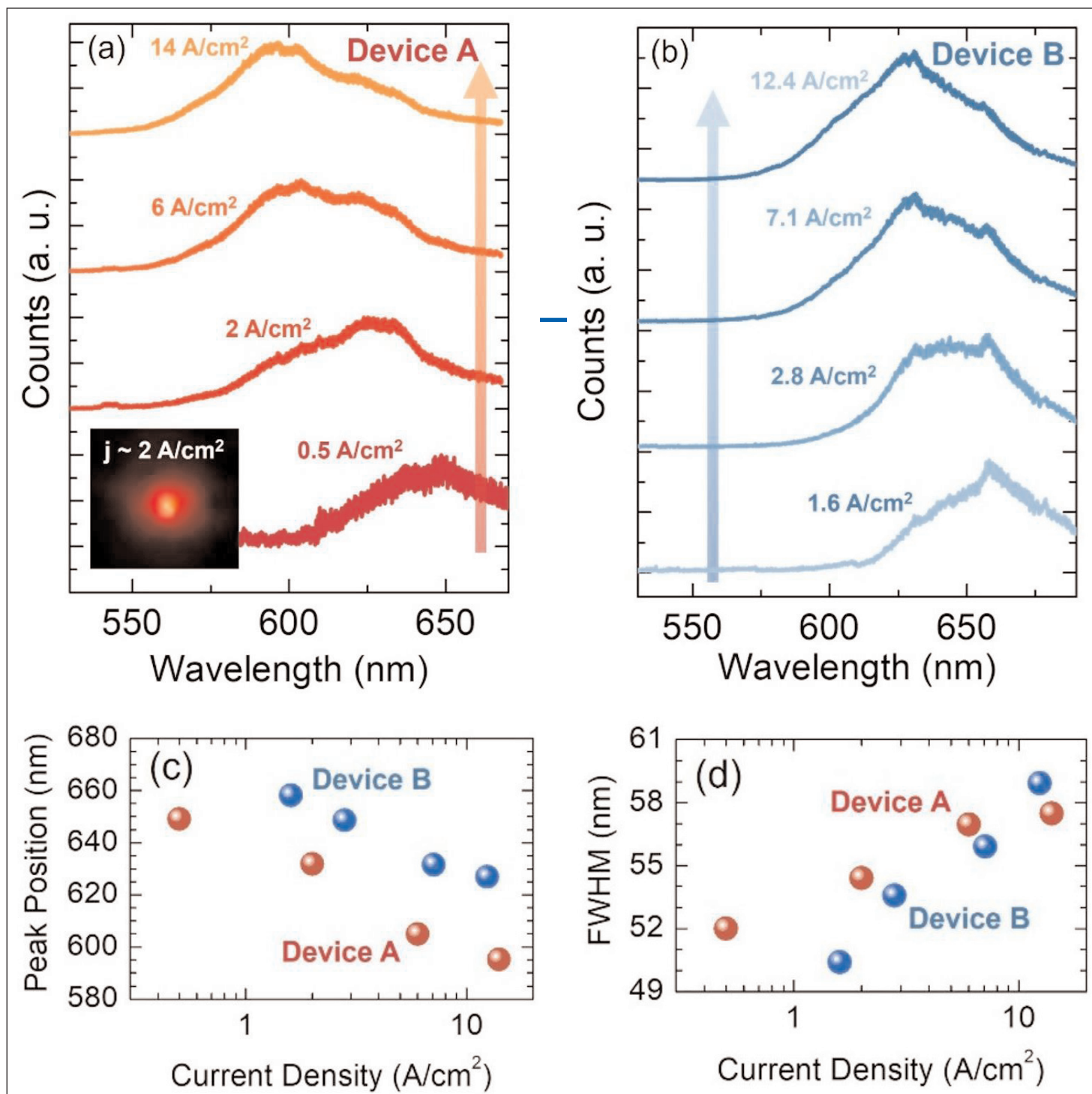


Figure 3. Electroluminescence (EL) spectra with various injection currents for devices (a) A and (b) B. Inset: (a) image of device under operation. (c) Peak position and (d) full-width at half-maximum (FWHM) versus current density.

The team credits “improved hole injection into the device active region, relatively low electron overflow and reduced current leakage” for the improved performance of LED A.

The spectral output (Figure 3) of device A peaked at 650nm, deep red, for an injection of 0.5A/cm². There is significant blue-shift, but the emissions remain in the red sector of the spectrum, greater than 600nm wavelength, up to 10A/cm² injection.

The team comments: “The strong blue-shift at higher

injection currents is likely a combination of the quantum-confined Stark effect (QCSE), as well as from the increased contribution of the SPSL in device emission. The QCSE can be potentially addressed through approaches such as strain engineering, polarization doping, or by creating an external optical cavity.” ■

<https://doi.org/10.1063/5.0129234>

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Emerging substrates market growing at 27% CAGR to over \$264m by 2028

SiC & GaN will comprise 25% of the power electronics market by 2028, says Yole.

Due to the need to improve the performance and the cost limits, new materials, platforms and designs are continually being investigated in the semiconductor industry. In the previous decade, some compound semiconductors, such as gallium arsenide (GaAs) for radio frequency (RF) and silicon carbide (SiC) for power electronics, have succeeded in competing with silicon and have entered the mass market.

So, which emerging semiconductor substrate will be the next game changer? In its new report 'Emerging Semiconductor Substrates 2023', Yole Intelligence (part of Yole Group) investigates the technological status of emerging semiconductor substrates, including gallium antimonide (GaSb), indium antimonide (InSb), bulk gallium nitride (GaN), gallium oxide (Ga_2O_3), bulk aluminium nitride (AlN), and diamond, as well as engineered substrates and templates. Furthermore, the market research and strategy consulting company examines various potential applications such as power electronics, RF and photonics, including laser diodes, light-emitting diodes (LEDs), sensors, and detectors.

Including GaSb, InSb, bulk GaN, Ga_2O_3 , bulk AlN, and diamond, as well as engineered substrates and templates, the emerging substrates market was valued at \$63.6m in 2022 is estimated to be growing at a CAGR of 27% to more than \$264.5m by 2028.

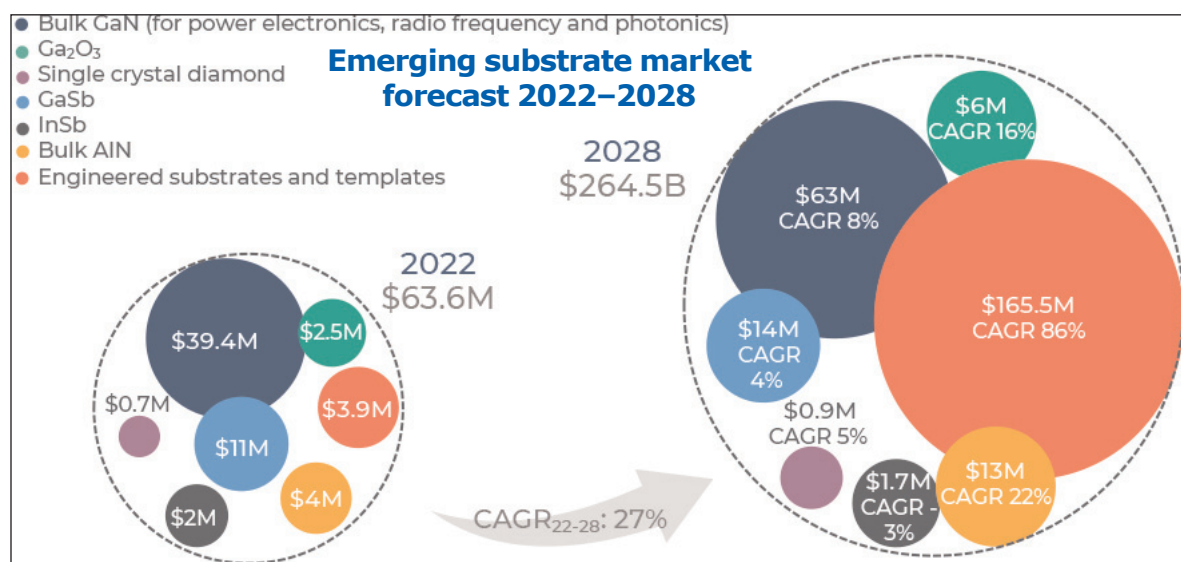
"The power electronics market, driven by several applications such as EV/HEV (electric and hybrid electric vehicles), renewable energy, and power supplies, is still dominated by silicon-based technologies," notes Taha Ayari Ph.D., technology & market analyst, Compound Semiconductor and Emerging Substrates, at Yole Intelligence. "Nevertheless, the wide-bandgap materials SiC and GaN (lateral GaN HEMT on silicon or sapphire)

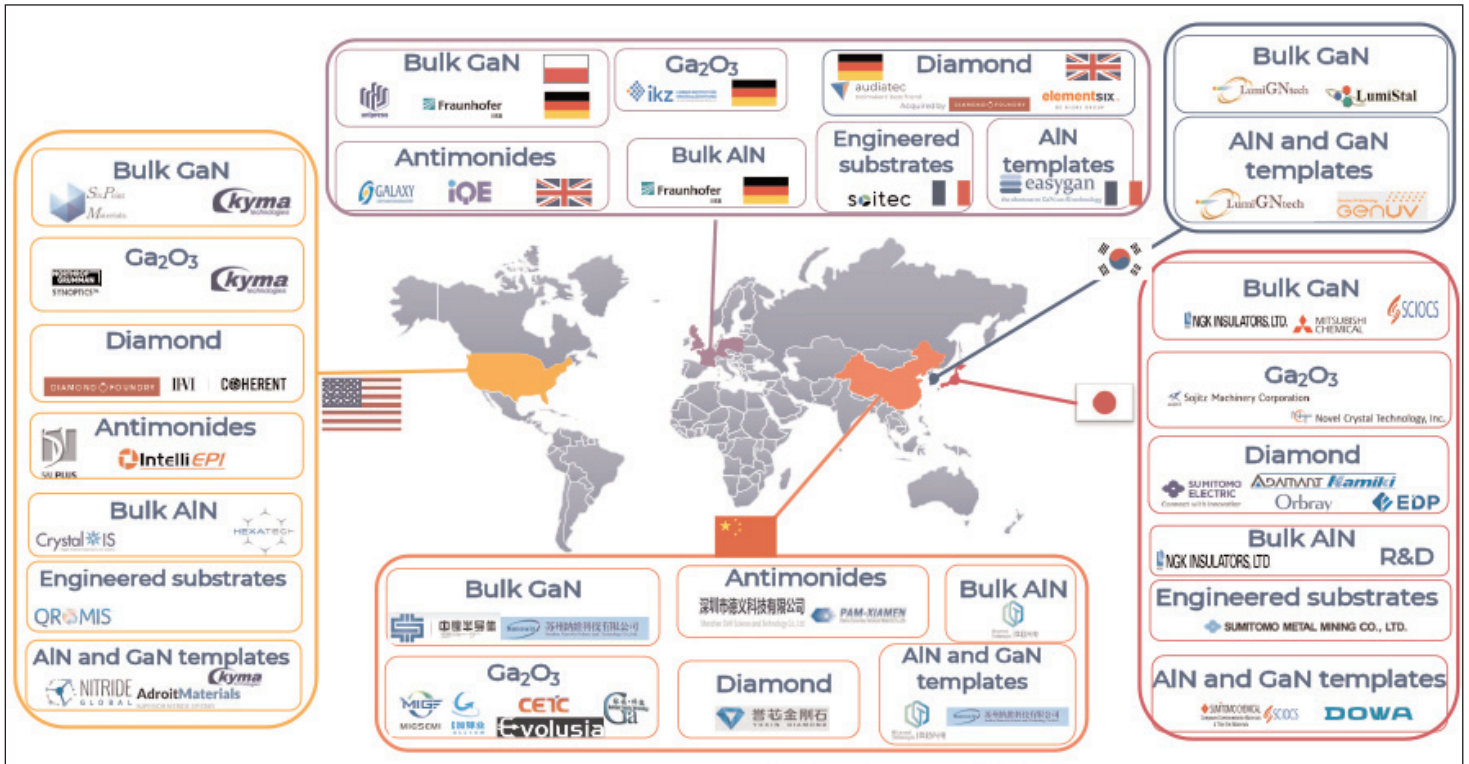
have penetrated the power electronics market after a long development process and are expected to constitute more than 25% of the power electronics market by 2028," he adds. "Benefitting from this momentum, Yole Intelligence expects bulk GaN for vertical GaN devices and engineered substrates (SmartSiC from Soitec, SiCkrest from SICOXS, and QST from Qromis) to grow in the coming five years."

The photonics market, on the other hand, enjoys stable growth with GaSb-based devices such as infrared (IR) lasers and imagers driven mainly by high-end and niche military applications. The report also reviews the market status of InSb.

Concerning bulk GaN substrates in consumer, industrial and automotive applications, the market is considered to be stable, with a stronger push into industrial applications. During the pandemic, UVC disinfection/purification systems started using bulk AlN substrates. This could drive the AlN substrate market to a compound annual growth rate (CAGR) during 2022–2028 of 22%, the highest among all the emerging photonics substrates.

"Emerging substrate activities focus mainly on technological development for better material quality, higher yields and lower production costs," notes Ali Jaffal Ph.D., technology & market analyst specializing in Compound Semiconductors and Emerging Substrates at Yole Intelligence. "This push needs, of course, to be





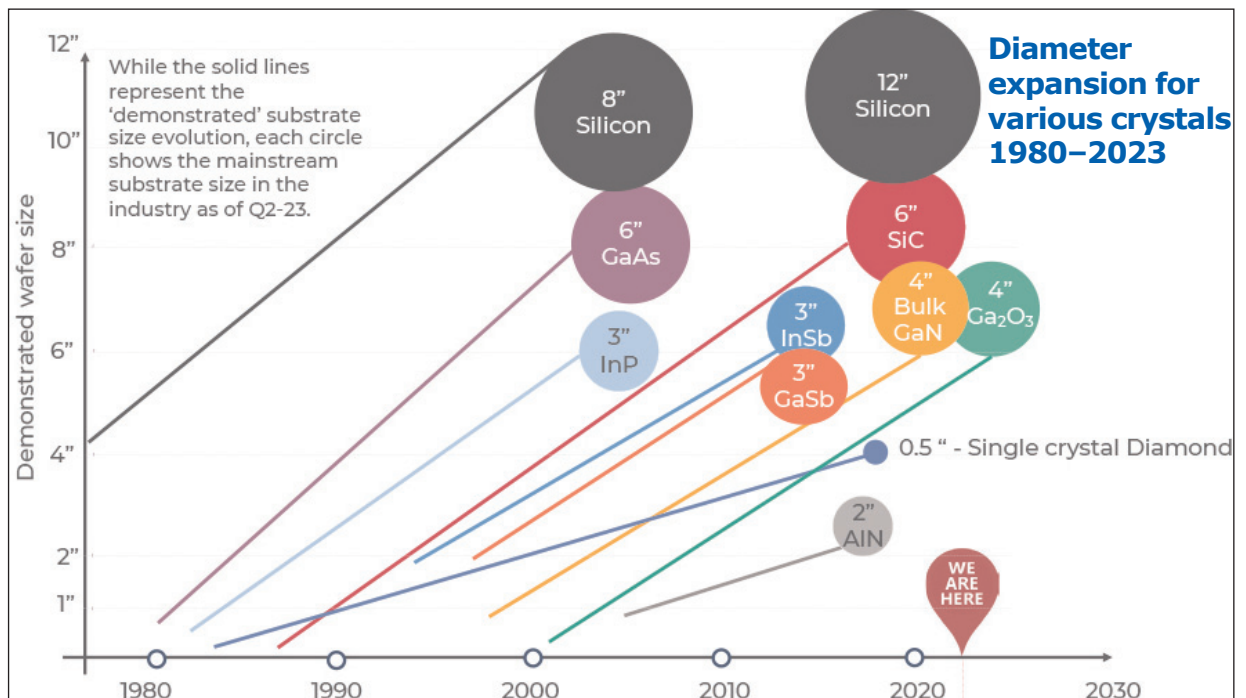
Geographical location of emerging substrate players.

supported by market demand and adoption in volume applications which defines the correct specification of the different substrates. This comes together with increasing the substrate diameter, which gives the impetus to emerging substrates industry to go towards mass production."

For the power electronics industry, a wafer size of at least 6-inches is needed for established foundries to be involved at high volumes. This pushes the substrate players to optimize the manufacturing techniques and to increase the wafer sizes. For diamond, the mosaic diamond method from etch pitch density (EDP) that delivers up to 28mm x 28mm and heterogeneous diamond growth on silicon or sapphire substrates from Orbray or Audiatec up to about 6-inch diameter have been developed. In addition, 6-inch bulk GaN substrates have been demonstrated using hydride vapor

phase epitaxy (HVPE) and other techniques, although more work is still needed to improve the material quality and meet application requirements. Similarly, for Ga₂O₃, different melt growth techniques are being used, with EFG (edge-defined film-fed growth) being the most promising to obtain 6-inch wafers with acceptable material quality in volume production. Regarding engineered substrates, advanced splitting and bonding techniques are used to overcome challenges for larger single-crystal substrates and better material quality. ■

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Mitsubishi Electric develops SBD-embedded SiC-MOSFET with new structure for power modules

A new chip structure prevents surge-current crowding in specific chips.

During the 35th International Symposium on Power Semiconductor Devices and ICs (ISPSD 2023) in Hong Kong (28 May–1 June), Tokyo-based Mitsubishi Electric Corp has developed a new structure for a silicon carbide metal-oxide-semiconductor field-effect transistor (SiC-MOSFET) embedded with a Schottky barrier diode (SBD), which it has applied in the FMF 800 DC-66 BEW 3.3kV full-SiC power module for large industrial equipment such as railways and DC power systems. Samples began shipping on 31 May. The chip's new structure is expected to help to downsize railway traction systems etc, as well as to make them more energy efficient, and contribute to carbon neutrality through the increased adoption of DC power transmission.

SiC power semiconductors are attracting attention due to their capacity to significantly reduce power loss.

Mitsubishi Electric, which commercialized SiC power modules equipped with SiC-MOSFETs and SiC-SBDs in 2010, has adopted SiC power semiconductors for a variety of inverter systems, including air conditioners and railways.

Compared with the conventional method of using separate chips, a chip that integrates a SiC-MOSFET and a SiC-SBD can be mounted in a module more compactly, enabling smaller modules, larger capacity and lower switching loss. It is expected to be widely used in large industrial equipment such as railways and electric power systems. Until now, the practical application of power modules with SBD-embedded SiC-MOSFETs has been difficult due to their relatively low surge-current capability, which results in the thermal destruction of the chips during surge-current events because surge currents in connected circuits concen-

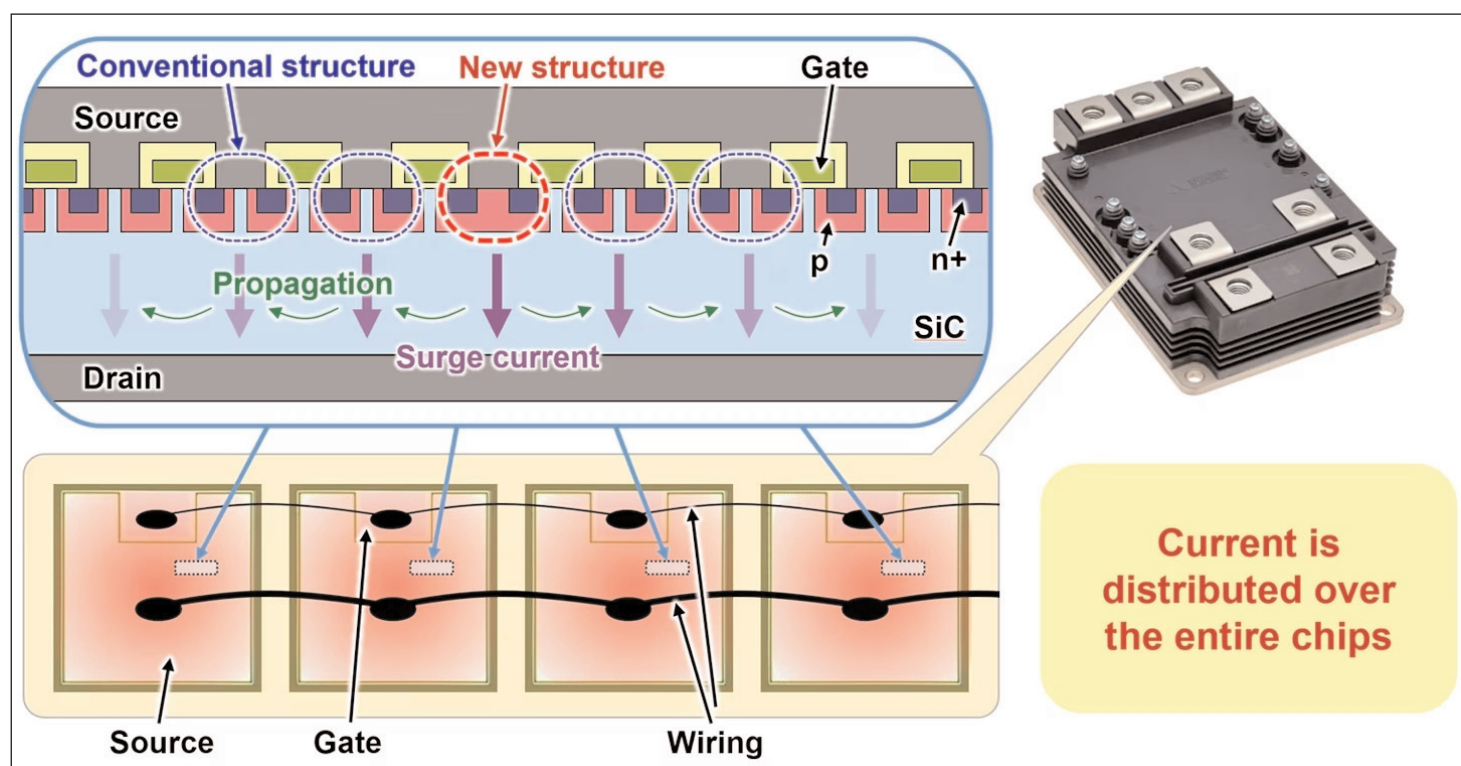


Figure 1. Newly developed chip structure (top: chip section; bottom: parallel-connected chips).

trate only in specific chips.

Mitsubishi Electric has now developed what it claims is the first mechanism by which surge current concentrates on a specific chip in a parallel-connected chip structure inside a power module, and a new chip structure in which all chips start energizing simultaneously so that surge current is distributed throughout each chip. As a result, the power module's surge-current capacity has been improved by a factor of five or more compared with the firm's existing technology, which is equal to

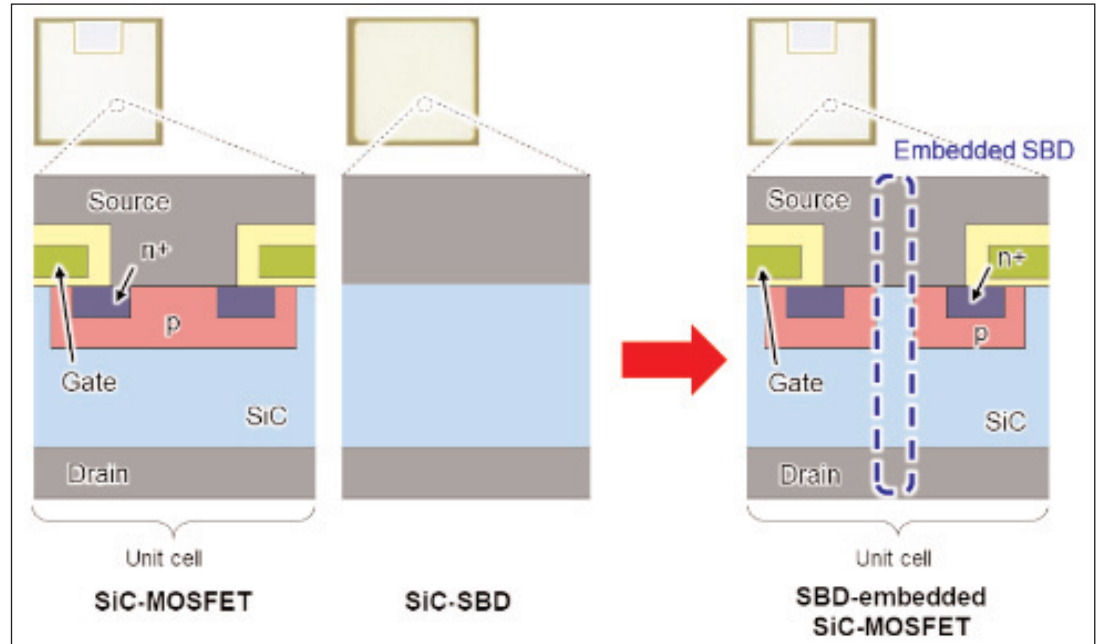


Figure 2. SBD-embedded SiC-MOSFET integrating a SiC MOSFET and a SiC SBD.

SBD-embedded MOSFET

In conventional SiC power modules, SiC-MOSFETs are used for switching and SiC-SBDs are used for rectifying, with the two separately manufactured chips being connected in parallel. Conversely, Mitsubishi Electric's SBD-embedded SiC-MOSFET (Figure 2) integrates the two chips by periodically forming the SiCSBD in the SiC-MOSFET unit cell.

Technology based on confirmation of reason for surge current on single chips

Conventionally, when surge current flows through multiple SBD-embedded MOSFET chips connected in parallel, the surge current is concentrated only on a specific chip, preventing the surge current withstand capability corresponding to the number of parallel chips from being obtained. Physical and device simulation analyses have now revealed that surge current is concentrated on a specific chip if the dimensions of that chip's built-in SBD vary even slightly from other chips, which is not uncommon, causing that specific chip to initiate a

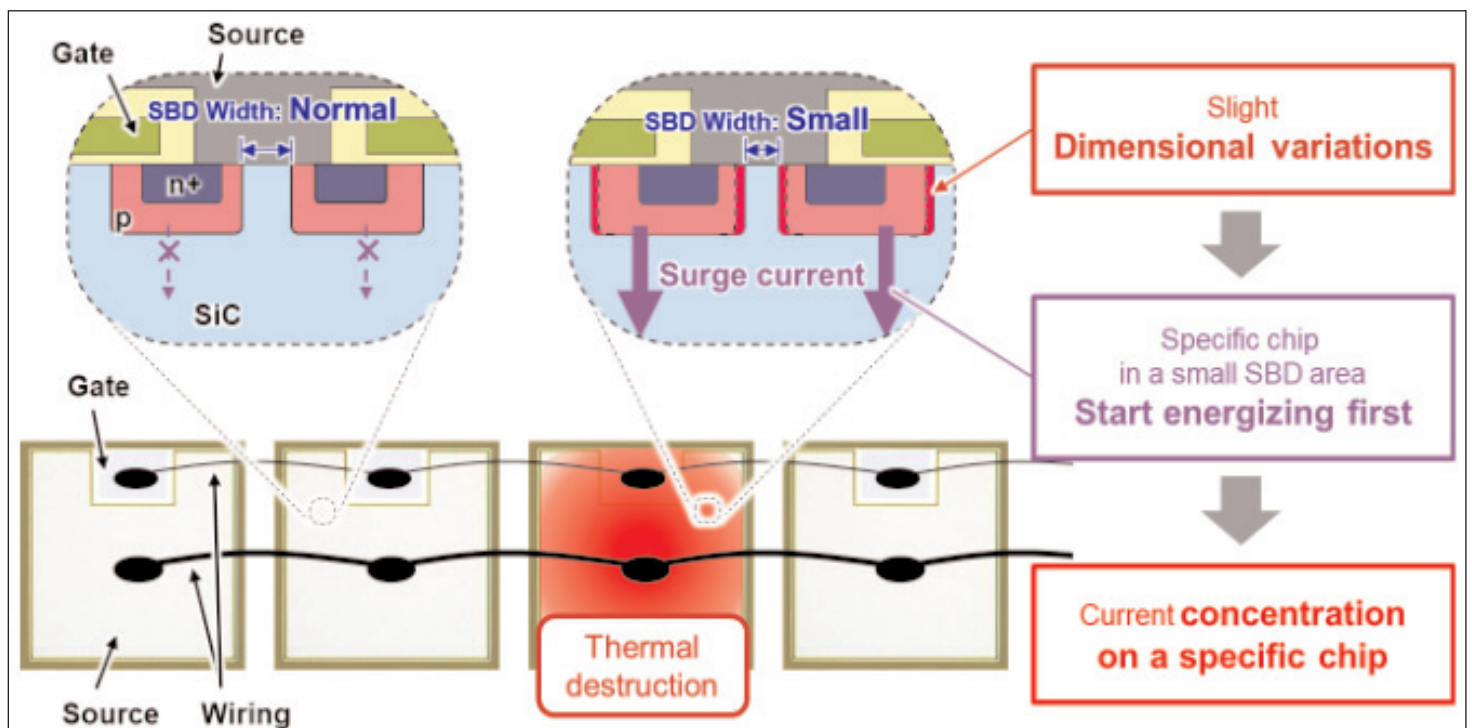


Figure 3. Conventional current-concentration mechanism on a specific chip.

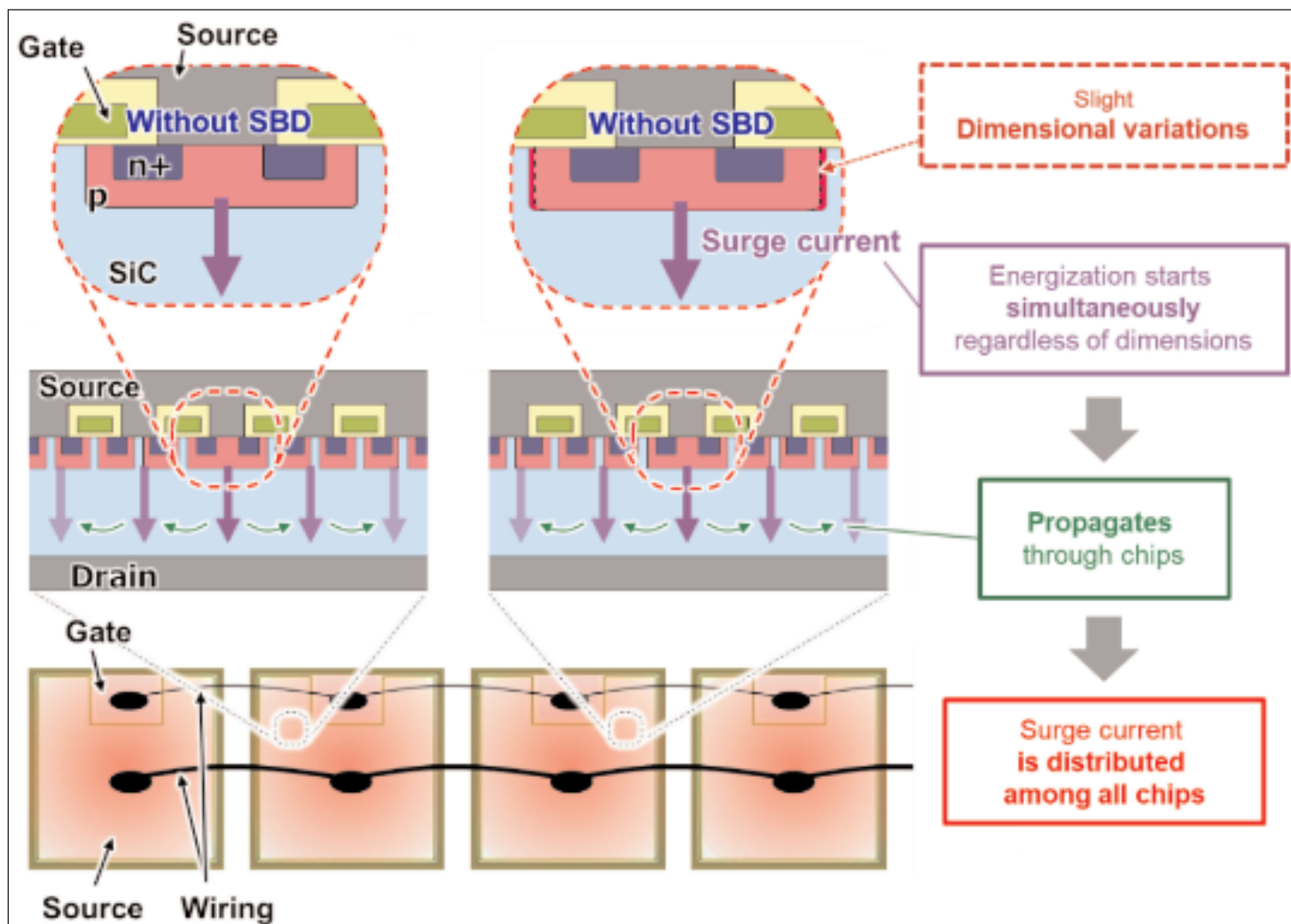


Figure 4. New structure avoids current concentration on a specific chip.

surge current flow before the other chips (Figure 3). Since the size variation needs only be extremely minor, such variations are basically impossible to avoid in normal chip manufacturing processes.

New chip structure simultaneously energizes all chips connected in parallel

To prevent surge current from concentrating on specific chips, Mitsubishi Electric has developed a new chip structure in which the built-in SBD is not placed in a unit cell that occupies less than 1% of the total chip area. This unit cell has a structure that allows surge current to flow faster than other unit cells with SBDs, and is unaffected by dimensional variations due to the absence of SBDs. Therefore, surge current can start energizing simultaneously in the corresponding unit cells of all chips without SBDs. In addition, because the surge current reduces resistance of the surrounding SiC, the energizing of the surge current is also triggered in the surrounding unit cells where the surge current is energized, in a chain reaction. This phenomenon causes surge current to propagate throughout the entire chip area, starting from the unit cell where the SBD is not present. Consequently, surge current is distributed over all areas of all

chips, preventing thermal breakdown of the chip due to the concentration of surge currents on a particular chip, thereby increasing the surge current withstand capability (Figure 4).

Improved surge current capability enables SBD-embedded SiC-MOSFET power module

Using the new chip structure, the surge current capability of the SBD-embedded SiC-MOSFET in parallel connection has been improved by more than five times compared with the firm's existing technology, which is equal to or greater than that of widely used conventional silicon power modules.

Also, because of the chain reaction of surge current, a small portion (less than 1%) of the total chip area is sufficient for a unit cell without the built-in SBD, and there is no effect on power module characteristics such as low ON-resistance and low switching loss due to the reduced area of the built-in SBD. As a result, chips can be connected in parallel, a requirement for power modules intended for high-power applications such as railways and electric power systems, thus allowing SBD-embedded SiC-MOSFET to be used in power modules. ■

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CEA-Leti proof of concept demonstrates higher electron mobility in GeSn than in silicon or germanium

Vertical GeSn transistors may enable low-power, high-performance chips and quantum computers.

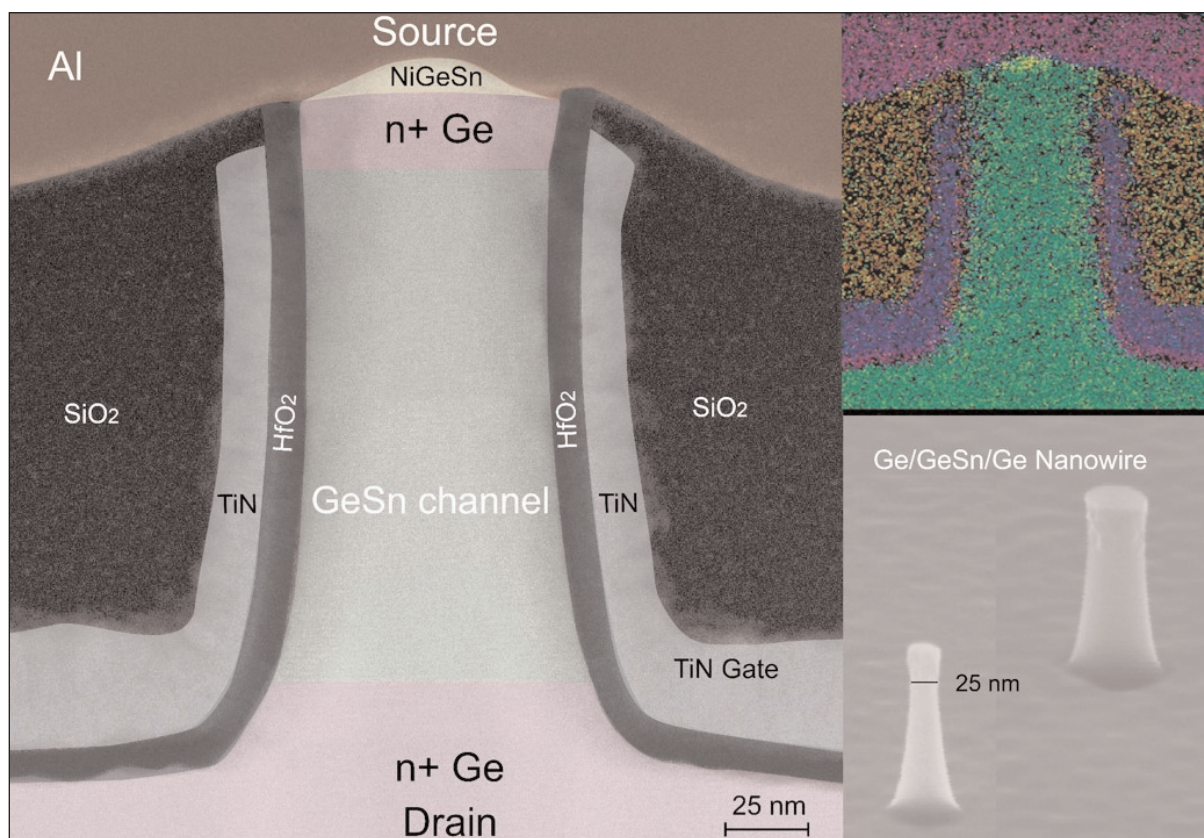
Micro/nanotechnology R&D center CEA-Leti of Grenoble, France has demonstrated that electrons and other charge carriers can move faster in germanium tin than in silicon or germanium, enabling lower operation voltages and smaller footprints in vertical devices than in planar devices. This proof-of-concept means that vertical transistors made of germanium tin are promising candidates for future low-power, high-performance chips and possibly quantum computers.

Germanium-tin transistors have an electron mobility that is 2.5 times higher than a comparable transistor made of pure germanium. GeSn is otherwise compatible with existing CMOS chip fabrication processes. Because both germanium and tin come from the same group of the periodic table as silicon, these transistors could be integrated directly into conventional silicon chips with existing production lines.

The paper 'Vertical GeSn Nanowire MOSFETs for CMOS Beyond Silicon' (Mingshan Liu et al, Nature Communications

Engineering volume 2, article number 7 (2023)) notes that "GeSn alloys offer a tunable energy bandgap by varying the Sn content and adjustable band off-sets in epitaxial heterostructures with Ge and SiGe. In fact, a recent report has shown that the use of $\text{Ge}_{0.92}\text{Sn}_{0.08}$ as source on top of Ge nanowires (NWs) enhances the p-MOSFET performances."

"In addition to their unprecedented electro-optical properties, a major advantage of GeSn binaries is also that they can be grown in the same epitaxy reactors as Si and SiGe alloys, enabling an all-group IV optoelec-



Cross sectional transmission electron microscopy image of a vertical GeSn/Ge gate-all-around (GAA) nanowire FET, with (inset top-right) energy-dispersive x-ray (EDX) elemental mapping (showing Sn in green and Ti in blue) and (inset bottom-right) overlapped SEM images of GeSn/Ge nanowires used for p-VFETs.

tronic semiconductor platform that can be monolithically integrated on silicon," the paper adds.

That project research included contributions from several organizations in addition to CEA-Leti, which delivered the epitaxial stacks. Epitaxy is carried out on a very ordered template, a silicon substrate, with a very precise crystal structure. By



changing the material, CEA-Leti duplicated its diamond crystalline structure in the layers it grew on top.

Epitaxy is performed at low temperature in a chemical vapor deposition (CVD) reactor, notes Jean-Michel Hartmann, a CEA Fellow, leader of the working group on IV epitaxy at CEA-Leti, and scientific director of the SSURF department.

Epitaxial layer deposition of this kind of stack is a complex step in a process flow requiring patterned cylinders and conformal gate stack deposition. CEA-Leti claims to be one of the few RTOs (research and technology organizations) globally that is able to deposit such complex in-situ-doped Ge/GeSn stacks.

"The collaboration demonstrated the potential of low-bandgap GeSn for advanced transistors with interesting electrical properties, such as high carrier mobilities in the channel, low operating voltages and a smaller footprint," says Hartmann, a co-author of the paper. "Industrialization is still far away. We are advancing on the state of the art and showing the potential of germanium tin as a channel material."

The work also included scientists from ForschungsZentrum Jülich in Germany; the University of Leeds in the UK; IHP- Innovations for High Performance Microelectronics in Frankfurt (Oder), and RWTH Aachen University in Germany.

Hartmann received the Electronics and Photonics Division Award at the recent Electrochemical Society conference in Boston, MA, USA. As the honoree, on 30 May Hartmann presented a paper 'Epitaxy of Group-IV Semiconductors for Nanoelectronics and Optoelectronics' covering how epitaxy can be put to



Jean-Michel Hartmann, leader of the working group on IV epitaxy at CEA-Leti, receiving the Electronics and Photonics Division Award at the Electrochemical Society conference.

good use to boost properties of devices. Hartmann's research focuses on the reduced-pressure chemical vapor deposition (RP-CVD) of group-IV semiconductors for nanoelectronics and optoelectronics. ■

www.nature.com/articles/s44172-023-00059-2

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7 Wafer processing materials

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9 Materials & metals

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San Diego Convention Center,

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E-mail: customerservice@spie.org

www.spie.org/conferences-and-exhibitions/optics-and-photonics

22–23 August 2023

SPIE-CLP Conference on Advanced Photonics (APC2023)

San Diego Marriott Marquis and Marina,

San Diego, CA, USA

E-mail: customerservice@spie.org

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3–6 September 2023

SPIE Sensors + Imaging 2023

incorporating:

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RAI Amsterdam,

Amsterdam, Netherlands

E-mail: customerservice@spie.org

www.spie.org/conferences-and-exhibitions/sensors-and-imaging

4–8 September 2023

European Conference on Power Electronics and Applications (EPE'23 ECCE Europe)

Aalborg Kongres & Kultur Center,

Aalborg, Denmark

E-mail: epe2023@aaau.dk

www.epe2023.com

6–8 September 2023

CIOE 2023 (The 24th China International Optoelectronic Exposition)

Shenzhen World Exhibition & Convention Center,

Shenzhen, China

E-mail: cioe@cioe.cn

www.cioe.cn/en

6–8 September 2023

SEMICON Taiwan 2023

TaiNEX 1&2, Taipei, Taiwan

E-mail: semicontaiwan@semi.org

www.semicontaiwan.org

17–22 September 2023

International Conference on Silicon Carbide and Related Materials (ICSCRM 2023)

Hilton Sorrento Palace Conference Centre,

Sorrento, Italy

E-mail: info@icscrm-2023.org

www.icscrm-2023.org

17–22 September 2023

26th European Microwave Week (EuMW 2023)

Berlin Messe, Germany

E-mail: eumwreg@itnint.com

www.eumweek.com

1–5 October 2023

European Conference on Optical Communication (ECOC 2023)

Glasgow, Scotland, UK

E-mail: postmaster@theiet.org

<https://ecoc2023.theiet.org>

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14–16 October 2023

SPIE/COS Photonics Asia 2023

Beijing International Convention Center, Beijing, China

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14–17 November 2023

SEMICON Europa 2023

Messe München, Munich, Germany

E-mail: semiconeuropa@semi.org

www.semiconeuropa.org

14–18 October 2023

2023 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)

Monterey, CA, USA

E-mail: cs@cshawevent.com

www.bcicts.org

24–26 October 2023

SPIE Photonex 2023

Scottish Event Campus (SEC), Glasgow, UK

E-mail: customerservice@spie.org

www.spie.org/conferences-and-exhibitions/phonex

29 October – 2 November 2023

IEEE Energy Conversion Conference & Expo (ECCE 2023)

Music City Center, Nashville TN, USA

E-mail: ECCE2023TPC@GMAIL.COM

www.ieee-ecce.org/2023

9–13 December 2023

69th annual IEEE International Electron Devices Meeting (IEDM 2023) – ‘Devices for a Smart World Built Upon 60 Years of CMOS’

Hilton San Francisco Union Square Hotel,

San Francisco, CA, USA

E-mail: iedm-info@ieee.org

www.ieee-iedm.org

13–15 December 2023

SEMICON Japan 2023

Tokyo Big Sight, Tokyo, Japan

E-mail: semicon@sakurain.co.jp

www.semiconjapan.org

27 January – 1 February 2024

SPIE Photonics West 2024

The Moscone Center, San Francisco, CA, USA

E-mail: customerservice@spie.org

www.spie.org/conferences-and-exhibitions/photonics-west

18–22 February 2024

2024 IEEE International Solid- State Circuits Conference (ISSCC 2024)

San Francisco, CA USA

E-mail: Issccinfo@yesevents.com

www.isscc.org

25–29 February 2024

IEEE Applied Power Electronics Conference (APEC 2024)

Long Beach CA, USA

E-mail: apec@apec-conf.org

<https://apec-conf.org>

7–11 April 2024

SPIE Photonics Europe 2024, co-located with SPIE Optical Systems Design 2024

Palais de la Musique et des Congrès, Strasbourg, France

E-mail: customerservice@spie.org

www.spie.org/conferences-and-exhibitions/photonics-europe

12–23 June 2024

2024 IEEE Symposium on VLSI Technology and Circuits

Hilton Hawaiian Village Waikiki Beach Resort,

Honolulu, HI, USA

E-mail: vlsi@vlsisymposium.org

www.vlsisymposium.org

16–21 June 2024

2024 IEEE/MTT-S International Microwave Symposium (IMS 2024)

Washington DC, USA

E-mail: exhibits@horizonhouse.com

www.ims-ieee.org/about-ims/past-and-future-ims

22–26 September 2024

European Conference on Optical Communication (ECOC 2024)

Frankfurt am Main, Germany

E-mail: michelle.dampier@nexusmediaevents.com

www.ecocexhibition.com/future-dates

October 2024

SEMICON West 2024

Moscone Center, San Francisco, CA, USA

E-mail: semiconwest@semi.org

www.semiconwest.org

16–20 February 2025

2025 IEEE International Solid- State Circuits Conference (ISSCC 2025)

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www.isscc.org



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