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Electric vehicles driving silicon carbide investments

onsemi buying GTAT • Rohm & Geely partner • VisIC raises $35m
BMW capacity deal for GaN Systems • indie buying TeraXion

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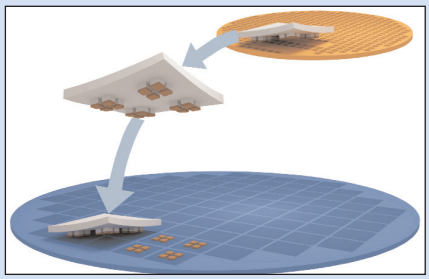
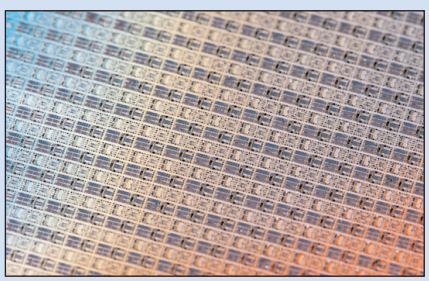
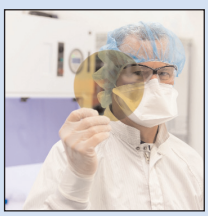


p31 X-FAB Silicon Foundries can now support volume heterogeneous integration via micro-transfer printing due to a licensing deal with X-Celeprint.

p48 Professor David Ginger is director of the new NSF-funded Center for Integration of Modern Optoelectronic Materials on Demand at the University of Washington.



p80 Aluminium scandium nitride could significantly improve the power density and efficiency of high-frequency amplifiers in 5G base stations, says Fraunhofer IAF



Cover: Silicon carbide wafer produced at SK Siltron CSS' Michigan plant, where a $300m expansion is to add a second facility and create up to 150 jobs in Bay County, MI, over the next three years to provide manufacturing and R&D capabilities for materials for electric vehicles. **p11**

editorial

Silicon carbide economies of scale

Continuing the recent trend of increasing investment in silicon carbide (SiC) manufacturing for power electronics applications, the last month has seen further significant investments, partnerships and technical and product developments throughout the supply chain.

In the USA, power IC supplier ON Semiconductor has agreed to acquire crystalline SiC & sapphire materials manufacturer GT Advanced Technologies for $415m (see page 10). The firm's aim is to secure a supply of wafering-ready SiC to meet growing demand for power-switching devices that can improve system efficiency in electric vehicles, EV charging and energy infrastructure. Onsemi plans to expand GTAT's R&D on 150mm and 200mm SiC crystal growth technology, as well as investing in the broader SiC supply chain (including wafer fab capacity and chip packaging).

Meanwhile, South Korea's SK Siltron says that, to provide manufacturing and R&D capabilities for materials for EVs, its US-based silicon carbide wafer manufacturing subsidiary CSS (formerly the SiC wafer unit of DuPont Electronics & Imaging until early 2020) plans over the next three years to invest $300m, adding a second site in Michigan and creating 150 jobs (more than doubling its workforce in the state) — see page 11. The expansion is part of a "new domestic supply chain forming to support new environmentally friendly vehicles," says the firm. Indeed, the US Secretary of Commerce states: "As we build towards a more sustainable future, it is important that we create new, robust supply chains in the US to support our corporations and the end consumer… The automotive industry has a tremendous opportunity with the rise of the electric vehicle."

In Asia, Japanese power semiconductor maker Rohm has entered into a strategic partnership for its silicon carbide power devices to be integrated into the high-efficiency traction inverters and onboard charging (OBC) systems of EV platforms being developed by Chinese auto maker Geely.

The motive for such business developments is provided by market research firms such as TrendForce, which estimates that silicon carbide device revenue is rising at a compound annual growth rate (CAGR) of 38% from $680m in 2020 to $3.39bn in 2025 (see page 7). EVs comprise 61% of consumption (primarily for powertrain inverters, OBCs and DC–DC converters), followed by solar/power generation/storage at 13% and charging stations at 9%.

The increased demand for SiC power devices is being met by a transition from 150mm- to 200mm-diameter SiC substrates. And, as silicon carbide takes a step further towards the economies of scale of silicon (which is 300mm at the leading edge, but still 200mm for legacy manufacturing), the industry's biggest process equipment maker, Applied Materials, has now launched new equipment dedicated to processing SiC wafers up to 200mm in diameter (see page 28). This initially comprises a CMP (chemical mechanical planarization) system and a hot ion implantation system. However, Applied says that its ICAPS (IoT, Communications, Automotive, Power and Sensors) business is developing additional products for the SiC power semicondcutor market, including in physical vapor deposition (PVD), chemical vapor deposition (CVD), etch and process control.

So, the shift to more environmentally friendly electric vehicles — coupled with the urgency to develop more secure regional supply chains and to increase chip-making capacity for the automotive industry — promises to drive a step change in the economies of scale throughout the silicon carbide manufacturing chain.

Mark Telford, Editor

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Increased demands on food safety to propel horticultural lighting LED revenue to $399m in 2021

North American marijuana markets drove 57% growth to $301m in 2020

Due to favorable policies by governments worldwide as well as massive adoption of horticultural LED lighting products in the medical and recreational marijuana markets in North America, horticultural lighting LED revenue grew 57% year-on-year to $301m in 2020, according to TrendForce's report '2021 Global LED Lighting Market Outlook — Light LED and LED Lighting Market Trend'. The market is expected to maintain its momentum throughout 2021, growing 33% year-on-year to $399m.

However, horticultural red light LED chips, especially high-end ones, will likely suffer a shortage in third-quarter 2021, as suppliers' production capacities for these chips are constrained by other products, including automotive and infrared LED products. At the same time, demand for horticultural LED lighting products cannot be fully met due to the ongoing shortage of power management integrated circuits (PMICs). Furthermore, delayed ocean freight schedules and North American governments' crackdown on illegal indoor marijuana cultivations have also impacted the shipment of these end-products, leading certain horticultural LED lighting suppliers to slow down their production plans and component procurement activities.

Even so, LED suppliers are still optimistic about the current market. Although changes in the global environment are expected to hinder market demand in the short run LED suppliers believe that such hindrance will likely be ameliorated by the end of third-quarter 2021.

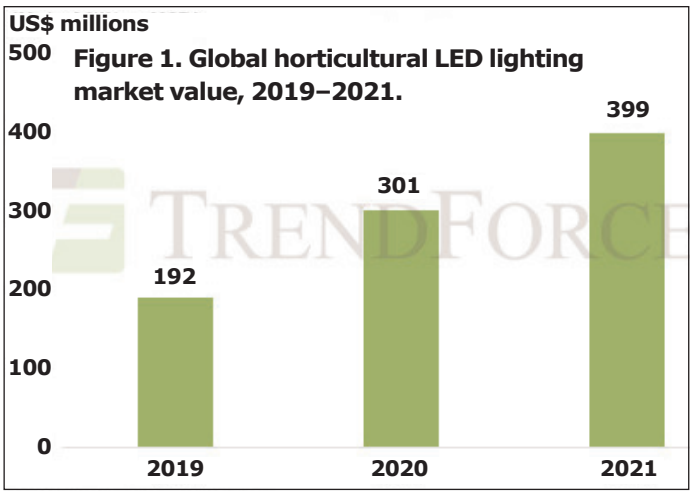

Figure 1. Global horticultural LED lighting market value, 2019–2021.

TrendForce's report indicates that horticultural lighting LED package suppliers include ams-OSRAM, Samsung LED, Cree LED, Seoul Semiconductor, Lumileds, Everlight, LITEON, and lightning. On the other hand, horticultural LED chip suppliers include Epistar, San'an, HC Semitek, HPO, and Epileds. The vast majority of these companies were able to benefit from the horticultural lighting market and posted remarkable earnings performances in first-half 2021, notes TrendForce.

Looking ahead, the demands on food safety will bring about a shortened food supply chain through such developments as indoor farming and build-outs of vertical farms, with a corresponding rise in the global horticultural lighting LED market, reckons the market research company. In addition, TrendForce believes that, as operators of greenhouses or emerging vertical farms continue to adopt LED lighting equipment in the long run, and LED lighting costs continue to decline, more and more indoor farmers will be convinced to replace their traditional lighting equipment with LED lighting equipment. The replacement demand from these operators will, in turn, become the key driver of the horticultural lighting LED market's future growth, forecasts TrendForce.

www.ledinside.com

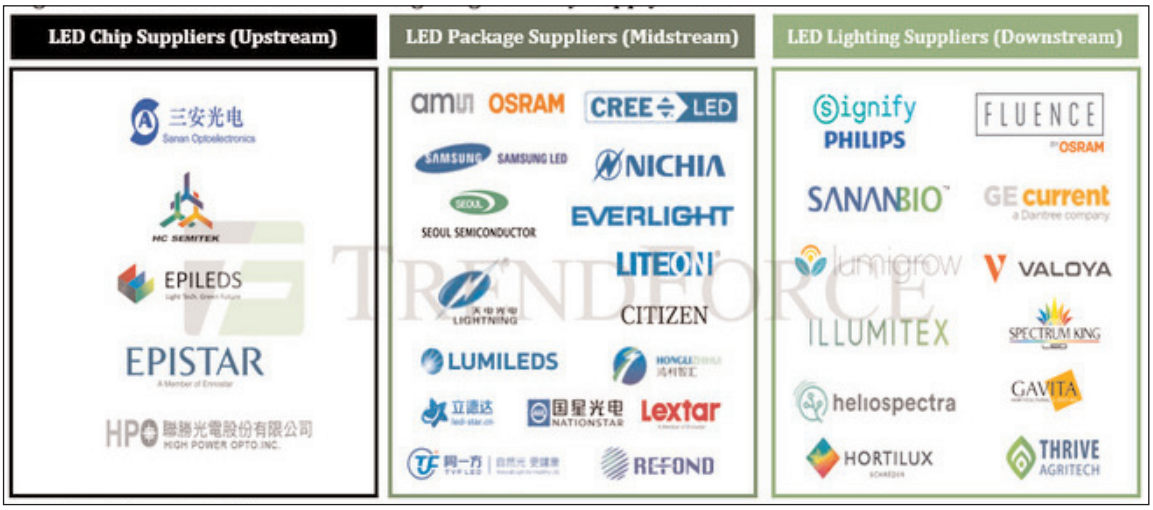

Figure 2. Global horticultural LED lighting industry supply chain.

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GaN power devices growing at 78% CAGR to $850m in 2025

Silicon carbide revenue to grow at 38% CAGR to $3.39bn

Demand for telecom base stations, converters, and charging stations has seen considerable growth this year as a result of ongoing developments in 5G telecoms, consumer electronics, industrial energy conversion, and new energy vehicles (NEV), according to TrendForce's latest investigations. This demand generated a corresponding surge in demand for components and devices powered by 'third-generation' semiconductors gallium nitride (GaN) and silicon carbide (SiC), and the GaN power device market is expected to see the greatest growth. TrendForce forecasts that GaN power device revenue will rise 73% year-on-year in 2021 to $83m, then grow at a 78% CAGR to $850m in 2025.

Regarding applications, consumer electronics, NEVs and telecoms/data centers, in order, comprise the three largest sources of GaN power device consumption, at 60%, 20% and 15%, respectively. TrendForce finds that about 10 smartphone OEMs have released more than 18 models of smartphones equipped with fast-charging capability, while notebook manufacturers are also indicating a willingness to adopt fast charging for notebook computers.

Annual silicon carbide revenue is expected to grow at a 38% CAGR to $3.39bn in 2025, with NEVs, solar power generation/storage, and charging stations representing the three largest sources of SiC power device consumption, at 61%, 13% and 9%, respectively. For the NEV industry, in particular, SiC power devices are most widely used in powertrain inverters, on-board chargers (OBCs) and DC–DC converters.

Major IDMs from Europe, USA and Japan still control vast majority of substrate supply

Due to their relative difficulty in epitaxial growth and the fact that the industry is moving from 6-inch towards 8-inch substrates as the mainstream, GaN and SiC substrates are 5–20 times more expensive to manufacture compared with traditional 8-inch and 12-inch silicon substrates, notes TrendForce. Supplies of most substrate materials are currently controlled by such major IDMs as US-based Cree and II–VI, Japan-based Rohm, and Europe-based STMicroelectronics. In response to this oligopoly, certain Chinese suppliers, including SICC and Tankeblue, have successively entered the substrate market with the support of China's 14th five-year plan. Their participation will likely accelerate China's goal of semiconductor self-sufficiency, believes TrendForce.

Although substrate suppliers in Europe, the USA and Japan enjoy an early presence in the market and possess relatively mature process technologies, TrendForce believes that Taiwanese suppliers still hold certain competitive advantages. For example, not only do Taiwanese companies have vast experience in silicon development, but Taiwan is also home to a comprehensive upstream/downstream silicon supply chain.

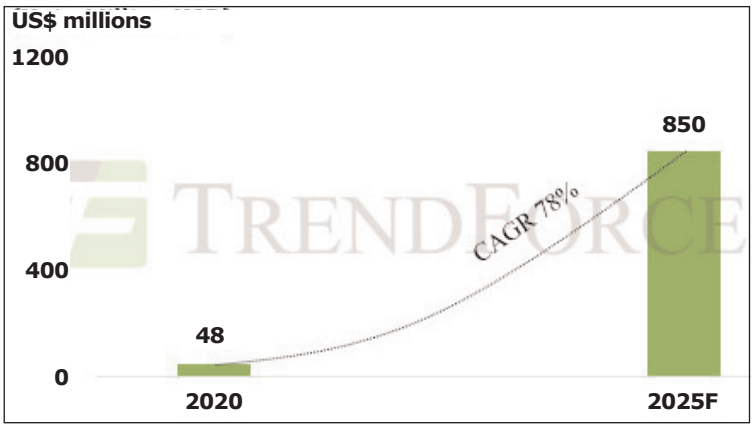

Figure 1. Global GaN power devices revenue, 2020–2025.

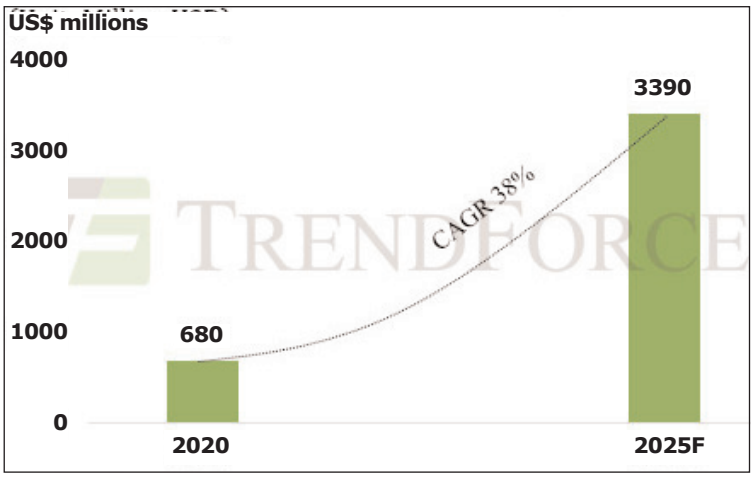

Figure 2. Global SiC power devices revenue, 2020–2025.

In addition to these advantages, Taiwan is further aided by policies that promote domestic material supply, design and technical development.

Taiwan is therefore well on its way to achieving its goal of becoming a center of advanced semiconductor fabrication that derives its strength from a gradually maturing front-end substrate and epitaxy industry chain, as well as mid- and back-end competencies in chip design, manufacturing and packaging, believes TrendForce. Currently, two major strategic alliances, led by Hermes-Epitek (with subsidiaries EPI and EPISIL), and SAS (with subsidiaries GW, AWSC, CWT, and ATC) are attempting to maximize their efforts in Taiwan's lagging substrate industry. Furthermore, jointly funded by KENMEC and TAINERGY, TAISIC has submitted 4-inch SiC substrates for qualification and is actively investing in 6-inch SiC substrate R&D, adds TrendForce.

www.trendforce.com

pSemi expands in APAC with new Taiwan branch office

Taipei office scales up manufacturing, boosts global customer support

Murata company pSemi Corp of San Diego, CA, USA – a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) – has announced the opening of a branch office in Taipei City, Taiwan. Building on its existing worldwide supply chain relationships, the Taiwan office joins other pSemi APAC locations in India, Korea, China and Japan. pSemi is actively hiring at locations worldwide.

"pSemi's RF business has grown tremendously, driven by the rapid adoption of 5G and our ability to connect the dots between circuit, system and device," says CEO Sumit Tomar. "Our new Taipei branch office scales up our manufacturing footprint, expands support for our strategic APAC customers and business partners, and furthers collaboration with our parent company Murata."

Murata established its presence in Taiwan more than 40 years ago, taking into consideration the nation's semiconductor manufacturing ecosystem, geographic proximity to other Asian countries and talent pool. Sharing space with Murata, pSemi's Taiwan office is located at Rm. 1503, 15F., No. 88, Section 2, Zhongxiao E. Road, Taipei 10050. It is in close proximity to Murata Electronics' factory in Taichung, enabling pSemi to leverage Murata's manufacturing footprint and to facilitate joint IC and module development.

www.psemi.com/careers

Tagore unveils 10–100W second-generation RF switches

Tagore Technology Inc — which was founded in January and has design centers in Arlington Heights, IL, USA and Kolkata, India developing gallium nitride-on-silicon (GaN-on-Si) technology for RF and power management applications — has launched a family of second-generation RF switches with 10–100W of average power.

The TS8x family of products is best suited for post-power amplifier (PA) harmonics filter switching for tactical and military communications (MilCom), land mobile radios (LMR) and private mobile radios (PMR).

Lower insertion loss performance significantly reduces power consumption and enhances the battery life of handheld communication devices, the firm says. Lower power dissipation also helps to ease thermal management requirements to reduce the size, weight and power (SWaP) of the overall system.

"Tagore's TS8x family of switches enables customers to replace all traditional PIN diode-based switches that require many passive components and high-voltage bias supply to save significant board space and overall cost, and simplify RF front end design," says chief sales & marketing officer Klaus Buehring.

The new family of products is pin- and footprint-compatible with existing products, allowing existing customers to enhance radio performance by switching to the latest generation of products.

www.tagoretech.com

Skyworks launches switches & LNA front-end modules

Targeted at automotive, cellular compensator and cellular telematics

Skyworks Solutions Inc of Irvine, CA, USA (which manufactures analog and mixed-signal semiconductors) has launched the SKYA21038, SKYA21039, SKYA21040 and SKYA21041 devices for automotive, cellular compensator and cellular telematics applications.

The SKYA21038 is a single-pole, double-throw (SPDT) switch intended for mode switching in WLAN applications. Using advanced switching technologies, the SKYA21038 maintains low insertion loss and high isolation for all switching paths. The high-linearity performance and low insertion loss make the switch suitable for low-power transmit/receive applications.

The SKYA21039 is a single-pole, triple-throw (SP3T) antenna switch that operates in the 2.4–2.5GHz frequency range. Switching between the antenna (RFC signal) and the RF1, RF2 and RF3 ports is accomplished with two control voltages (V1 and V2). The low loss, high isolation, high linearity, small size and low cost make the switch suitable for all WLAN and Bluetooth systems operating in the 2.4–2.5GHz band.

The SKYA21040 integrates a single-pole, triple-throw (SP3T) switch and low-noise amplifier (LNA) with a bypass mode in an ultra-compact package. The device is capable of switching between WLAN receive, WLAN transmit and Bluetooth and is provided in a small (1.5mm x 1.5mm) dual flat no-lead (DFN) 8-pin, package.

The SKYA21041 integrates a single-pole, double-throw (SPDT) switch and low-noise amplifier with a bypass mode in an ultra-compact package. The device is capable of switching between WLAN receive and WLAN transmit. The SKYA21041 is provided in a small (1.2mm x 1.4mm) 6-pin, dual flat no-lead (DFN) package.

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onsemi acquiring GTAT for $415m

Acquisition expands SiC capabilities and assures customer supply

Power semiconductor IC supplier ON Semiconductor of Phoenix, AZ, USA has entered into a definitive agreement to acquire silicon carbide (SiC) and sapphire materials manufacturer GT Advanced Technologies Inc of Hudson, NH, USA for $415m. Founded in 1994, GTAT has experience in crystalline growth, including SiC.

The transaction is expected to better position onsemi to secure and grow the supply of SiC and to meet rapidly growing customer demand for SiC-based solutions in the sustainable ecosystem, including power switching devices for improving system efficiency in electric vehicles (EVs), EV charging and energy infrastructure. onsemi reckons that combining its manufacturing capabilities with GTAT's technical expertise will accelerate SiC development and position it to better serve customers as the sustainable ecosystem rapidly ramps up over the next decade. The enhanced SiC capability is expected to allow onsemi to assure customers of the supply of critical components and to further commercialize intelligent power technologies.

"This transaction reflects our confidence and stated commitment to meaningfully invest in silicon carbide solutions to support the creation of intelligent power and sensing technologies to help build a sustainable future," says onsemi's president & CEO Hassane El-Khoury. "We are focused on deepening our leadership and innovation in game-changing technologies that support the automotive and industrial sectors, and GTAT brings outstanding technical capabilities and expertise in developing wafering-ready silicon carbide, which we intend to accelerate and expand to better empower customers in our high-growth end markets," he adds.

"Today's announcement marks the start of a new chapter for GTAT," says GTAT's president & CEO Greg Knight. "onsemi is strategically positioned to scale our capabilities, providing the resources and platform to maximize the potential of our cutting-edge production techniques and ensure we remain on the forefront of advanced crystalline growth."

The acquisition also reinforces onsemi's commitment to make substantial investments in disruptive, high-growth technologies, consistent with its recently announced 2025 target financial model described during its Analyst Day presentation. Capital expenditures are expected to be about 12% of revenue in 2022 and 2023, as onsemi invests to drive differentiation and leadership, including in SiC. The transaction is not expected to impact the firm's 2025 target financial model.

onsemi plans to invest in expanding GTAT's R&D efforts to advance 150mm and 200mm silicon carbide crystal growth technology

onsemi plans to invest in expanding GTAT's R&D efforts to advance 150mm and 200mm SiC crystal growth technology, while also investing in the broader SiC supply chain, including fab capacity and packaging.

The transaction, which has been unanimously approved by the boards of directors of both onsemi and GTAT, is expected to close in first-half 2022. Completion is subject to regulatory approvals and other customary closing conditions. Approval of onsemi's stockholders is not required in connection with the proposed transaction.

onsemi intends to fund the transaction through cash on hand and available capacity under its existing revolving credit facility. The firm expects the transaction to be marginally dilutive to its non-GAAP earnings per share in the immediate term and to be accretive within one year after close.

www.gtat.com

Qorvo launches 125W GaN power amplifier module for S-band radar

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defences applications) has introduced a 125W power amplifier module (PAM) designed to support S-band (3.1–3.5GHz) commercial and defense radar applications.

Sampling now for qualified customers, the new QPA2513 PAM is a two-stage 50V_d gallium nitride on silicon carbide (GaN-on-SiC) power amplifier solution that is internally matched to 50Ω and features high gain (30dB) and power-added efficiency (62%) in a 70% smaller (25mm x 12.5mm) surface-mount package than competing two-stage solutions, it is reckoned. Because of its performance, the QPA2513 is said to significantly reduce overall system power consumption.

In addition, the QPA2513 power amplifier module has been designed to reduce size, weight and power (SWaP) at the system level, making system design, board assembly and testing easier, and reducing system-level manufacturing cycle times, the firm adds.

www.qorvo.com

SK Siltron CSS announces $300m Michigan expansion, adding second facility and up to 150 jobs

Facility to manufacture silicon carbide wafers for EV power systems

SK Siltron CSS, which manufactures silicon carbide (SiC) wafers, plans to invest $300m and create up to 150 jobs in Bay County, MI, over the next three years to provide manufacturing and R&D capabilities for materials for electric vehicles (EVs). The expansion will more than double the firm's Michigan employee base and add a new site in Bay City, to join its existing site in nearby Auburn.

Silicon wafer supplier SK Siltron of Gumi, South Korea is an affiliate company of Seoul-based SK Group (South Korea's third-largest conglomerate), whose companies have been expanding their presence in the USA with multi-billion-dollar investments in their own businesses and partnerships in renewable energy and sustainable technologies.

SK Siltron acquired the SiC Wafer unit of Delaware-based DuPont Electronics & Imaging (E&I) in early 2020 and established SK Siltron CSS as a US subsidiary. Since then, SK Siltron CSS has doubled its employee base in Michigan, to about 130 skilled workers and professional engineers.

The company says that CSS's silicon carbide wafer technology has benefited from its close collaboration and direct access to SK Siltron's high-volume manufacturing (HVM) expertise in scaling up production of semiconductor wafers. The silicon carbide wafers can be used in EV system components including power converters, chargers and inverters. In addition to helping to increase driving ranges for EVs, the electrical and thermal properties of silicon carbide can help to reduce charging times, relax system cooling requirements and shrink the power module size and weight.

"The rise in popularity of electric vehicles has the auto industry searching for new innovative technologies to meet customer demand," says CEO Jianwei Dong. "Our Michigan expansion will allow us to manufacture advanced materials that can enhance the performance of an EV and support the growth of a more sustainable automotive future."

A silicon carbide wafer produced at SK Siltron CSS' Michigan facility. The company plans to expand its Michigan operations to increase production of these wafers, which can be used in power system components for electric vehicles.

"The rise in popularity of electric vehicles has the auto industry searching for new innovative technologies to meet customer demand," says CEO Jianwei Dong. "As we build toward a more sustainable future, it is important that we create new, robust supply chains in the US to support our corporations and the end consumer," states US Secretary of Commerce Gina M. Raimondo

Pending both state and local approvals, the SK Siltron CSS expansion is part of a new domestic supply chain forming to provide the components required to support new environmentally friendly vehicles.

"As we build toward a more sustainable future, it is important that we create new, robust supply chains in the US to support our corporations and the end consumer," states US Secretary of Commerce Gina M. Raimondo. "The automotive industry has a tremendous opportunity with the rise of the electric vehicle, and we're excited to see companies like SK Siltron CSS expanding to help support the transition to a green future."

The company says that it will work closely with state and local partners to recruit and train potential employees (70% of which will be skilled workers, while 30% will be professional engineers).

www.sksiltron.com
www.sk.com

ROHM and Geely partner on silicon carbide power devices

Geely to develop traction inverters and onboard charging

Power semiconductor maker ROHM and Chinese automobile manufacturer Geely Automobile Group Co Ltd have entered into a strategic partnership to develop advanced technologies in the automotive field.

The firms have been collaborating on a variety of automotive applications since 2018, when they first agreed to a technical exchange. This partnership is expected to further promote cooperation and accelerate innovation for automotive applications.

Geely is working to extend the cruising range of electric vehicles (EVs) while reducing battery costs and shortening charge times by developing high-efficiency traction inverters and onboard charging (OBC) systems that adopt ROHM's power solutions centered on silicon carbide (SiC) power devices. At the same time, Geely says that it is committed to developing high-performance advanced driver assistance systems (ADAS) and intelligent cockpit systems using a wide range of products and s olutions, including communication ICs and discrete devices.

As a first step, traction inverters equipped with ROHM's SiC power devices are being integrated in electric vehicle platforms currently being developed by Geely.

Through the partnership, ROHM and Geely aim to contribute to sustainability by promoting the development of low-carbon technologies in the automotive industry and offering solutions for achieving greater safety and security in an increasingly mobile society.

http://global.geely.com

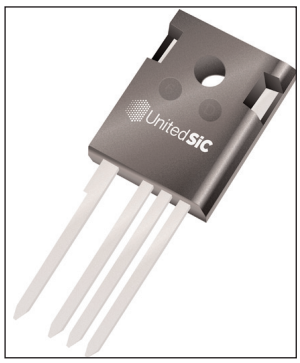
UnitedSiC expands 750V SiC FET range with 6mΩ option

Nine new devices increase design flexibility

Power semiconductor maker United Silicon Carbide Inc (UnitedSiC) of Princeton, NJ, USA says it has responded to power designers' calls for higher-performance, higher-efficiency field-effect transistors (FETs) by announcing a 750V, 6mΩ device. At an on-resistance $R_{DS(on)}$ value of less than half the nearest SiC MOSFET competitor, the new 6mΩ device also provides a robust short-circuit withstand time rating of 5μs.

The launch includes nine new device/package options in the 750V SiC FET series, rated at 6, 9, 11, 23, 33 and 44mΩ. All devices are available in the TO-247-4L package, while the 18, 23, 33, 44 and 60mΩ devices also come in the TO-247-3L package. Complemented by the already available 18mΩ and 60mΩ devices, this 750V expanded series provides designers with more device options, enabling more design flexibility to achieve an optimum cost/efficiency trade-off while maintaining generous design margins and circuit robustness, says the firm.

UnitedSiC's Gen 4 SiC FETs are a 'cascode' of a SiC JFET and a co-packaged silicon MOSFET. Together, these provide the full advantages of wide-bandgap technology:



UnitedSiC's 750V SiC FET in a TO-247-4L package,

high speed and low losses with high-temperature operation, while retaining an easy, stable and robust gate drive with integral ESD protection.

These advantages are quantified by figures of merit (FoMs) such as $R_{DS(on)}$ x A, a measure of conduction losses per unit die area. Gen 4 SiC FETs achieve what are claimed to be the lowest values in the market at both high and low die temperatures. The FoM $R_{DS(on)}$ x E_{OSS}/Q_{OSS} is important in hard-switching applications and is half the nearest competitor value, it is reckoned. The FoM $R_{DS(on)}$ x $C_{OSS(tr)}$ is critical in soft-switching applications, and UnitedSiC claims that its device values are around 30% less than competitor parts, rated at 650V compared with UnitedSiC's at 750V.

For hard-switching applications, the integral body diode of SiC FETs is superior in recovery speed and forward voltage drop to competing Si MOSFET or SiC MOSFET technologies. Other advantages incorporated into the Gen 4 technology are reduced thermal resistance from die to case by using advanced wafer thinning techniques and silver-sinter die-attach. These features enable maximum power output for low die temperature rise in demanding applications.

With their latest improvements in switching efficiency and on-resistance, the new SiC FETs are suitable for challenging emerging applications. These include traction drives and on- and off-board chargers in electric vehicles and all stages of uni- and bi-directional power conversion in renewable energy inverters, power factor correction (PFC), telecoms converters, and AC/DC or DC/DC power conversion generally. Established applications also benefit from use of the devices for an easy boost in efficiency due to their backwards compatibility with silicon MOSFET and IGBT gate drives and established TO-247 packaging.

"The new range additions now provides further options for all performance and budget specifications, and a wider range of applications," comments president & CEO Chris Dries.

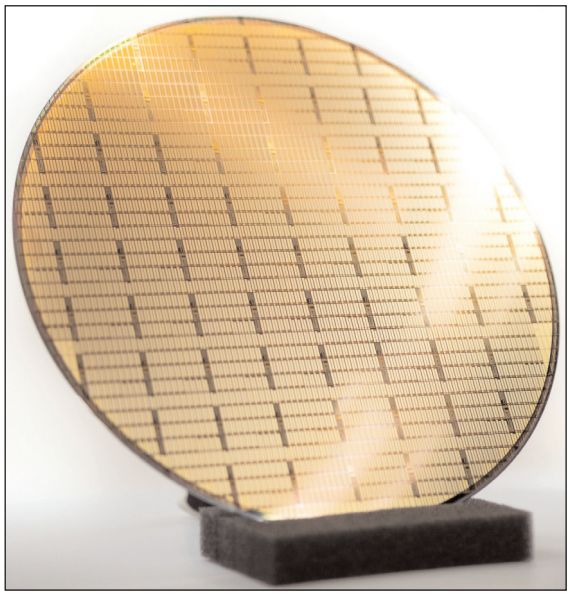
www.unitedsic.com

Infineon and Panasonic agree to develop and produce Gen2 GaN technology

650V HEMTs on 8-inch silicon to be launched in first-half 2023

Infineon Technologies AG of Munich, Germany and Panasonic Corp of Osaka, Japan have signed an agreement for the joint development and production of the second generation (Gen2) of their proven gallium nitride (GaN) technology, offering higher efficiency and power density levels.

The performance and reliability combined with the capability of 8-inch GaN-on-silicon wafer production mark Infineon's strategic outreach to the growing demand for GaN power semiconductors. In accordance with market requirements, Gen2 will be developed as 650V GaN HEMTs. The devices are intended to allow for ease of use and to provide an improved price-performance ratio, targeting, amongst others, high- and low-power switched-mode power supplies (SMPS) applications, renewables, and motor drive applications.



"In addition to the same high reliability standards as for Gen1, with the next generation customers will benefit from even easier control of the transistor as well as a significantly improved cost position, thanks to moving to an 8-inch wafer manufacturing," says Andreas Urschitz, president of Infineon's Power and Sensor Systems Division.

Like the jointly developed Gen1 devices (known as Infineon's CoolGaN and Panasonic's X-GaN), the second generation will be based on the normally-off GaN-on-Si transistor structure.

This, in combination with the robustness of the hybrid-drain-embedded gate injection transistor (HD-GIT) structure, makes the components some of the most long-term reliable solutions on the market, it is claimed.

Market launch of the new 650V GaN Gen2 devices is planned for first-half 2023.

http://panasonic.net
www.infineon.com

Infineon Technologies introduces 22kW reference design for industrial general-purpose motor drive

CoolSiC MOSFET with 1700V blocking voltage is central part of auxiliary power supply

In power electronics and the semiconductor market the system approach is gaining momentum. To support this trend, Infineon has introduced a pre-tested industrial reference design targeted at significantly reducing the time to market.

The reference design is a general-purpose motor drive that features a nominal power of 22kW and can be operated directly on a 380-480V three-phase grid. The design can be fully re-used for customization and allows customers to evaluate Infineon's products under real operating conditions. It is suitable for applications such as pumps, fans, compressors and conveyor belts.

The design combines Infineon's latest technologies in one system. It includes the EasyPIM 3B IGBT7 module FP100R12W3T7_B11 for high current and high power density, the EiceDRIVER Compact 1ED3131MC12H for optimal EMI performance and low power losses, as well as the XENSIV current sensor TLI4971-A120T5 for measuring high currents with minimal power loss. The CoolSiC MOSFET IMBF170R1K0M1 with a blocking voltage of 1700V is the central part of the auxiliary power supply. The system also contains two microcontrollers — the XMC4800 for control and the XMC4300 for communication, including a pre-installed software package for motor control. This combination allows evaluation of these products in one design and experience of their interaction.

To complete the modular approach, the system is optionally available with a 3D-printed housing, which encloses all electronic components and the cooling system. The housing includes a touch-screen to display current operation conditions, as well as EtherCAT and USB interfaces for external connections.

The REF-22K-GPD-INV-EASY3B reference design can be ordered now.

www.infineon.com/coolsic

Cree's quarterly revenue up 34.5% year-on-year

Steeper-than-expected demand for SiC devices leads to supply constraints

For full-year fiscal 2021 (ended 27 June), for continuing operations, Cree Inc of Durham, NC, USA has reported revenue of $525.6m, up 12% on fiscal 2020's $470.7m, due to growth in its device businesses (particularly in power devices), partially offset by lower materials revenue.

Most recently, fiscal fourth-quarter 2021 revenue was $145.8m, up 6.2% on $137.3m last quarter and 34.5% on $108.4m a year ago. This was despite losing $3–5m through supply constraints due to a COVID-19 outbreak causing a seven-day closure at the firm's contract manufacturer in Malaysia. This was the fourth consecutive quarter of sequential growth for Cree's Wolfspeed silicon carbide (SiC) and gallium nitride (GaN) power & RF device business. Year-on-year, RF device revenue grew largely due to increased 5G activity as communications infrastructure providers continue to support the rollout by carriers. Power device revenue grew 46% (including automotive devices in particular more than doubling).

"Customers are ramping up production earlier and steeper than originally anticipated," says CEO Gregg Lowe. "We continued to grow and convert opportunities in our device pipeline, further establishing our industry leadership position in silicon carbide," he adds.

On a non-GAAP basis, gross margin was 32.3%, up on 30% a year ago but down from 35% last quarter, due primarily to the growth in the firm's device products and higher manufacturing costs in the short term. "In addition, we were negatively impacted [by about one percentage point] by the production shutdown at our contract manufacturer in Malaysia, which resulted in gross margin being at the lower end of our [32–34%] guidance range," notes chief financial officer Neill Reynolds. "We view the gross margin impact as short term in nature due to the sub-optimal device production footprint we have in North Carolina and expect to modestly improve going forward as we work through factory transitions and eventually shift production to our new Mohawk Valley fab in calendar year 2022," he adds.

In May 2019, Cree began a multi-year factory optimization plan. As well as expanding crystal growth and wafer production capacity to a second building in Durham, NC (part of a plan to increase materials capacity by 30x), in September 2019 Cree announced that the plan is being anchored by a new automated 200mm silicon carbide device fabrication facility at Marcy in Mohawk Valley, New York State.

Operating expenses rose to $82m, fueled by investments in R&D including development projects that are well underway at the Mohawk Valley pilot line in order to support the firm's 200mm SiC wafer launch as well as increased sales & marketing expenses as Cree pursues new business opportunities.

Net loss for full-year fiscal 2021 was $104.7m ($0.93 per diluted share), versus net income of $76.6m ($0.71 per diluted share) for fiscal 2020.

Quarterly net loss has increased slightly from fiscal Q3/2021's $24.7m ($0.22 per diluted share) to $26.9m ($0.23 per diluted share), but this is cut from $28.9m ($0.27 per diluted share) a year ago.

This excludes a $73.9m write-down expense related to a modification of Cree's long-range plan regarding part of its campus in Durham – originally intended for expanding LED production capacity — which Cree had subsequently considered using to expand the manufacturing footprint for its silicon carbide materials product line.

We expect this to represent the most significant period of investment between now and 2024 as we execute our capacity expansion plan

After Cree completes its ongoing SiC materials production capacity expansion in Durham, it now plans that — rather than completing construction of the new buildings — it will expand further elsewhere. The carrying value of the abandoned assets has been reduced to an estimated salvage value.

Additionally, subsequent to Cree's sale of its LED Products business unit to SMART Global Holdings Inc in March (for up to $300m), the firm liquidated its approximately 3.3% common stock ownership interest in ENNOSTAR Inc (formerly Lextar Electronics Corp) and received net proceeds of $66.4m.

Cash outflow from operations has doubled from the prior quarter to –$53.6m. Capital expenditure (CapEx) has risen to $168.1m. Free cash outflow has hence risen to –$221.7m. Fiscal 2021 required a significant amount of investment in CapEx, totalling a record $566m. "We expect this to represent the most significant period of investment between now and 2024 as we execute our capacity expansion plan including the launch of our Mohawk Valley fab at 200mm in the first half of 2022," notes Reynolds.

Overall, during fiscal Q4/2021, cash, cash equivalents and short-term investments fell from $1293m to $1154.6m. Cree summarizes that it still has a strong balance sheet, with liquidity to support its growth strategy, zero withdrawn on its line of credit, and convertible debt with a total face value of $1bn.

Quarterly design-ins were a record of slightly more than $1bn. This took full-year fiscal 2021 design-ins to about $2.9bn, representing more than 1100 customer projects. Automotive represents roughly two thirds of this, including a major award from a leading global automotive manufacturer, while the rest is spread across a wide variety of applications including an electric farm tractor, residential energy storage systems, and an electrical

vertical takeoff and landing (VTOL) aircraft for passenger and cargo transport.

"Demand in the automotive and RF markets continues to be very good, while at the same time we are encouraged by growing interest across a variety of industrial and energy customers," says Lowe. "Our device opportunity pipeline is now above $15bn and the team is continuing to uncover new opportunities at a very good pace."

For fiscal first-quarter 2022, Cree expects revenue of $144–154m, driven by the continued demand in power devices, partially offset by the current supply constraints plus lower productivity as Cree's Malaysian contract manufacturer continues to ramp activities following the recent COVID-19 outbreak (an impact of $5–7m).

Gross margin is expected to be 31.5–33.5%, flat to slightly up on fiscal Q4/2021 as modest improvements in productivity at the Durham site are offset by higher costs in Malaysia as a team works through COVID-19-related challenges (an impact again of about one percentage point, due to lower staffing levels imposed by the local government). "As previously noted, lower yields and factory transitions in our Durham fabs will continue to present some short-term challenges on gross margin performance and will remain a headwind until we ship our production to our new Mohawk Valley fab," says Reynolds.

Operating expenses are expected to rise to $85m due to R&D spending and including plant growth at Mohawk Valley to support the 200mm wafer launch.

Net loss is targeted to be $25–29m ($0.21–0.25 per diluted share).

"We are experiencing a significantly steeper demand curve from our customers for silicon carbide devices than we had previously anticipated. This has resulted in supply constraints. For some customer orders will not be fulfilled in fiscal year 2022 and channel inventory levels will remain low until capacity comes online in our Mohawk Valley fab," says Reynolds. "In the meantime, we are working to accelerate capacity, CapEx investments, improve output in our Durham facilities, and manage through the COVID-related challenges with our contract manufacturer in Malaysia. As we remain in the midst of a rapid capacity expansion for both materials and our wafer fabs, we anticipate CapEx (net of expected reimbursements from the state of New York) to be approximately $475m in fiscal 2022," he adds.

"We expect CapEx to be more heavily weighted to the first half of the fiscal year, with Q1 representing the peak investment period as we ensure a ramp at Mohawk Valley remains on track. We are still on schedule to operationalize the world's largest silicon carbide fab in the first half of calendar year 2022 [when it will begin device qualification production runs]. Access to capacity and semiconductors is top of mind for many of our customers and we want to be ready to meet that demand, given the steeper ramps that we are now experiencing for devices."

Cree will incur restructuring costs from the movement of equipment to the Mohawk Valley fab as well as disposals on certain long-lived assets in Durham. Also, start-up and pre-production-related costs associated with the ramp-up at Mohawk Valley for fiscal 2022 will be about $80m, of which $60m will be cash-related costs. "We anticipate more than 50% of these costs will be incurred in the second half of fiscal year 2022 as we qualify and ramp up," says Reynolds.

"Our massive pipeline and record design-ins give us further confidence in our ability to achieve our target revenue for fiscal 2024 of $1.5bn [comprising about $600m in materials and $900m in devices], based on the steepening demand curve for silicon carbide devices through 2024 and beyond," says Lowe.

www.cree.com

Cree | Wolfspeed to transfer from Nasdaq to NYSE

Corporate name changes from Cree to Wolfspeed on 4 October

Cree, which provides silicon carbide (SiC) technology through its Wolfspeed business, is to transfer the listing of its common stock from The Nasdaq Global Select Market to the New York Stock Exchange. Cree expects to commence trading as a NYSE-listed company at market open on 4 October under the new ticker symbol 'WOLF'. The firm will continue to trade its common stock on the Nasdaq until the close of the market on 1 October. As previously announced, the firm will also change its corporate name from Cree Inc to Wolfspeed Inc, effective 4 October.

"We are pleased to join the NYSE, one of the world's most prestigious trading platforms, as we continue on our transformational journey as a pure-play global semiconductor powerhouse leading the industry transition from silicon to silicon carbide," says CEO Gregg Lowe. "Our company name change to Wolfspeed capitalizes on our 30-year heritage of working with silicon carbide and underscores our ambitious plans to compete and win in the rapidly expanding marketplace, which we believe will continue to provide long-term value for our customers and shareholders," he adds.

Cree is hosting an Investor Day on 17 November at the New York Stock Exchange in New York City. Cree | Wolfspeed CEO Gregg Lowe, CFO Neill Reynolds and other members of the senior management team will discuss the firm's progress on its transformation strategy and share more details about its long-term outlook.

Texas Instrument's GaN used in Delta Electronic's enterprise server power supplies for data centers

Power density, new architectures and integration can reduce total cost of ownership

Dallas-based Texas Instruments Inc (TI) — which designs, manufactures and tests analog and embedded processing chips for markets such as industrial, automotive, personal electronics, communications equipment and enterprise systems — says that its gallium nitride on silicon (GaN-on-Si) technology and C2000 real-time microcontrollers (MCUs) are being combined with Delta Electronics' high-efficiency power electronics expertise in the design of an enterprise server power-supply unit (PSU) featuring an 80% improvement in power density with 1% better efficiency — up to 99.2% — for data-center applications, compared with enterprise server power supplies using a traditional architecture. A 1% improvement equals 1MW (or 800 households) total cost of ownership (CoO) savings per data center, according to Energy Innovation.

Delta Electronics — which provides power- and thermal-management solutions and AC/DC, DC/DC and DC/AC power systems for applications including IT, electric vehicle (EV) charging, appliances and industrial power — chose TI due to its decade-long investment in GaN technology as well as its real-time control solution with C2000 MCUs.

"Our GaN technology enables a whole new world of higher-efficiency and smaller, more reliable solutions," says Steve Lambouses, vice president for High Voltage Power at TI. "In addition to technology investments, TI's investments in internal manufacturing will allow new technologies like GaN to scale quickly and support customers like Delta," he adds.

"Delta's long-term focus on reducing mankind's carbon footprint through energy-efficient products and solutions entails long-term collaboration with industry leaders such as TI in regards to next-generation technologies. GaN has crossed the threshold from being a future technology to an immediate, viable option available today for new designs of power supply systems," says Jimmy Yiin, VP & general manager of the Power and System Business Group at Delta Electronics. "This is especially true for server PSUs, for which we are looking to exceed 98% efficiency and 100W/inch^3 of power density," he adds. "The next several years will be exciting because GaN will revolutionize power design and architectures as we know them."

Texas Instrument's investments in internal manufacturing will allow new technologies like GaN to scale quickly and support customers like Delta Electronics

Integrated GaN ICs deliver higher efficiency, power density and system reliability

- In high-voltage, high-power industrial applications, integrated power-supply solutions are better able to achieve high performance within limited board space. TI's GaN field-effect transistors (FETs) integrate a fast-switching driver, plus internal protection and temperature sensing.
- The ICs are backed by more than 40 million hours of device reliability testing and more than 5GWh of power conversion testing, providing rigorous reliability data to support engineers who want to consider GaN to build power systems that are smaller, lighter and more efficient.
- When coupled with TI GaN power solutions, TI's C2000 real-time MCUs deliver benefits such as complex, time-critical processing, precision control, and software and peripheral scalability, says the firm. Additionally, the MCUs unlock the potential of GaN-based power solutions for server PSUs by supporting different power-design topologies and high switching frequencies to maximize the design's power efficiency.

Manufacturing and long-term investment strategy offer volume scalability

- TI says that its unique combination of process, package and circuit-design techniques simplifies manufacturing and enables it to scale GaN-on-Si production volume by configuring different options to support the changing needs of telecom, industrial and automotive companies.
- TI's GaN epitaxy and assembly/test footprint enables the firm to address tool redundancies, as required.
- TI reckons that its long-term investment and flexible manufacturing strategy will allow it to grow as a GaN and real-time MCU supplier, as market demand increases and the trend continues toward smaller systems supporting more data.

During the TI Live! Tech Exchange virtual event (27–29 September), TI and Delta Electronics co-presented an 'Industry Insight' session 'The Impact of GaN Technology and What It May Mean for Future Industrial Designs'. During the event, TI experts discussed power management, automotive, real-time control, vision sensing and design trends in a series of keynotes, roundtable discussions, technical sessions and demonstrations.

www.ti.com/power-management/gan/overview.html

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GaN Systems signs capacity agreement with BMW

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) has signed a comprehensive capacity agreement with BMW Group for GaN Systems' automotive-grade GaN power transistors, which increase the efficiency and power density of critical applications in electric vehicles (EVs).

GaN power semiconductors are a key ingredient to achieve the small size, light weight and high efficiency required in the next generation of high-performance electric vehicles. Under the terms of the agreement, GaN Systems will provide capacity for multiple applications in series production. The guaranteed volumes by GaN Systems are a key building block for reliability in the supply chain for automotive players like BMW, the firm says.

"Electric vehicles represent the future of transportation, and we are delighted to continue to support BMW with our design and production capacity," says GaN Systems' CEO Jim Witham. "This multi-$100m agreement demonstrates BMW's commitment to innovation and sustainability."

BMW's relationship with GaN Systems began more than four years ago when BMW's engineers found that small-size, lightweight, low-cost onboard chargers (OBCs), DC/DC converters, and traction inverters were enabled by GaN. This led to investment from BMW's venture capital firm BMW i Ventures to support and accelerate automotive qualification of the GaN technology.

"The close collaboration among GaN Systems and BMW's engineers has helped to solidify the technology for automotive series production, resulting in the most advanced GaN power transistors in the marketplace today," says Kasper Sage, managing partner BMW i Ventures. "As electric vehicles become more prominent, the demand for critical semiconductor components is only going to increase, thereby making strategic partnerships with suppliers like GaN Systems even more important."

www.gansystems.com

GaN Systems launches 3kW bridgeless totem pole PFC + LLC resonant converter power supply unit

GaN Systems has introduced a high-efficiency, high-power-density 3kW bridgeless totem pole (BTP) PFC + LLC resonant converter power supply unit (PSU) that exceeds the 80+ Titanium standard. The combination enables designers to create lower-cost power supplies that meet demands to deliver more power in a smaller footprint and new energy-efficiency requirements, including the EU's 'Lot 9' 2023.

"With the expanding volume of data, game-changing solutions are needed to reduce energy consumption and contribute to a more sustainable future in our data centers, and these PFC and LLC reference designs take PSUs to the next level," says Paul Wiener, VP of strategic marketing.

Increasing efficiency and power density while reducing size and cost obstacles

New efficiency mandates, increasing power and data demands, and the shift to 'dollars per density' (where density is a measure of size and power of the power supply) spur the immediate need to change data-center economics with smaller, more efficient, and reliable power supply designs.

GaN brings higher efficiency, higher power density, lower cost, and increased sustainability to the data-center ecosystem. GaN Systems concluded that significant energy and cost savings are achieved by switching from silicon-based PSUs to GaN-based PSUs. Since data centers vary in size, the savings are based on a 10-rack unit of measure. From a sustainability perspective, each set of 10 racks reduces CO_2 emissions by 100 metric tons per year and, financially, GaN-based PSUs increase data-center profits by $3m per year.

3kW AC/DC PSU design

Most high-efficiency power supplies are designed with a bridgeless or semi-bridgeless PFC stage and a resonant DC–DC stage such as an LLC resonant converter. GaN Systems says that, together, the 3kW BTP-PFC and 3kW LLC converter designs exceed 80+ Titanium efficiency requirements, achieve high power density above 80W/inch^3, and reduce PSU total cost.

- 3kW BTP is the latest technology for a high-efficiency PFC. GaN Systems says that its reference design offers less conduction loss and enables near 99% peak efficiency due to no body diode loss and the higher performance of GaN transistors. Other benefits include using 40% fewer components and a 10–25% reduction in system cost.
- GaN Systems says its 3kW LLC reference design offers higher frequency (>200kHz for higher power density) and higher efficiency at both light and full load. The 54V output can support 48V power architectures for data centers. The design highlights a power density of 146W/inch^3 (air-forced cooling) and >98% peak efficiency, achieved with a resonant frequency at 250kHz and at a maximum frequency at 400kHz.
- Both 3kW BTP PFC and LLC reference designs use the latest-generation 650V E-mode transistor GS-065-030-2-L (said to be the first GaN product on the market that enables designers to get the advantages of low-cost GaN in applications at the 3000W level).

ST introduces 45W and 150W MasterGaN devices for high-efficiency power conversion

MasterGaN3 & MasterGaN5 integrated in 9mm x 9mm GQFN packages

Aiming to ease the transition to high-efficiency wide-bandgap semiconductor technology, device maker STMicroelectronics of Geneva, Switzerland has released the MasterGaN3 and MasterGaN5 integrated power packages for applications up to 45W and 150W, respectively.

Joining MasterGaN1, MasterGaN2, and MasterGaN4, which target applications from 65W to 400W, the additions give extra flexibility to choose the optimum gallium nitride device and driver solution when designing switched-mode power supplies (SMPS), chargers, adapters, high-voltage power factor correction (PFC), and DC/DC converters.

ST says that its MasterGaN concept simplifies migrating from ordinary silicon MOSFETs to GaN wide-bandgap power technology. The devices integrate two 650V power transistors with optimized high-voltage gate drivers and associated safety and protection circuitry, eliminating gate-driver and circuit-layout design challenges. Combined with the higher switching frequencies possible with GaN transistors, these integrated devices enable power supplies that are up to 80% smaller than silicon-based designs as well as being extremely robust and reliable.

The GaN power transistors of MasterGaN3 devices have asymmetrical on-resistance ($R_{ds(on)}$) of 225mΩ and 450mΩ, making them suited to soft-switching and active-rectification converters. In MasterGaN5 both transistors have 450mΩ $R_{ds(on)}$ for use in topologies such as LLC-resonant and active clamp flyback.

In common with other MasterGaN family members, both devices have inputs compatible with logic signals from 3.3V to 15V, which simplifies connection of a host DSP, FPGA or microcontroller, and external devices such as Hall sensors. They also integrate protection including low-side and high-side undervoltage lockout (UVLO), gate-driver interlocks, over-temperature protection, and a shutdown pin.

Each MasterGaN device is supported with a dedicated prototype board to help designers jump-start new power supply projects. The EVALMASTERGAN3 and EVALMASTERGAN5 boards contain circuitry to generate single-ended or complementary driving signals. There is an adjustable dead-time generator, as well as connections for the user to apply a separate input signal or PWM signal, add an external bootstrap diode to help with capacitive loads, and insert a low-side shunt resistor for peak-current-mode topologies.

Housed in a 9mm x 9mm GQFN package optimized for high-voltage applications with 2mm creepage distance between high-voltage and low-voltage pads, MasterGaN3 and MasterGaN5 are in production now, priced from $6.08 for MasterGaN3 and $5.77 for MasterGaN5, for orders of 1000 pieces.

www.st.com

Astranis chooses EPC Space's rad-hard GaN power devices for small geostationary communications satellites

15% greater lifetime and 20% greater throughput, without increasing hardware costs

EPC Space LLC of Haverhill, MA, USA has been selected by Astranis to provide rad-hard gallium nitride (GaN)-based power devices for use in DC power supplies on the latest satellite build. Astranis announced earlier that it has started to build four new small geostationary communications satellites, three of which are already spoken for signed deals with new, yet-to-be-announced customers.

This new build of Astranis satellites is expected to offer 15% greater lifetime and 20% greater throughput than the first-generation model, without increasing satellite hardware costs.

Astranis is building small, low-cost telecommunications satellites to connect the 4 billion people who currently do not have access to the Internet. Each spacecraft operates from geostationary orbit (GEO) with a next-generation design weighing only 400kg. By owning and operating its satellites and offering them to customers as a turnkey solution, Astranis can provide bandwidth-as-a-service and unlock previously unreachable markets, it is reckoned.

The rad-hard GaN power devices that EPC Space is providing to Astranis provide high precision, small size, low weight, and can withstand the harsh environment of space.

"This program will add to the tens of thousands of our units already on board of satellites flying in LEO and GEO orbit with mission lives of more than 10 years," says EPC Space's CEO Bel Lazar.

www.epc.space

VisIC raises $35m in funding round led by GoldenSand

Industrial partner SuZhou joins as co-investor with extra $10m

To support "strong demand coming from a rising number of automotive clients", VisIC Technologies Ltd of Ness Ziona, Israel – a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors – has completed a $35m funding round led by GoldenSand Capital and HG Semiconductors through Fast Semi Corp. Industrial partner SuZhou joined the investment round as a co-investor with an additional $10m.

VisIC provides GaN electronic devices for electric transportation (xEV) applications, focused on high-power automotive solutions.

"The electrification of the automotive industry has generated significant demand for power components, which we foresee to continue its strong growth for the next decade," says VisIC's CEO & co-founder Dr Tamara Baksht.

"At the same time, the efficiency of battery energy usage is critical for the cost and performance of electric cars, and GaN-based components are superior over competing technologies for high efficiency. With this investment round, we will be able to expand our product offer and provide better customer support to our customers."

Sonny Wu, representing Fast Semi, will join VisIC's board of directors. Sonny co-founded GSR Ventures in 2004 and is currently chairman of GoldenSand Capital, with notable investments in the technology and new energy space, including Lattice Power (which won the China National First Prize for Science & Technology in 2015), Silevo Solar (sold to SolarCity/Tesla in 2014), SEEO (one of the first solid-state battery companies, later sold to Bosch in 2013), Aleees (the largest lithium iron phosphate material company in Asia), and Ronbay New Energy Technology Co Ltd (the fastest-growing EV battery NMC 811 cathode material firm in China, with an IPO on the Shanghai STAR exchange in July 2019).

As a board member he will lead VisIC's marketing of automotive GaN devices in the China market through GSR Semiconductors and its High Power and Fast Charge Technology Lab in ShenZhen,

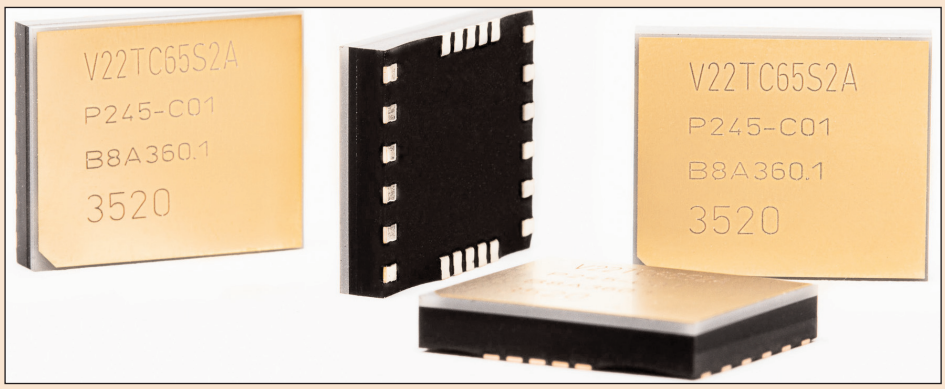
"GSR is investing in technologically game-changing companies and I am very impressed by VisIC's product and by its highly knowledgeable team," comments Sonny Wu. "We are excited about the opportunity to work with Tamara Baksht, Gregory Bunin and the team to accelerate the usage of GaN."

www.visic-tech.com

VisIC introduces 7.2kW bidirectional totem-pole power factor correction reference design

D³GaN power switch for high-power on-board chargers for EVs

VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors for automotive high-voltage applications — has announced its new reference design for totem-pole power factor correction (PFC) aimed at on-board chargers (OBC) for electric vehicles (EVs). The firm says that the reference design is another step in the ongoing effort to support customers and improve the power conversion systems to fit the demanding size, cost and efficiency targets for the automotive market.



VisIC's top-cooled V22TC65S1A GaN devices.

On-board chargers now embrace the bidirectional requirements of the vehicle-to-grid (V2G) and grid-to-vehicle (G2V) functions by using new topologies such as the totem-pole PFC. The new reference design from VisIC is targeted at the higher-power segment of 7.2kW with increased efficiency, size and cost structure.

Based on the VisIC V22TC65S1A 22mΩ, 650V, 100A GaN device that is optimized for the PFC stage, the design requires a single device per leg and achieves a power density above 130W/inch^3, or 8kW/L, operating at 140kHz without paralleling GaN devices and giving an efficiency above 98%.

The reference design kit includes everything needed to operate the unit in both PFC and inverter modes, from the on-board firmware on MCU to the coldplate for high-power operation, as well as all the design files.

www.visic-tech.com

Odyssey announces CEO transition and appointment of John Edmunds as chairman

Co-founder & CTO Rick Brown made interim CEO; Alex Behfar resigns as CEO & board member

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA, which is developing high-voltage power switching components based on proprietary gallium nitride (GaN) processing technology, says that co-founder, chief technology officer & board member Rick Brown has been appointed as interim CEO, effective 22 September. He replaces Alex Behfar, who has resigned as CEO, chairman & board member. The firm has initiated a search for a permanent CEO to succeed Behfar.

"Alex was instrumental in efforts to advance our proprietary technology that will allow for gallium nitride (GaN) to replace silicon carbide (SiC) as the leading high-voltage power switching semiconductor material," comments Brown. "The premium power switching device market, which is described as applications where SiC-based systems perform insufficiently, is projected to reach over $3.5bn by 2025. While we have benefited from Alex's contributions, we remain on a very strong course and wish him well in his future endeavors," he adds.

"I am proud of the successes that we have achieved together, and the company is well positioned for long-term growth," says Behfar.

The board of directors has also appointed John Edmunds as chairman. He recently joined the Odyssey board as an independent member and brings over 40 years of financial experience, including 20 years as a public company chief financial officer with fast-growing semiconductor companies.

"During this transition period, it is our priority to ensure that we receive input broadly in naming the best individual to lead the company, while maintaining a stable and effective organization," states Edmunds. "We will continue to share updates about our leadership and technology developments and appreciate the continued support of our shareholders as we bring Odyssey closer to the commercial launch of its unique vertical GaN high-voltage power switching semiconductors."

www.odysseysemi.com

Navitas and Live Oak II announce extra $10m PIPE investment, raising total expected to $155m

GaN power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland and its partner Live Oak Acquisition Corp II, a publicly traded special-purpose acquisition company (SPAC), have provided updates related to their proposed business combination, which values the combined entity at a pro forma equity value of $1.04bn. Live Oak II is a blank check company whose business purpose is to effect a merger, capital stock exchange, asset acquisition, stock purchase, reorganization or similar business combination with one or more firms.

Since gallium nitride (GaN) is reckoned to run up to 20x faster than silicon, Navitas' proprietary GaNFast power ICs are said to deliver up to 3x faster charging and 3x more power in half the size and weight, and with up to 40% energy savings compared with silicon chips. Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power ICs, which monolithically integrate GaN power field-effect transistors (FETs) and drive plus control and protection circuits, enabling faster charging, higher power density and greater energy savings for mobile, consumer, enterprise (data center, 5G), renewables (solar, energy storage) and electric vehicles (EVs)/eMobility markets. With over 130 patents issued or pending, and significant trade secrets including a proprietary process design kit (PDK), Navitas believes it has a multi-year lead in next-generation GaN power ICs.

Since news of the business combination on 7 May, the number of OEM chargers in mass production containing Navitas GaNFast power ICs has increased from 75 to over 140 (more than all GaN competitors combined, reckons Navitas). The number of GaNFast power ICs shipped has also increased, from over 18 million to over 25 million (with zero reported field failures).

In addition to its disclosed tier-1 customers such as Dell, Amazon, LG Electronics, Xiaomi and Belkin, Navitas recently showcased testimonials from partners across all target end-markets. This includes OPPO in the fast-charger market for smartphones, Lenovo in mobile and data center, Enphase Energy in the solar market, and EV system supplier Brusa Elektronik AG.

Increased PIPE

When Navitas and Live Oak II entered into the definitive agreement for the business combination, Live Oak II also entered into subscription agreements for an oversubscribed and upsized $145m private placement of Class A common stock in Live Oak II at $10 per share (the 'PIPE' private investment in public equity) from a diversified group of institutional investors.

On 17 August, Live Oak II entered into a subscription agreement with an affiliate of Atlantic Bridge (an existing investor in Navitas) for an extra $10m of Class A common stock to be issued in the PIPE, on the same terms as the existing PIPE investors.

Previously, in December 2020, Live Oak II raised $253m, and its units, Class A common stock and warrants are listed on the NYSE under the tickers 'LOKB.U', 'LOKB' and 'LOKB WS', respectively.

Redemption backstop

Live Oak II has also entered into a redemption backstop agreement with Encompass Capital Advisors LLC, an institutional investment manager primarily focused on investing across the energy eco-chain.

In the agreement, and subject to certain conditions and including limitations on pricing, Encompass has agreed to direct certain fund entities and/or managed accounts, for which it has investment discretion to offer to purchase up to 2 million shares of LOKB Class A common stock prior to the closing of the business combination. Encompass has also agreed to not redeem any shares of Class A common stock in connection with the business combination, and to vote any shares of Class A common stock held by Encompass as of the record date for the special meeting in favor of the business combination and all other proposals to be presented at the special meeting, provided that such proposals have been approved and recommended by the LOKB board for approval by LOKB's stockholders.

"We welcome Encompass and their support of our business, particularly given their focus on the renewables and electric vehicle end markets," says Navitas' co-founder & CEO Gene Sheridan. "This kind of support means that we can focus on new generations of products, new markets, and new customers."

www.navitassemi.com

Live Oak II's registration statement declared effective by SEC

Live Oak II's registration statement on Form S-4 filed in connection with its proposed business combination with Navitas has been declared effective by the US Securities and Exchange Commission (SEC).

Live Oak II also announced a record date of 13 September and a meeting date of 12 October for its special meeting of stockholders to approve the business combination. Its closing is subject to approval by Live Oak II's stockholders, and the satisfaction of other customary closing conditions.

Upon closing, the combined company is expected to be listed on the Nasdaq Global Market with its common stock and warrants trading under the new ticker symbols 'NVTS' and 'NVTSW', respectively.

Navitas and SHARGE shrink 100W fast charger by a further 12%, now 60% smaller than silicon solution

GaN design delivers simultaneous fast-charging for four mobile devices

Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has announced the launch by SHARGE (Shine Technology (Shenzhen) Co Ltd) of the upgraded 100W GaN Charger Pro, which is reckoned to be 60% smaller than legacy silicon four-output chargers, and 12% smaller than the 2020 GaN model, with optimized design and performance. With 3x USB Type-C and 1x USB Type-A outputs, the GaN Pro can simultaneously fast-charge four mobile devices, from earbuds and smartphones up to the 16" Apple MacBook Pro using dynamic power sharing to optimize charging speeds.

Founded in 2014, Navitas introduced what it claimed to be the first commercial gallium nitride power integrated circuits. Its proprietary GaNFast power ICs monolithically integrate GaN power field-effect transistors (FETs) and GaN drive plus control and protection circuits in a single SMT package. Since GaN is reckoned to run up to 20x faster than silicon, GaNFast power ICs are said to deliver up to 3x faster charging and 3x more power in half the size and weight, and with up to 40% energy savings compared with silicon chips. An estimated $13.1bn market opportunity includes mobile fast chargers and adapters, data centers, solar energy and electric vehicles (EVs).

By exploiting the high-speed, high-efficiency performance of GaNFast technology, SHARGE's 100W GaN Pro measures only 77mm x 59mm x 29mm (131cc) to achieve a power density of 0.76W/cc at a lightweight 220g, and retails for only RMB535 ($83).

Navitas' GaNFast in SHARGE 100W fast charger.

The 100W GaN Charger Pro features three USB-C ports and one USB-A port, supporting PD/QC/PPS and other common protocols. The C1 and C2 ports alone can deliver up to 100W of power, while the C3 and A1 ports alone can deliver up to 20W and 22.5W, respectively. When multiple interfaces are used simultaneously, it can provide power to different devices through dynamic power distribution. With four charging ports, users can replace four regular silicon single-port chargers with one charger, saving bulk, weight and AC-outlets.

To achieve the size and weight reductions, the 100W GaN Charger Pro uses GaNFast power ICs in two high-speed 'soft-switching' topologies. The first is a CrCM boost power-factor correction (PFC) circuit, using Navitas' NV6127 (125mΩ) GaN power ICs to convert rectified AC power to a stable 400V DC rail. This is followed by a high-speed, isolating LLC DC–DC stage with two NV6115 (170mΩ) ICs to efficiently step-down the voltage to ~20V for the USB-PD output stages. A single system-controller IC (MPS HR1211) operates both circuits. The GaNFast ICs are rated at 650/800V, and up to 2MHz switching frequency in small QFN SMT packages. Thanks to the integration of GaN FET, GaN drive, protection and control, no external drivers are needed (which saves PCB space) and high-speed (switching-frequency) operation shrinks the size and cost of transformers, filters and capacitors.

"As a pioneer in GaN fast charging, with rich experience in design, production, certification and launch, XinSPower has become the 'go-to' partner for Asus, IDMIX, Baseus, SHARGE, ZENDURE, MOMAX and other brands," claims Xianqing Liu, general manager of industrial fast-charger manufacturer XinSPower (Shenzhen Xinspower Technology Co Ltd), which was founded in 2008 and has become the GaNFast foundry for those brands. "GaN will be used in more high-power charging and more diversified charging devices in the future," he adds. "XinSPower and Navitas will jointly come up with GaN-enabled products — e.g. wireless charger, power strips, mobile power and other more diversified charging applications — to help major brands to create breakthrough models."

www.sharge.tech
www.navitassemi.com

CSC participating in €1.7m PowerElec project on metrology tools for wide-bandgap quality control

EMPIR–EURAMET-funded project led by UK's NPL, together with Infineon, IQE, Aixtron and CSC

The Compound Semiconductor Centre (CSC, a joint venture founded in 2015 between Cardiff University and epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK) — which is a partner in the CSconnected compound semiconductor cluster formed in South Wales in 2017 — has announced its participation in PowerElec, a new €1.7m project within the European Metrology Programme for Innovation and Research (EMPIR–EURAMET) running from June 2021 to May 2024 to develop and apply new metrological tools for quality control of wide-bandgap semiconductors.

As a key technology for the electrification of transport, smart-energy distribution and next-generation communications, power electronics is expected to aid the UK's 'green recovery' and net-zero ambitions. The next generation of power electronics will be driven by the shift from silicon to wide-bandgap compound semiconductor materials (gallium nitride, silicon carbide and, in future, gallium oxide), which offer huge performance benefits in terms of efficiency, weight, high-frequency and high-temperature performance over existing silicon-based solutions. However, their sensitivity to nanoscale material defects presents a barrier to upscaling and commercial adoption. The project will develop new instrumentation, non-destructive measurement methods and agreed standards for the characterization of wafer quality at multiple levels in the material and device fabrication process.

The project is led by the UK National Physical Laboratory, with key European industry partners (Infineon, IQE, Aixtron, CSC) as well as other national metrology institutes and international standards organizations to support the growth of European compound semiconductor supply chains.

"Metrology is often undervalued in a transition from development to commercialization, but it is critical to have comprehensive metrology to support yield and cost control when scaling new semiconductor technologies," says Rob Harper, GaN Programme Manager at CSC. "The activity will complement CSC's activities in GaN-on-SiC and GaN-on-silicon RF and power epitaxial products, which include lateral HEMTs and vertical trench FETs," he adds.

"The UK has a leading position in compound semiconductor materials technology, centred on the South Wales CSconnected Cluster, and we are pleased to be part of a new European ecosystem to address high-growth segments in a global power electronics market worth in excess of $35bn per annum," comments CSC's director Wyn Meredith.

www.euramet.org/research-innovation/research-empir

Transphorm's revenue grows 33% in June quarter, driven by GaN demand for fast chargers

Company closes $5m private placement and completes planned fab transaction after quarter-end

For its fiscal first-quarter 2022 (ended 30 June 2021), Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion applications — has reported revenue of $3.2m, up 33% on $2.4m last quarter. Growth was driven by record product sales from ramping shipments of GaN devices for fast chargers and adapters as well as increased traction for higher-power conversion applications including gaming, data centers and crypto-mining. Year-ago revenue was $6.3m, but that included $5m of licensing revenue from manufacturing partner Nexperia (related to funding of technology development).

"We achieved another consecutive quarter of strong sequential growth and record product revenue," notes president & co-founder Primit Parikh. "We more than doubled shipments of Transphorm's GaN power devices for the third consecutive quarter to fulfill growing customer demand in the consumer adapter and high-power markets," he adds.

On a non-GAAP basis, operating expenses have grown further, from $3.9m a year ago and $4.5m last quarter to $4.6m.

Net loss has grown further, from $0.3m ($0.01 per share) a year ago and $5.2m ($0.13 per share) last quarter to $5.3m ($0.13 per share). However, this includes a $1.5m loss in joint ventures. Operating loss was $4.6m.

Net cash used in operating activities was $4.8m, while $2m was invested in joint ventures and $0.35m in purchases of property and equipment. So, during the quarter, cash and equivalents fell by about $7m, from $9.5m to $2.5m. However, in a subsequent private placement transaction completed on 13 August, the firm closed $5m of equity financing at $5 per share from a multi-billion-dollar public company in Asia with international operations in the semiconductor ecosystem.

"We recently completed the planned transition of our AFSW wafer fab into a new JV with a strong strategic financial partner that shares our goals of accelerating GaN adoption," says Parikh. "Looking ahead, our team remains focused on expanding capacity over the coming quarters, as we continue to secure and ramp a growing pipeline of design wins," he adds.

"Along with the strong operating performance, the company remains committed to its previously communicated ambition to uplist on the NASDAQ later in the calendar year," states CEO Mario Rivas. "In July, we were also excited to strengthen our board, with the addition of Ms Kelly Smales as an independent director, with an extensive semiconductor finance background."

www.transphormusa.com

Enkris' demonstrates CMOS-compatible high-voltage GaN-on-Si HEMT epiwafers reaching 300mm

Optimized AlN nucleation layer yields crack-free epiwafers meeting leakage current requirements

Enkris Semiconductor of Suzhou Industrial Park, China — which was founded in 2012 as a pure-play foundry for gallium nitride (GaN) epitaxial wafers for power electronics, RF, micro-LED and UVC applications — says that it has demonstrated a series of high-quality 300mm GaN-on-silicon high-electron-mobility transistor (HEMT) epiwafers of what it claims are excellent thickness uniformity and low wafer bow for 200V, 650V and 1200V power applications, paving the way for device processing using more sophisticated 300mm CMOS-compatible lines.

Advances in GaN epitaxy on large-size silicon substrates have enabled GaN-on-Si power devices with high performance and reliability by combining the full advantage of both the properties of GaN and production in a CMOS-compatible processing line, says Enkris. Commercial GaN power devices based on GaN-on-Si HEMT technology are gaining in popularity for a wide range of applications such as consumer electronics, industrial electronics and data centers, and in the energy, automotive and mobility sectors. Driven by cost reduction and more sophisticated integrated circuit design, the industry is now moving towards larger wafer sizes, notes Enkris.

Following its launch of commercial 200mm GaN-on-Si HV (high-voltage) HEMT epiwafers in 2014, Enkris has now transferred its AlGaN/GaN HEMT epitaxy process to 300mm silicon substrates, while maintaining the thickness uniformity as well as low wafer bow within 50μm. The vertical voltage breakdown measurements suggest that the wafers are suitable for 200V, 650V and 1200V power applications (see Figure 1).

The 300mm GaN-on-Si HEMT epitaxial layer structure adopted to solve the key issues of wafer cracking/bow and high crystalline defects is shown in Figure 2(a). Growth starts with an AlN nucleation layer, followed by a strain relief stack, GaN channel, AlGaN barrier and GaN cap. The narrow x-ray diffraction (XRD) AlN(002) peak and good uniformity of FWHM (full width at half maximum), as shown in Figure 2(b), indicate a high crystalline quality across the whole 300mm-diameter wafer.

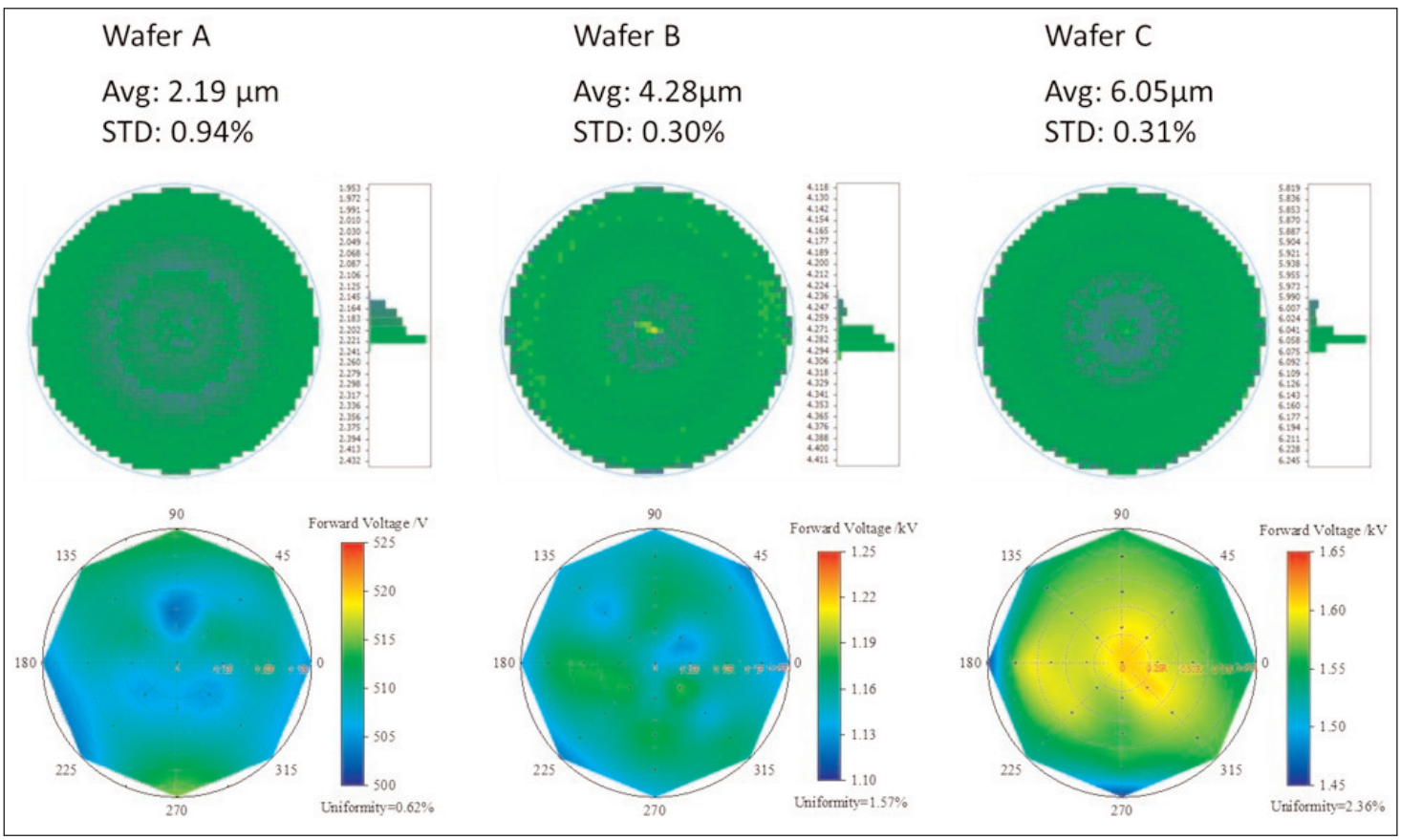


Figure 1: Thickness map and vertical breakdown voltage (leakage current = 1μA/mm² @ RT) of a series of Enkris 300mm GaN-on-Si HEMT epiwafers targeting 200V, 650V and 1200V power applications, respectively.

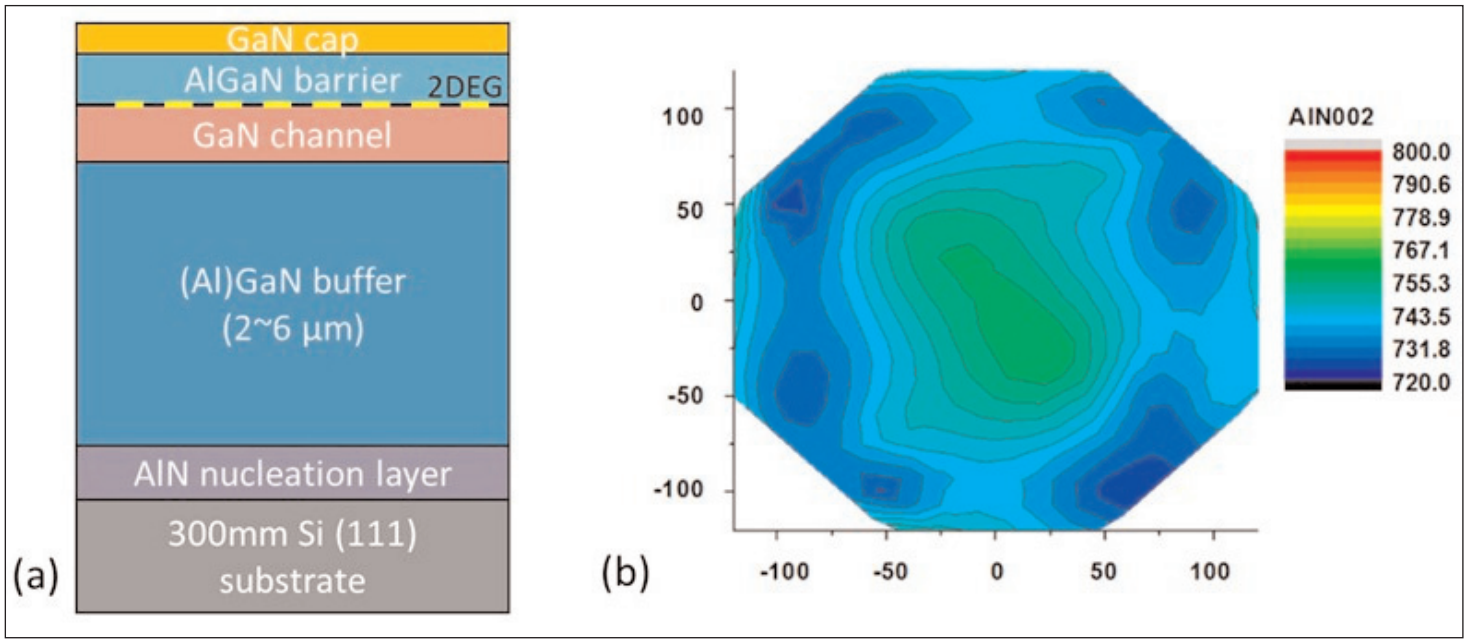


Figure 2: (a) Schematic structure of Enkris 300mm GaN-on-Si HEMT epiwafers. (b) Map of XRD AlN(002) FWHM, giving an average FWHM value of 743arcsec and a STD of 2%.

Figure 3 shows the aluminium composition in the AlGaN barrier and the two-dimensional electron gas (2DEG) carrier concentration measured at nine positions from wafer center to wafer edge. The measurements give an average value of 19.9% and a standard deviation (std) of 0.68% of Al composition in the AlGaN barrier (Figure 3a), suggesting a uniform 2DEG electrical characteristics. This has been confirmed by the capacitance–voltage (CV) measurements, revealing an average electron concentration of $7.2x10^{12}cm^{-2}$ with a std <2% (Figure 3b).

"Thanks to our optimized AlN nucleation layer, we are able to produce crack-free GaN-based HEMT epiwafers that meet the leakage current requirements on large-size silicon substrates up to 300mm," says CEO Dr Kai Cheng. "Despite the challenges in the epitaxy process, strain management and defect control when moving to 300mm wafer size, we have achieved excellent structural quality and electrical properties in the AlGaN/GaN HEMT structures. This will certainly encourage the development of high-power integrated circuits to yield system-on-chip and further reduce the cost of GaN power devices," he reckons.

www.enkris.com

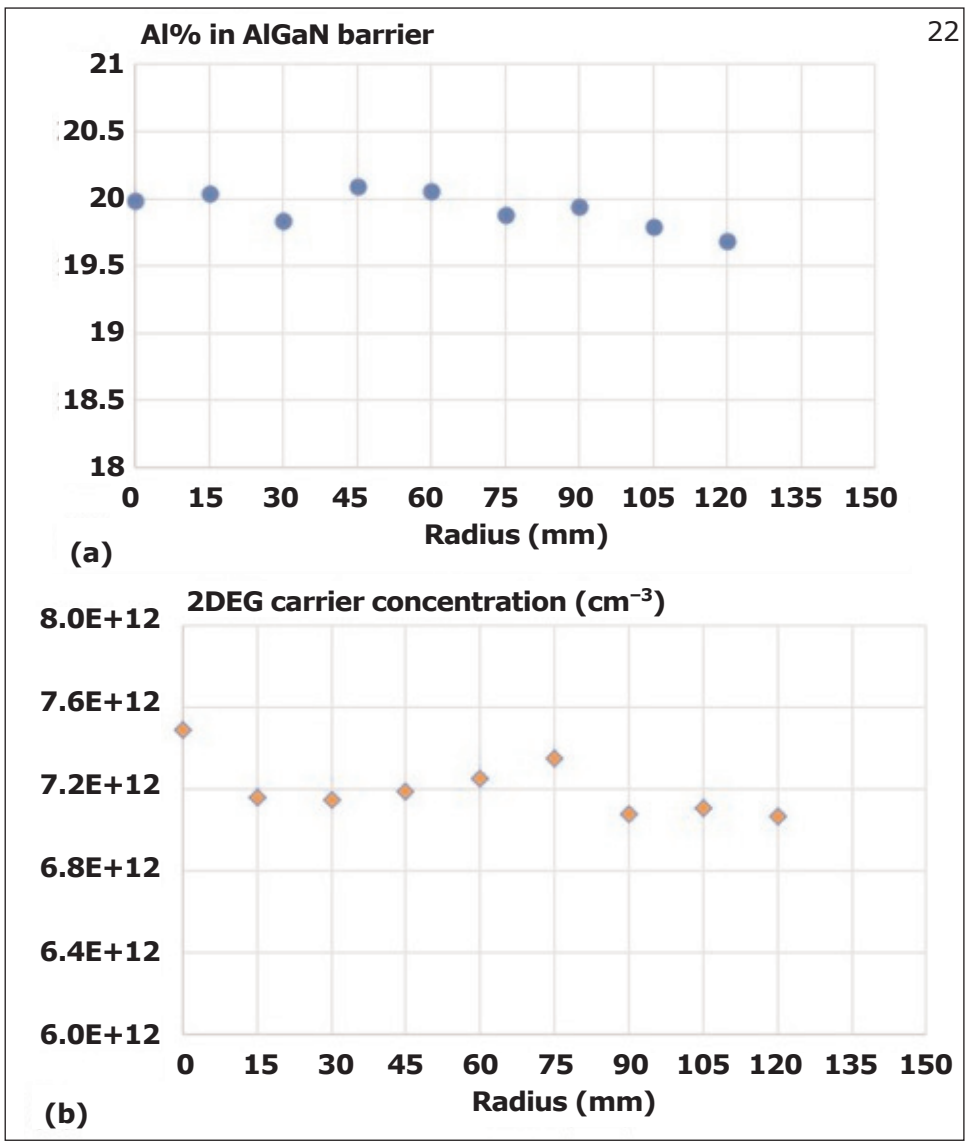


Figure 3: Al composition and 2DEG electron concentration measured from Enkris' AlGaN/GaN HEMT epiwafer grown on 300mm silicon substrates.

Engis launches high-precision vertical grinding machines

EVG series reduce or eliminate need for lapping wafers

Engis Corp of Wheeling, IL, USA, which provides superabrasive lapping, grinding, honing and polishing products, has launched the EVG Series of high-precision vertical grinding machines for the production of ultra-smooth surfaces. The machines have been designed to grind advanced materials to a high degree of precision in flatness and surface quality, greatly reducing or even eliminating the need for subsequent lapping, moving directly from grinding to final polish.

Applications include grinding or back-thinning of semiconductor wafers — e.g. silicon carbide (SiC), gallium arsenide (GaAs), sapphire, silicon, gallium nitride (GaN), aluminium nitride (AIN) and indium phosphide (InP) — of semiconductor processing equipment components (e.g. ceramic chucks, glass ceramic) and of substrates for semiconductor advanced packaging, including MEMS (ceramic, polyimide).

The new machines are available in three different models (EVG-200, EVG-250 and EVG-300), all of which incorporate a programmable logic controller, 400rpm (maximum) work-table speed and 2000rpm (maximum) wheel speed. Sizes vary from 800 x 800 x 1900 for the EVG-200 up to 1050 x 1050 x 2020 for the EVG-300. All have been designed with ergonomics in mind, with easy access to the work area and with a variety of chuck options.

Engis' new EVG machines.

Advanced machine control options are available, providing automated grinding wheel dressing, automated positioning of the grinding wheel relative to the workpiece, and workpiece thickness measurement. For maximum control, an upgrade to in-process thickness measurement with feedback to the grinding cycle in real time is also available.

The most advanced model offers automated thickness options: multi-point contact probing for multiple wafer grinding or a choice of contact or non-contact continuous in-process measurement for single-wafer machining.

EVG Series machines are equipped with Engis grinding wheels based on the Mixed Abrasive Diamond (MAD) wheel technology, which tailors the wheel to the material being processed.

Engis says that its specialist application engineers can provide specific process recommendations for particular materials and applications.

www.engis.com

Arizona State & Michigan State diamond spin-offs sign MoU

Materials and device startups team for commercialization of diamond semiconductors

Arizona State University (ASU) diamond device startup Advent Diamond Inc and Michigan State University (MSU) diamond materials startup Great Lakes Crystal Technologies (GLCT) have signed a memorandum of understanding (MoU) to team together to capitalize on mutually beneficial company growth opportunities in crystalline diamond-based materials, devices and applications.

The MoU identifies a number of specific partnership opportunities including joint federal R&D grant proposals, intellectual property licensing, co-marketing of products and capabilities, co-development of new products, and strategic customer-supplier relationships.

"This strategic alliance between Advent and GLCT is poised to make the commercialization of diamond semiconductor devices successful," reckons Advent's CEO Manpuneet Benipal.

"Our partnership with Advent is very exciting because they have a great team, we have complementary mission statements, and there is much we can do better together than separately," says GLCT's president & CEO Keith Evans. "Our respective technical founders often team together as well, such as co-chairing diamond workshops and conference symposia, and in pursuing joint federal R&D support."

GLCT's technical founder and MSU professor Tim Grotjohn and Advent's technical founder and ASU professor Bob Nemanich last year joined forces to win four years of US Department of Energy (DOE) support to establish an ASU-led, MSU-supported, Energy Frontier Research Center (EFRC) called 'Ultra Materials for a Resilient, Smart Electricity Grid' (ULTRA).

www.adventdiamond.com
www.glcrystal.com

Applied Materials launches CMP and hot ion implant systems for 200mm silicon carbide wafer production

Further products for 200m SiC PVD, CVD, etch and process control being developed

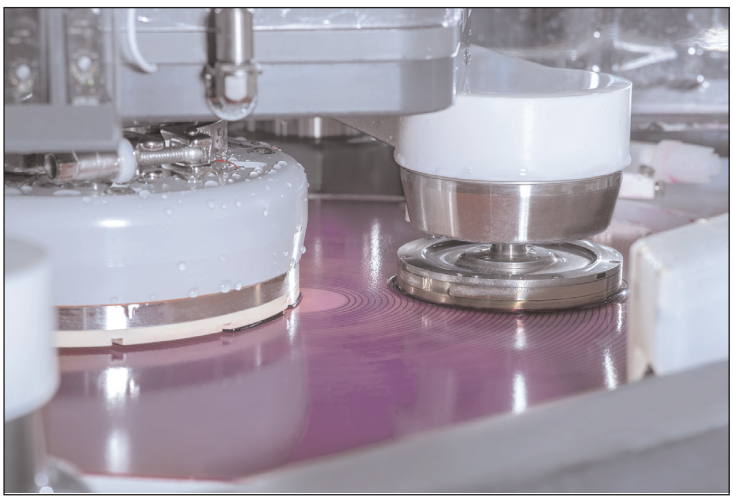
Process equipment maker Applied Materials Inc of Santa Clara, CA, USA has announced new products that aimed at helping to enable silicon carbide (SiC) chipmakers to transition from 150mm wafer production to 200mm production. This approximately doubles die output per wafer, helping to satisfy the growing demand for premium electric vehicle (EV) powertrains.

"To fuel the computer revolution, chipmakers moved to ever-larger wafer sizes, dramatically increasing chip output to satisfy burgeoning global demand," says Sundar Ramamurthy, Group VP & general manager of the ICAPS group at Applied Materials. "Today we are in the early stages of another revolution that will benefit from Applied's expertise in materials engineering at an industrial scale," he adds.

"Electrification of the transportation industry is a rising trend, and we are accelerating this inflection point by leading the global transition from silicon to silicon carbide with our Wolfspeed technology," says Gregg Lowe, president & CEO of SiC materials and device maker Cree Inc of Durham, NC, USA. "Delivering the highest-performing silicon carbide power devices on larger 200mm wafers enables us to increase end-customer value and meet growing demand," he adds. "Applied's support in helping speed qualification of 200mm processes in Albany and multi-equipment installations at our Mohawk Valley Fab is expediting this transition," Lowe says. "Moreover, new technologies being developed by Applied's ICAPS team, such as hot implant, have broadened and deepened our technical collaboration and helped accelerate our power technology roadmap."

New 200mm SiC CMP system

SiC wafer surface quality is critically important to SiC device fabrication as any defects on the surface of the wafer will migrate through the subsequent layers. To produce uniform wafers with the highest-quality surfaces, Applied has developed the Mirra Durum CMP (chemical mechanical planarization) system, which integrates polishing, material removal measurement, cleaning and drying in a single system. The new system has demonstrated a 50x reduction in finished wafer surface roughness compared with mechanically grinded SiC wafers and a 3x reduction in roughness compared with batch CMP processing systems.



Applied Materials' new Mirra Durum CMP system.

The new VIISta 900 3D hot ion implant system.

Hot implant increases SiC chip performance and power efficiency

During SiC chip fabrication, ion implantation places dopants within the material to help enable and direct the flow of current within the high-power-producing circuits. The density and hardness of SiC material makes it extremely challenging to inject, accurately place and activate the dopants while minimizing damage to the crystal lattice, which reduces performance and power efficiency. Applied has solved this challenge with its new VIISta 900 3D hot ion implant system for 150mm and 200mm SiC wafers. The hot implant technology injects and diffuses ions with minimal damage to the lattice structure, resulting in a more than 40x reduction in resistivity compared with implant at room temperature, it is reckoned.

Applied's ICAPS (IoT, Communications, Automotive, Power and Sensors) business is developing additional products for the SiC power chip market, including in PVD (physical vapor deposition), CVD (chemical vapor deposition), etch and process control.

www.appliedmaterials.com

Aehr receives $19.4m order for FOX-XP test and burn-in systems from major automotive semiconductor supplier

Systems to support testing of silicon carbide power devices for EVs

Aehr Test Systems of Fremont, CA, USA has received a $19.4m order from its lead silicon carbide (SiC) test and burn-in customer for multiple FOX-XP systems — to be delivered over the next nine months — to meet its increased production capacity needs.

The customer is a leading Fortune 500 supplier of semiconductor devices with a significant customer base in the automotive semiconductor market, and is using the FOX-XP systems for test and burn-in of silicon carbide devices for electric vehicles (EVs). The corresponding Aehr proprietary WaferPak Contactors for these systems, which are used to make contact with every device on each of 18 wafers in parallel per system, will be purchased in follow-on orders.

"We continue to work closely with this customer to achieve their test requirements and are excited to receive this order for multiple systems, which exceeds the total number of systems this customer has purchased from us to date," says president & CEO Gayn Erickson. "These additional systems are to meet capacity needs of silicon carbide devices used for power conversion components in on-board and off-board electric vehicle chargers as well as the inverters used in electric vehicle motor controllers. This customer also expects silicon carbide capacity in other major markets, including home electric storage and solar power conversion, and we look forward to meeting their demand over the next several years and into the future," he adds.

Aehr Test is currently ramping its FOX Wafer Level Test and Burn-in Systems and WaferPak Contactors to meet the silicon carbide market opportunity that it believes is "only just beginning". Silicon carbide power semiconductors have emerged as the preferred technology for battery electric vehicle power conversion in on-board and off-board electric vehicle battery chargers, and the electric power conversion and control of the electric engines. "The devices reduce power loss by as much as >75% over power silicon alternatives like insulated-gate bipolar transistor (IGBT) devices, which has essentially changed the entire market dynamic. The challenge with silicon carbide is that it is known to have high infant mortality rates. However, with the reliability burn-in and screening that Aehr is able to offer with our FOX product solutions, these defects can be removed to provide extremely reliable devices for these mission-critical applications," continues Erickson.

Aehr's FOX-XP solution allows for one of the key reliability screening tests to be completed on an entire wafer full of devices, testing all of them at one time while also testing and monitoring every device for failures during the burn-in process to provide critical information on those devices. "This is an enormously valuable capability, as it allows our customers to screen devices that would otherwise fail after they are packaged into multi-die modules, where the yield impact is 10 times or even 100 times as costly. Our FOX-P family of products are very cost-effective solutions for ensuring the critical quality and reliability of devices in this market, where performance and reliability can not only mean increased battery life, but also whether you have to walk home from a vehicle whose power semiconductor fails in the power train," says Erickson.

The total market for silicon carbide wafers for power semiconductors for electric vehicles in 2021 will be 133,000 150mm-equivalent wafers, and the total market will exceed 1.23 million 150mm-equivalent wafers in 2030

Aehr's proprietary test and burn-in solutions include customized WaferPaks and DiePaks that are needed not only for new systems orders but also for each new device design or new device added to production test. "As we increase our installed base of FOX systems with current and new customers, particularly with our FOX-NP and FOX-XP multi-wafer and singulated die/module test and burn-in systems, we expect our consumables business will continue to grow in absolute value and as a percentage of our total sales. Over the long term, we expect to see a steady rate of more than 50% of our total annual revenue coming from these consumables," notes Erickson.

The power semiconductor market for electric vehicles is expected to triple between 2020 and 2026, growing at a nearly 26% compound annual growth rate (CAGR) to $5.6bn, according to market research firm Yole. Also, a report from Deloitte forecasts total EV grow at a CAGR of 29% from 2020 to 2025, before reaching 31.1 million by 2030 and securing about 32% of the total market share for new car sales. Market research firm Exawatt (exa-watt.com) estimates that the total market for silicon carbide wafers for power semiconductors for electric vehicles in 2021 will be 133,000 150mm-equivalent wafers, and the total market will exceed 1.23 million 150mm-equivalent wafers in 2030. "These forecasts highlight the tremendous opportunity Aehr Test has in front of it with its wafer-level test and burn-in solution for electric vehicle semiconductors," believes Erickson.

www.aehr.com

X-FAB first foundry to offer high-volume micro-transfer printing after licensing agreement with X-Celeprint

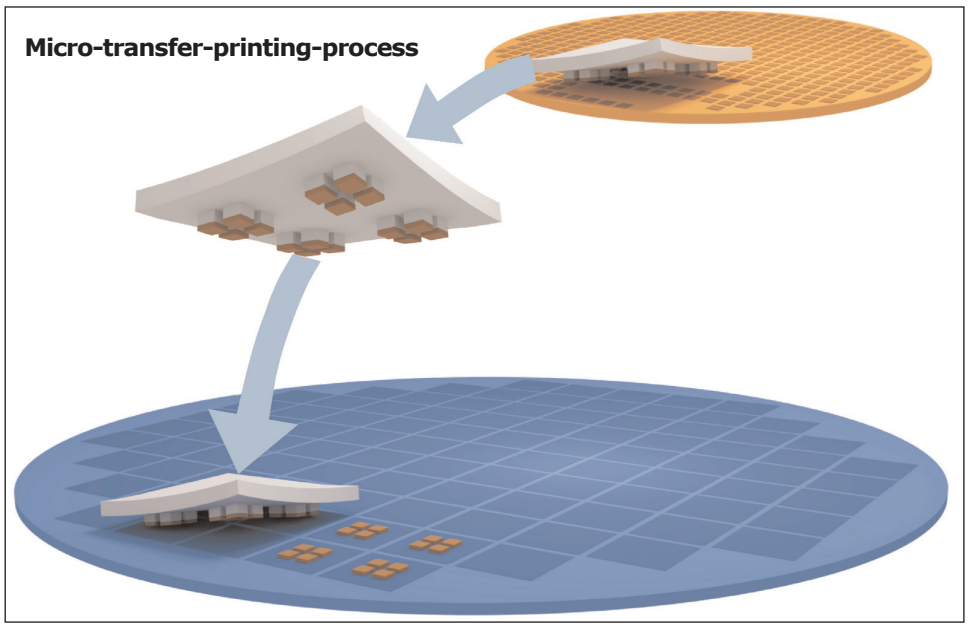
Long-term collaboration leads to scalable methodology for heterogeneous integration

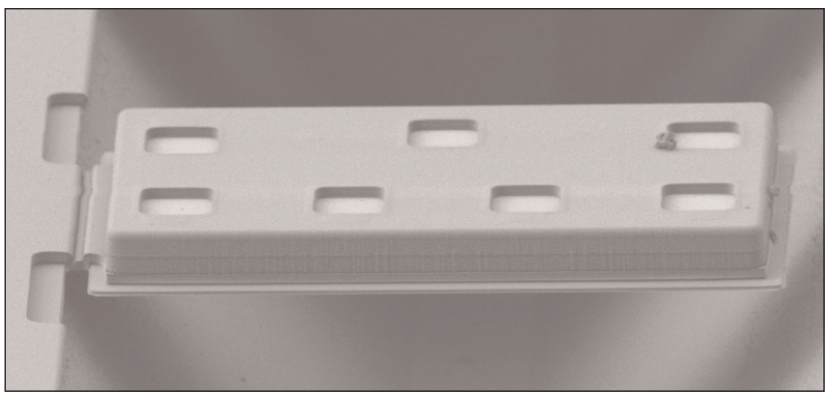
Analog/mixed-signal, micro-electro-mechanical system (MEMS) and specialty semiconductor foundry X-FAB Silicon Foundries SE of Tessenderlo, Belgium is now able to support volume heterogeneous integration via micro-transfer printing (MTP) due to a licensing agreement secured with X-Celeprint Ltd of Cork, Ireland — a subsidiary of Tessenderlo-based XTRION N.V. that uses facilities at Ireland's Tyndall National Institute and in Research Triangle Park, NC, USA to develop and license patented MTP and related technology.

A diverse range of semiconductor technologies can hence be combined, each optimized for particular functional requirements. These will include silicon-on-insulator (SOI), gallium nitride (GaN), gallium arsenide (GaAs) and indium phosphide (InP) as well as MEMS.

X-FAB says that, to become the first foundry to provide MTP-based heterogeneous integration, it has made substantial investments over the last two years. It has also established new optimized workflows and cleanroom protocols that will allow customers to work with the foundry on heterogeneous design projects — benefitting from a low-risk and fully scalable business model that offers migration to volume production.

X-Celeprint's proprietary massively parallel pick-and-place MTP technology stacks and fans-out ultra-thin dies based on different process nodes, technologies and wafer sizes. This results in the formation of virtually monolithic 3D stacked ICs, which have enhanced performance, greater power efficiency, and take up less space. Furthermore, all this can be achieved at an accelerated rate, significantly shortening time-to-market, it is reckoned.





X-chip held by nitride tether on source wafer.

"By licensing X-Celeprint's disruptive MTP technology, we are uniquely positioned in our ability to facilitate the incorporation of numerous different semiconductor technologies. X-FAB customers will be able to utilize a technology that no other foundry is offering, and existing X-Celeprint customers may now tap into capacity levels that will easily meet their future demands," says Volker Herbig, VP of X-FAB's MEMS business unit. "As a result, we can assist customers looking to implement complete multi-functional subsystems at the wafer level, even when there are high degrees of complexity involved. Signal conditioning, power, RF, MEMS, and CMOS sensors, optoelectronic devices, optical filters, and countless other possibilities will all be covered," he adds.

"Our agreement with X-FAB represents a major milestone in the commercialization of MTP technology, broadening the number of customers and applications," reckons X-Celeprint's CEO Kyle Benkendorfer. "High-volume heterogeneous integration of elements derived from various different source wafers will provide the semiconductor industry with significant new capabilities, including access to higher-density devices with more functionality, fabricated at high yields and lower cost, within shorter timeframes."

www.xfab.com
www.x-celeprint.com

IQE's first-half 2021 GaAs revenue grows 30%, offsetting drops for GaN-on-SiC and Photonics

For first-half 2021, epiwafer and substrate maker IQE plc of Cardiff, UK has reported revenue of £79.5m, down 11.5% on first-half 2020's record £89.9m. However, after adjusting for a significant foreign exchange (FX) headwind of £8.1m, revenue was £87.7m on a constant-currency basis (down only 2.5%), as trading remained robust across each of the firm's primary business segments.

Revenue segmentation £'m	H1 2021 reported	H1 2021 constant currency	H1 2020 reported	YoY constant currency change (%)
Wireless	41.6	45.9	45.5	0.9
Photonics	36.4	40.1	43.4	(7.6)
CMOS++	1.5	1.7	1.0	74.1
Total revenues	**79.5**	**87.7**	**89.9**	**(2.5)**

Sustained wireless handset-related growth

Wireless revenue has fallen by 8.6% from £45.5m to $41.6m. However, on a constant-currency basis, this is £45.9m, up 0.9% year-on-year. This includes gallium arsenide (GaAs) rising by 30% (to 84% of Wireless revenue) due to strong demand for epiwafers used in power amplifiers for 5G handsets and WiFi 6/6E routers. However, for gallium nitride on silicon carbide (GaN-on-SiC) for 5G infrastructure products there was a 53% year-on-year reduction (to 16% of Wireless revenue), reflecting global 5G deployment cycles, in particular lower numbers of massive MIMO (mMIMO) deployments in Asia compared with 2020.

Photonics revenue fell 16.1% from £43.4m to £36.4m (or £40.1m, down just 7.6%, on a constant-currency basis). IQE has maintained a strong market share in vertical-cavity surface-emitting lasers (VCSELs), with volume gains in world-facing light detection & ranging (LiDAR) applications, offset by a reduction in VCSEL revenue of 26% year-on-year due to smaller chip sizes required for facial recognition technology. However, the firm has also seen continued strong demand for advanced sensing for defence and security applications. Of Photonics revenue, VCSELs comprised 48%, Infrared products 38%, and indium phosphide (InP) 14%.

CMOS++ revenue has risen from £0.95m to £1.5m, or £1.7m (up 74%) on a constant-currency basis.

Operating loss has been cut from £5m in first-half 2020 to £1.9m. However, this is a £2.2m profit on a constant-currency basis.

Adjusted EBITDA (adjusted earnings before interest, tax, depreciation and amortization) was £11.6m, down from first-half 2020's £16.3m, but level year-on-year on a constant-currency basis (after accounting for a foreign exchange headwind of £4.7m).

Adjusted net cash inflow generated from operations was £9.1m, down from first-half 2020's £16.2m but representing 78% conversion of adjusted EBITDA.

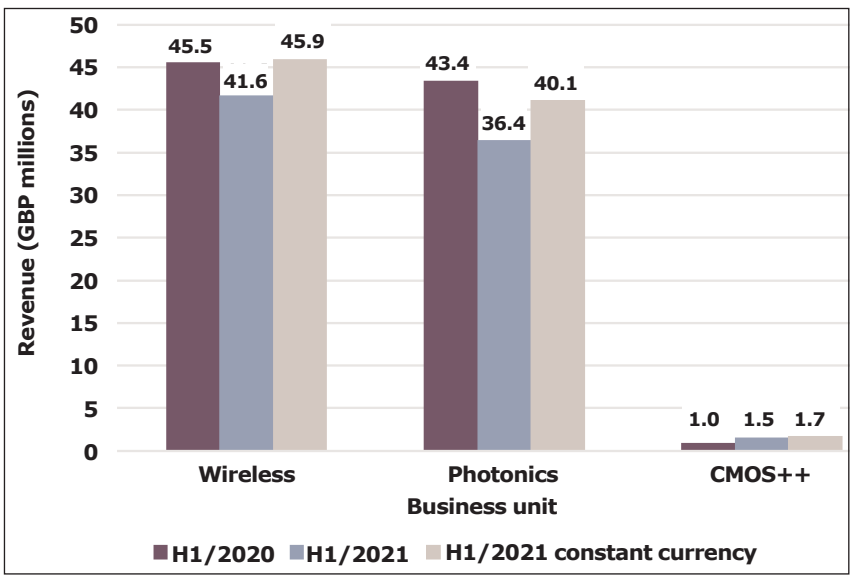
Property, plant & equipment (PP&E) capital expenditure (CapEx) was £6.1m in first-half 2021, including the first payment on three new Aixtron G4 metal-organic chemical vapor deposition (MOCVD) reactors for IQE Taiwan. In addition, capitalized development expenditure was £1.8m. In total, net cash used in investing activities was £8.1m.

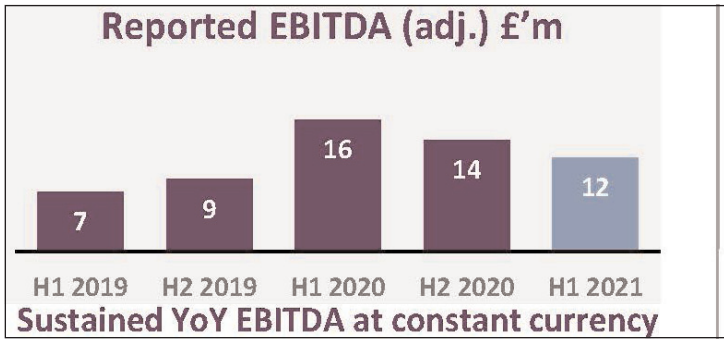
Net cash used in financing activities totalled £4.8m (comprising £3.1m in repayment of borrowings and £2m in payment of lease liabilities).

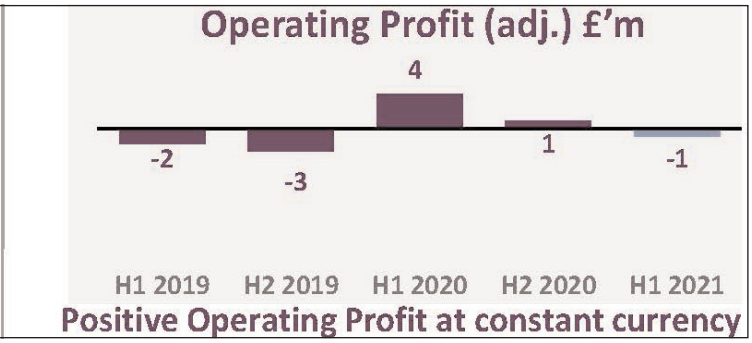
Hence, overall (compared with cash generation of £8.3m in first-half 2020 and £16m in full-year 2020), cash and cash equivalents fell by £3.9m during first-half 2021 from £24.7m to £20.6m (although this is still up on £17.4m at the end of first-half 2020). This is net of bank loans (repayable over a period to 29 August 2024) of £19.7m (cut from £24.8m at the end of first-half 2020 and £22.7m at the end of 2020).

Diversification of 5G infrastructure and other opportunities

During first-half 2021, orders were placed for three new Aixtron G4 MOCVD reactors and three refurbished Aixtron G3 reactors (for delivery in second-half 2021) to increase wireless GaAs capacity at IQE Taiwan by over 20%, underpinning further anticipated growth in 2022 and beyond. Also, on 18 August a Taiwan Court determination was received relating to the







acquisition of minority shareholdings in IQE Taiwan. The matter will be finalized upon resolution of an appeal by a small number of shareholders.

IQE has seen increasing interest from several chip foundries in gallium nitride on silicon (GaN-on-Si) technologies, with joint development programs progressing in second-half 2021 to develop a diversified and cost-effective offering to the RF infrastructure market, with potential longer-term applicability to power electronics and 5G mmWave.

Also, after the end of first-half 2021, IQE signed a multi-year strategic partnership with a major semiconductor foundry to develop epiwafers for 5G small cells.

Photonics developments

IQE says it has reported strong development progress on long-wavelength VCSELs for below-screen applications and for advanced sensing in healthcare applications. In particular, it has achieved key power and reliability milestones for its IQDN-VCSEL technology for advanced sensing applications at longer wavelengths (1100–1600nm) on 150mm GaAs substrates.

The firm has also expanded its VCSEL portfolio with the turnkey IQVCSEL product line, which is aimed at accelerating the ability of customers to introduce new products, expanding the VCSEL market.

"Results reflect the resilience of our business and highlight the ongoing commitment and hard work of our people who have, despite additional headwinds, largely sustained the record levels of performance at IQE that we reported a year ago," comments outgoing CEO Dr Drew Nelson.

Board updates

"In November 2020 the company announced the search for my successor and my intention to continue in an ambassadorial and advisory role at IQE," says Nelson. As announced in November 2020, Nelson will transition to non-executive director with the title of president. "I look forward to supporting the company in the next stage of IQE's development in my role as president & non-executive board member, while also helping drive the development of the Compound Semiconductor Cluster," says Nelson.

The process for recruiting a new CEO is nearing completion, with a preferred candidate identified who possesses relevant international semiconductor market experience. Discussions are ongoing to conclude the appointment process.

To prepare IQE for the appointment of a new CEO, Phil Smith has been appointed interim executive chairman. "As part of my expanded role, I will focus on the execution of IQE's strategy and preparing the business for the arrival of the incoming CEO," says Smith.

IQE has appointed Victoria Hull as non-executive director and incoming Remuneration Committee Chair, and appointee to the Audit & Risk and Nominations Committee. Sir David Grant is retiring from the board and his position as Remuneration Committee Chair on 18 September.

Outlook for full-year 2021 and beyond

In Wireless, the market for GaAs power amplifiers is expected to continue to be strong through second-half 2021 and grow further in 2022, driven by continued 5G penetration of the smartphone handset market and by WiFi 6 & 6E.

The market for GaN for 5G infrastructure has been weak in first-half 2021 due to the nature of global 5G deployments. This is expected to continue in third-quarter 2021. However, IQE sees potential opportunities for higher volumes in Q4 ahead of an anticipated return to growth in 2022.

In Photonics, production of VCSELs and advanced sensing for defence and security markets is expected to continue at relatively stable levels, with possible volume opportunities in VCSELs in Q4 related to the success of handset launches.

IQE notes that a significant foreign exchange headwind is being experienced in 2021 on a reported basis, as IQE's revenues are predominantly earned in US$ but reported in GBP. However, on a constant-currency basis, full-year 2021 revenue is expected to be similar to 2020. At this level, adjusted EBITDA is also expected to be similar on a constant-currency basis.

IQE reiterates its guidance for full-year 2021 capital expenditure (CapEx) on property, plant & equipment (PP&E) of £20–30m, as investments are made in tool capacity to underpin anticipated growth in both Wireless and Photonics products in 2022 and beyond. A total of nine new, refurbished or re-commissioned tools will be coming online at the end of 2021/beginning of 2022.

IQE says that capitalization of development costs is expected to be £5–8m for full-year 2021 as it continues to invest in its IT transformation and in future products to meet anticipated growing demand for compound semiconductors driven by the macro trends of 5G and connected devices.

www.iqep.com

ACM launches tool for wafer-level packaging and plating in compound semiconductor manufacturing

Automated system for flat & notched wafers; multiple orders ship in Q3

ACM Research Inc (ACM) of Fremont, CA, USA, a supplier of wafer processing solutions for semiconductor and wafer-level packaging (WLP) applications, has launched the Ultra ECP GIII plating tool to support WLP for compound semiconductors, with product offerings for silicon carbide (SiC), gallium nitride (GaN) and gallium arsenide (GaAs). The tool is also capable of plating gold (Au) into backside deep hole processes with greater uniformity and better step coverage.

A fully automated platform supports high-volume manufacturing that accommodates both flat and notched 6-inch wafers, and incorporates ACM's proprietary second anode power and paddle technologies for optimal performance.

"The compound semiconductor market is growing rapidly, with strong demand from electric vehicles, 5G communication, and RF and AI applications," says CEO & president David Wang. "Historically, compound semiconductor manufacturing processes have seen limited levels of automation, and have been subject to restricted production volumes. Further, most plating has been performed by vertical-type plating tools with poor uniformity performance," he adds. "ACM's new Ultra ECP GIII plating tool overcomes these challenges to meet the growing volume and advanced performance demands for compound semiconductors."

ACM's Ultra ECP GIII plating tool.

The Ultra ECP GIII leverages two key ACM technologies to achieve performance benefits: second anode and paddle technology.

Second anode technology is said to deliver superior uniformity control by effectively tuning wafer-level plating performance to overcome issues created by electrical field distribution differences. It can be used to optimize big die at wafer edge area patterns and notch area to achieve plating uniformity within 3%.

Paddle technology achieves stronger agitation to enhance mass transfer, resulting in significantly better step coverage in deep holes, it is said. Improved step coverage enables a reduction in Au film thickness, achieving cost savings.

ACM has received two orders for the Ultra ECP GIII from China-based compound semiconductor manufacturers. The first order was delivered in July to support wafer-level packaging with copper–nickel–tin-silver plating modules using second anode technology, and was integrated with a vacuum pre-wet chamber and a post-clean chamber. The second order (scheduled to be delivered later in the quarter ending 30 September) is for a gold (Au) plating system.

www.acmrcsh.com

AI used to detect crystal structure loss & notify operator

In its first use of artificial intelligence (AI) techniques to manage crystal control processes, Linton Crystal Technologies (LCT) of Rochester, NY, USA — which designs and makes equipment for producing monocrystalline ingots of silicon and materials such as germanium and gallium arsenide (GaAs) — has developed an early-warning system for when crystal structure loss is likely. This is the firm's latest upgrade to its Kayex Intelligent Crystal Control System (KICCS) for its Czochralski (CZ) process crystal growers.

"With one operator overseeing many CZ growers at once, it's not likely that structure loss will be detected immediately, or even in a timely manner. This results in a lot of wasted time, energy and material devoted to pulling a dead crystal," says senior software engineer Jeromy Tompkins. "This upgrade essentially makes the machines smarter, so they can alert the operator when it seems the crystal has lost structure. The operator then has the ability to make an informed decision as to whether or not to stop the growing process early."

The automatic facet detection feature uses the KrystalVision application within KICCS to draw data from real-time furnace images. Advanced techniques are used to analyze the stream, evaluating the statistical probability of structure loss based on facet presence and location. If structure loss is predicted, an alarm is sent to the operator's control panel.

"In developing the update, we implemented algorithms for facet detection using traditional image processing and it worked well. However, the AI approach added an ability to locate facets that was unrivaled by the traditional approach," says Tompkins. "This is a big step forward in facet detection and we also now have traction in AI, so we can make advancements with it fairly rapidly using the data we've collected."

Linton recently hired software engineer Yiliang Shi to support its advances in machine learning and automation. This was the first project she worked on since joining the company. "We were all really excited to see the results of this project and the power of AI to achieve what traditional algorithms struggle with," she says. "There are so many opportunities going forward because we'll be able to draw upon both traditional and AI tools, based on the needs of the project."

www.lintoncrystal.com

Argonne uses AI to optimize ALD in real time

Manufacturers increasingly rely on atomic layer deposition (ALD) to make new types of films, but figuring out how to tweak the process for each new material takes time. The problem is partly that researchers primarily use trial and error to identify optimal growth conditions. But a recent study suggests that using artificial intelligence (AI) can be more efficient (N Paulson, 'Intelligent Agents for the Optimization of Atomic Layer Deposition', ACS Applied Materials & Interfaces vol.13 (2021) issue 14, 17022).

At the US Department of Energy's (DOE) Argonne National Laboratory researchers describe multiple AI-based approaches for optimizing the ALD processes autonomously, detailing the relative strengths and weaknesses of each approach, as well as insights that can be used to develop new processes more efficiently and economically.

"All of these algorithms provide a much faster way of converging to optimum combinations because you're not spending time putting a sample in the reactor, taking it out, doing measurements etc, as you typically would today. Instead you have a real-time loop that connects with the reactor," says principal materials scientist Angel Yanguas-Gil, co-author.

Cutting edge, but with challenges

ALD excels at growing precise, nanoscale films on complex, 3D surfaces such as the deep and narrow trenches patterned into silicon wafers. This has motivated scientists worldwide to develop new thin-film ALD materials for future generations of semiconductor devices.

However, developing and optimizing these new ALD processes is challenging and labor-intensive. Researchers have to consider many different factors that can alter the process, including:

- the complex chemistries between the molecular precursors;
- reactor design, temperature and pressure; and
- the timing for each dose of their precursors.

To find ways of overcoming these challenges, Argonne scientists evaluated three optimization strategies — random, expert system and Bayesian optimization — the latter two utilizing different AI approaches.

Set it and forget it

Researchers evaluated their three strategies by comparing how they optimized the dosage and purge times of the two precursors used in ALD.

The goal: find the conditions that would achieve high and stable film growth in the shortest time. Scientists also judged the strategies on how quickly they converged on the ideal set of timings using simulations that represented the ALD process inside a reactor.

Linking their optimization approaches to their simulated system let them measure film growth in real time after each cycle, based on the processing conditions that their optimization algorithms generated.

"All of these algorithms provide a much faster way of converging to optimum combinations because you're not spending time putting a sample in the reactor, taking it out, doing measurements etc, as you would typically. Instead you have a real-time loop that connects with the reactor," says principal materials scientist Angel Yanguas-Gil, another co-author.

This set up also made the process automatic for the two AI approaches by forming a closed-loop system.

"In a closed-loop system, the simulation performs an experiment, gets the results, and feeds it to the AI tool. The AI tool then learns from it or interprets it in some way, and then suggests the next experiment," says computational scientist Noah Paulson (lead author).

Despite some weaknesses, the AI approaches effectively determined the optimal dose and purge timings for different simulated ALD processes. It is reckoned that this makes the study among the first to show that thin-film optimization in real time is possible using AI.

"It opens up the possibility of using these types of approaches to rapidly optimize real ALD processes, a step that could potentially save manufacturers precious time and money when developing new applications in the future," concludes senior chemist and co-author Jeff Elam.

The scientists used Argonne's Blues cluster in its Laboratory Computing Resource Center.

The research was funded by the Laboratory Directed Research and Development (LDRD) program at Argonne.

https://pubs.acs.org/doi/10.1021/acsami.1c00649

http://nano.anl.gov

Asian opto device maker orders Riber MBE 412 system

System to be used for growing antimonides

Riber has received an order from "an established optoelectronic device manufacturer in Asia" for a MBE 412 system.

The system will be used for the growth of wafers in the antimonide material system, "an area of technology for which our product range is attracting significant interest worldwide," says Riber.

The pilot-production-oriented MBE 412 machine will be used to prepare device structures for applications including automotive driver assistance, medical diagnostics, and smart building sensors, the firm adds.

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Wales highlights new research and education opportunities in semiconductor technologies

Swansea's Centre for Integrative Semiconductor Manufacturing and Cardiff's Translational Research Hub target EVs and optical and wireless communications for 5G and beyond

Focusing on the technologies behind electric vehicles (EVs) and optical and wireless communications for 5G and beyond, Wales is soon to be home to two new research and innovation facilities comprising about 6000m^2 of work space including cleanrooms and labs.

The Centre for Integrative Semiconductor Manufacturing (CISM) at Swansea University's Bay campus will focus on multiple semiconductor platforms for healthcare and a net-zero future in applications such as clean energy systems and power electronic components that are driving the electric revolution. Meanwhile, Cardiff University's Translational Research Hub (TRH) at its Maindy Campus will provide facilities for communications and sensing technologies based on integrated compound semiconductors.

Swansea is currently recruiting students onto a newly launched MSc program in Semiconductor Technology and Applications. Cardiff University already offers two MSc programs along with PhD opportunities through its Centre for Doctoral Training (CDT). In all programs students will gain hands-on laboratory experience developing knowledge and skills in device processing, characterization and applications of compound semiconductors, building a skilled workforce for the Wales region.

Nearing completion at Cardiff University's Maindy Campus, the new Translational Research Hub (TRH) will be home to the Institute for Compound Semiconductors (ICS). With state-of-the-art equipment, facilities and highly skilled people, the ICS aims to position Cardiff as the UK and European leader in compound semiconductor technologies.

Swansea's CISM is due to come on-line in August 2022 and will be equipped with the latest manufacturing-relevant tools for 6" and 8" silicon and compound semiconductor wafer processing, plus unique deposition and processing equipment for next-generation materials such as wide-bandgap, organic and perovskite semiconductors and advanced dielectrics.

The complementary investments at Cardiff and Swansea supplement existing activities and will provide routes to markets through the growing CSconnected semiconductor community that is placing Wales at the epicentre of the global connectivity, electrification and net-zero revolution.

The South Wales semiconductor community is expanding rapidly, with 3000–5000 additional, highly skilled new jobs anticipated over the coming 5 years across the region.

To take advantage of the extensive employment opportunities Colleges and Universities in South Wales are delivering semiconductor programs for students and ongoing continuing professional education.

www.swansea.ac.uk/campus-development/developing-bay/key-projects-bay/cism

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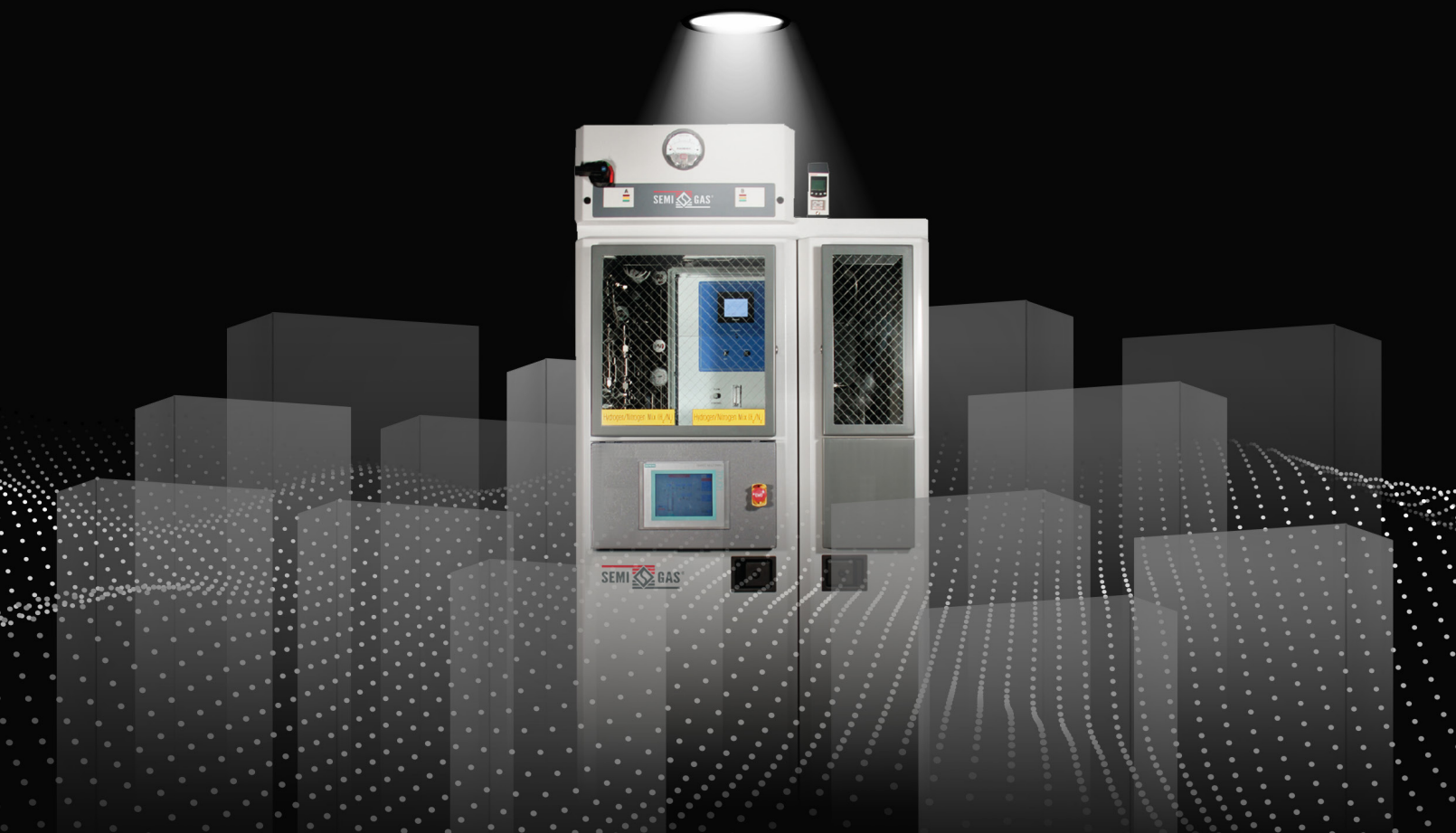

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SETi's Violeds technology helps to suppress spread of Delta variant of COVID-19

Surface disinfection tests show 99.9999% disinfection in 5 seconds

Sensor Electronics Technology Inc (SETi) of Columbia, SC, USA (which makes UV-A, UV-B and UV-C deep-ultraviolet LEDs, emitting at wavelengths of 200–430nm) and UV LED product maker Seoul Viosys Co Ltd (SVC) — both subsidiaries of South Korean LED maker Seoul Semiconductor — have announced surface disinfection test results showing that Violeds UV LED technology fully disinfected the COVID-19 delta variant by 99.3% in 1 second and 99.9999% in 5 seconds. In addition, in SETi and Seoul Viosys' own experiment, Violeds not only removed fine dust but also disinfected 90% of viruses in the air in 5–7 minutes and 99.9% within 30 minutes in 60m^3 and 120m^3 spaces, proving again that Violeds technology can support prevention of airborne transmission.

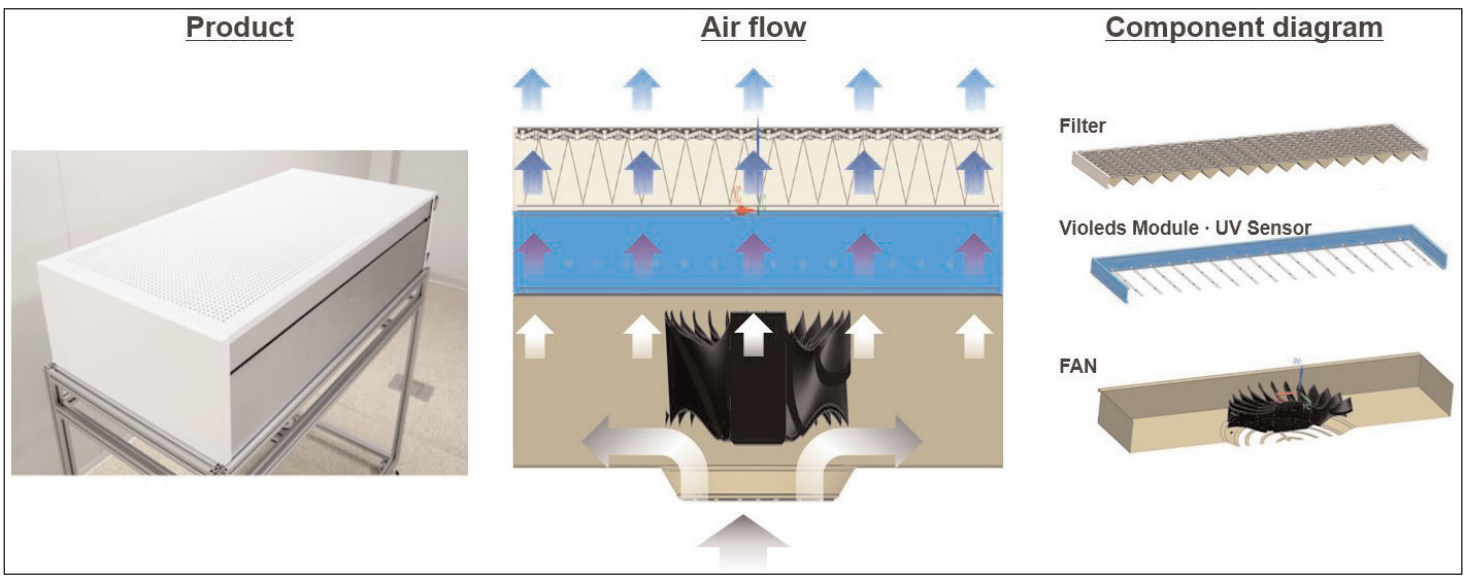
The bio research team of SETi and Seoul Viosys built its own 120m^3 airborne disinfection laboratory to conduct experiments suiting the size of general multi-use facilities, and implemented an optimal solution that provides high disinfection power with minimal air circulation. Considering that the contagious viruses are circulating indoors for a long time, the team collected the airborne viruses in the 120m^3 space and irradiated them with Violeds light. As a result, viruses were disinfected by 90% in 7 minutes and 99.9% in 30 minutes. Regarding the experiment, SETi and Seoul Viosys sought advice from professor Kun Sub Chung of Yonsei University and the Solid State Lighting & Energy Electronics Center (SSLEEC) at the University of California at Santa Barbara (UCSB) in the USA.

The Violeds air disinfection solution introduced by SETi and Seoul Viosys is equipped with a Violeds module in the air purifier used in the semiconductor cleanroom, where absolute clean air is essential, to remove the dust and virus simultaneously. The principle is that when the HEPA filter filters the dust, Violeds disinfects the viruses collected with the dust.

The air disinfection experiment was carried out as follows. After the viruses were sprayed into the air in the form of small particles, the research team turned on the air purifier unit with the Violeds disinfection module and confirmed that the virus was inactivated by more than 90%.

The virus used in the experiment was PhiX-174, which has been found to be very similar to COVID-19 (SARS-CoV-2) in many respects and is being used for airborne virus testing at domestic and foreign accredited testing institutes such as Korea Testing Laboratory (KTL).

www.s-et.com
www.seoulviosys.com



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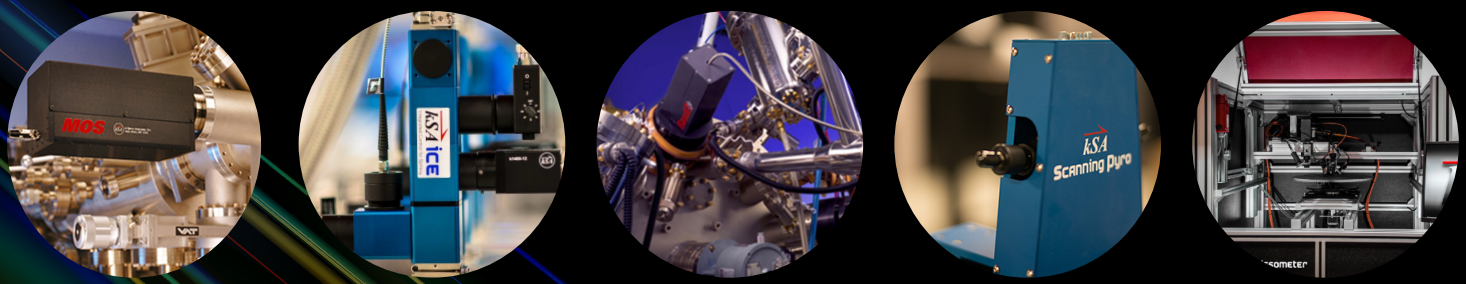

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Seoul Semi launching WICOP TE for headlamps with thermal management effect for electric vehicles

South Korean LED maker Seoul Semiconductor Co Ltd has launched WICOP TE (Top Electrode) LED technology, designed to significantly improve the thermal efficiency of headlamps for vehicles.

The firm reckons that WICOP (Wafer Integrated Chip on PCB) LEDs were applied to 10% of global vehicle production in 2020, and are expected to see increasing demand in the future electric vehicle market. Seoul Semiconductor expects to accelerate the move to expand its market share in the global automotive lighting LED market (which is worth about $2.7bn).

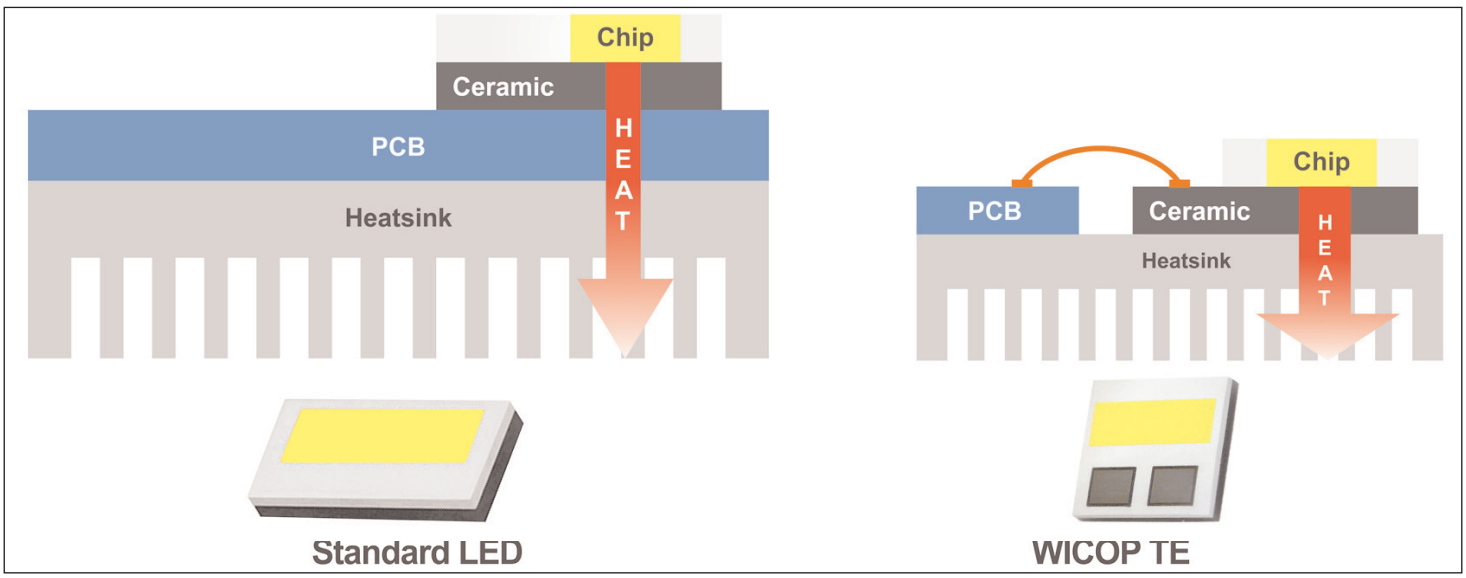
Due to the growing demand for electric vehicles, interest in high-efficiency LED products is growing for headlamps and for reducing battery consumption. Accordingly, the thermal dissipation performance of the headlamp has become key to improving efficiency and lifetime to counter the temperature increase.

Seoul Semiconductor's WICOP TE for headlamps has deviated from the previous method of attaching the LED package to the printed circuit board (PCB) and can attach the package directly on the heat-sink, designed to quickly discharge the heat generated in the headlamp.

In July, Seoul Semiconductor obtained a permanent injunction against 13 automotive lighting brand LED products infringing WICOP patents. At the 23rd DVN US Workshop in Novi, MI, USA (21 September), the firm introduced WICOP TE products, SunLike natural-sunlight-spectrum LEDs with interior colors and beneficial effects for learning and good sleep, and Violeds UV LEDs for disinfection in automotive air-conditioning systems.

"Weight reduction and heat dissipation performance of headlamps are more important due to increased demand for electric vehicles and slim headlamp design trends," says Seoul Semiconductor. "Seoul Semiconductor has already applied high-efficiency and high-heat-dissipation WICOP products to more than 100 global vehicle brands, and we expect to increase automotive LED sales through continuous demand expansion in the future."

www.SeoulSemicon.com



Toyoda Gosei unveils UV-C high-speed surface disinfector

More than 99.9% of viruses and bacteria eliminated in 7 seconds

Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan says that in November it will launch a 'UV-C High-Speed Surface Disinfector', which uses deep ultraviolet (UV-C) LEDs that effectively kill viruses and bacteria. Pre-orders of the product were being accepted from 1 September.

Toyoda Gosei says that, with the recent rise in awareness of infection prevention, it is launching various products that disinfect air and surfaces using UV-C LEDs. The UV-C High-Speed Surface Disinfector is reckoned to eliminate more than 99.9% of viruses and bacteria on both top and bottom surfaces of smart phones and other devices in 7 seconds. The disinfector employs a special optical mechanism to concentrate the irradiating UV-C. It can be used in restaurants, hotels, offices, hospitals and various other places to disinfect small personal items upon entry and during personal interactions to improve the hygienic environment, the firm says.

www.toyoda-gosei.com

Seoul Semiconductor launches Z5M4 high-power LED package with WICOP technology

LED maker seeks greater market share in $2bn high-power LED market

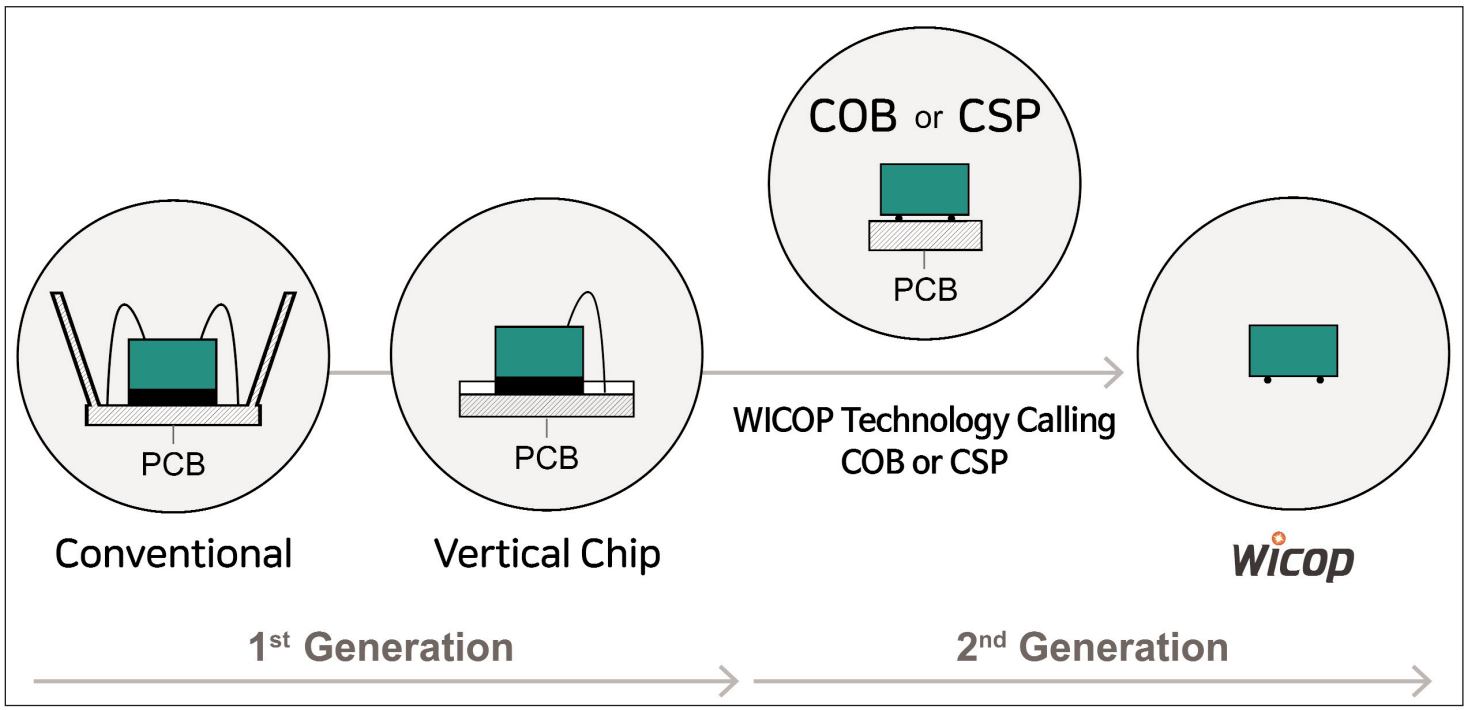
South Korean LED maker Seoul Semiconductor Co Ltd has introduced the Z5M4 high-power LED package with WICOP technology. Z5M4 is reckoned to be 10% brighter than the conventional products and can easily replace the existing high-power products, says the firm. Accordingly, Seoul Semiconductor aims to expand its market share in the $2bn global high-power LED market for street lighting, bay-lighting and horticulture lighting, which has been created by vertical chip manufacturers.

The Z5M4 LED with WICOP (Wafer Integrated Chip on PCB) technology is designed to be compatible one-to-one with existing high-power products, and its heat dissipation structure makes it a high-power LED package suitable for high brightness and high efficiency. It provides high luminous efficiency of 175lm/W and can be used for up to 100,000 hours.

Seoul Semiconductor obtained a permanent injunction against Philips TV product and 13 automotive lighting brand LED products infringing WICOP patents in 2019 and 2021.

"Seoul Semiconductor's Z5M4 LED for high-power lighting will quickly encroach the $2bn market dominated by vertical technology companies," reckons the firm. "We plan to apply this product not only to high-power lighting but also to electronic device flash and automotive lighting, followed by SunLike LED, a natural-sunlight-spectrum LED technology," it adds.

www.SeoulSemicon.com



Comparison of WICOP and product design that Seoul Semiconductor claims was stolen under the name of COB or CSP.

Lumileds adds PC Red-Orange to LUXEON 2835 Color Line

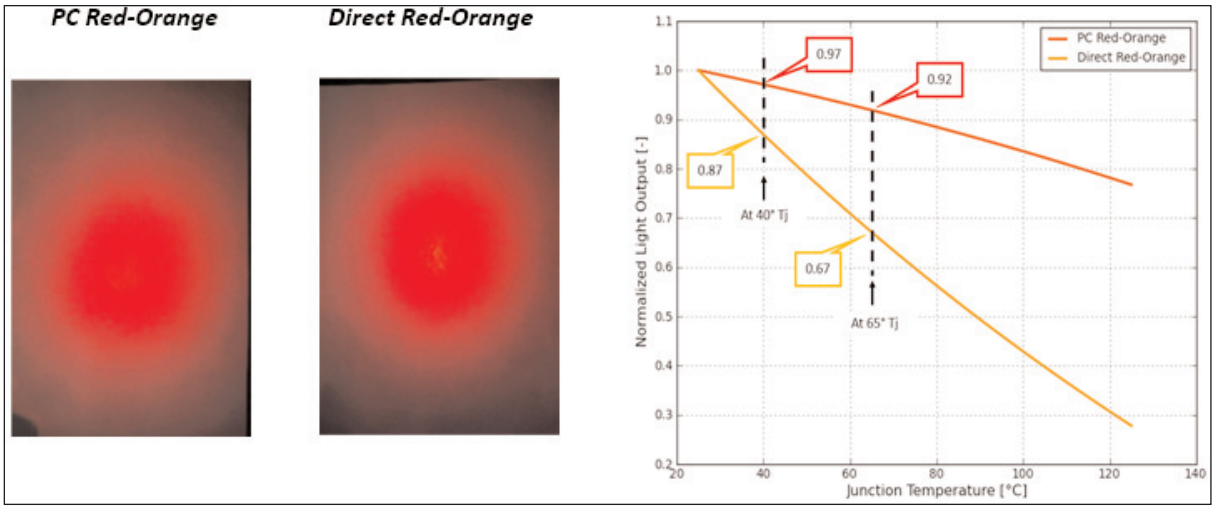
Range now includes 12 color options and three white CCTs

Lumileds has added PC Red-Orange to its LUXEON 2835 Color Line, further extending its portfolio.

The PC Red-Orange comes with high color purity, and it is said to offer better and more predictable performance in operating conditions.

With the addition of PC Red-Orange, the LUXEON 2835 Color Line now includes 12 color options and three different white correlated color temperatures (CCTs).

www.lumileds.com/products/color-leds/luxeon-2835-color-line



Lumileds adds LUXEON 7070 LED

Output of 2000 lumens is three times that of typical 5050 LED

Lumileds LLC of San Jose, CA, USA has launched LUXEON 7070 as a high-power addition to its LUXEON LED family.

LUXEON 7070 LEDs are said to lower system costs while maintaining or improving efficiency. With the ability to emit up to 2000 lumens, LUXEON 7070 delivers three times the output of a typical 5050 LED, reduces the number of LEDs required, and can reduce the cost of optics, PCBs and assembly, says Lumileds.

The new LUXEON 7070 supports lifetime performance and reliability requirements set by regulatory bodies and municipalities. With L90 >100,000 hours and Lumileds' proprietary coating to provide corrosion resistance in punishing environments, it is reckoned to be the longest-life, most robust option in its class.

LUXEON 7070 is hot-color-targeted (85°C) and available in a wide range of correlated color temperatures (CCTs) of 2200–6500K, with a color rendering index (CRI) of 70, 80 or 90. LUXEON 7070 is available now via Future Lighting Solutions and Lumileds' distribution network.

www.futureelectronics.com
www.lumileds.com/products/high-power-leds/luxeon-7070

PIRT wins $1m, one-year US Air Force award

Uncooled SWIR camera to be integrated with BAE Systems' Open Seeker Architecture for precision targeting

Princeton Infrared Technologies Inc (PIRT) of Monmouth Junction, NJ, USA — which designs and manufactures indium gallium arsenide (InGaAs)-based shortwave-infrared (SWIR) line-scan cameras, visible-SWIR science cameras, and 1D and 2D imaging arrays — has announced a $1m one-year award from the US Air Force Armament Directorate to fund the development of a 640x512 uncooled SWIR camera integrated with BAE Systems' Open Seeker Architecture (OSA) for low-cost targeting and tracking applications. This was through the Air Force Weapons Pitch Day, where over 60 small businesses competed for the one-year contracts.

PIRT will modify the camera form factor to fit on a glide munition. It will work with the Air Force Armament Directorate to begin integrating the OSA-compliant SWIR prototype camera and to conduct tower and captive carry tests to demonstrate the advance capabilities.

"We are very excited to be integrating our SWIR cameras with BAE Systems' OSA to allow targeting of stationary and moving targets in GPS-denied areas for various types of munitions," says PIRT's president Martin H. Ettenberg Ph.D.

www.princetonirtech.com

Cambridge spin-off Porotech appoints former Arm executive as chief commercial officer

Micro-LED display start-up aiming to scale up

Gallium nitride (GaN) material technology developer Porotech (a spin-out from the Cambridge Centre for Gallium Nitride at the UK's University of Cambridge) has appointed former Arm executive Helen Adams as chief commercial officer (CCO). During her 11 years at Cambridge-based chip designer Arm, Adams rose to become vice-president of sales for Europe and the Asia Pacific region, leading a team delivering $1bn annual sales revenue.

"With a track record of success in technology sales and sales management in the semiconductor industry, Helen is an excellent fit for our growing business," reckons CEO & co-founder Dr Tongtong Zhu. "We are already seeing high levels of demand for our products, and in June we raised £3m to fund further development work. Helen's appointment is the next step along our scale-up trajectory."

Helen Adams.

Porotech says that, due to its micro-LED production technique using porous gallium nitride (GaN), its display technology enables brighter, sharper, more vivid micro-displays for even the smallest devices. The technology offers performance improvements that are suitable for mass production yet can be customized for individual needs.

Despite only spinning out in January last year, Porotech has been generating revenue for 13 months, with a string of repeat orders. The firm says that it is working with some of the biggest global names in display technology. In November 2020, it launched the first commercial native red indium gallium nitride (InGaN) LED epi-wafer for micro-LED applications. In August, the firm announced its first partnership — with China-based micro-LED display technology firm Jade Bird Display (JBD).

Micro-LEDs represent next-generation technology for displays in products such as smartphones and smartwatches, as well as virtual reality (VR) and augmented reality (AR) headsets. They are particularly useful in outdoor settings, where sunlight can often make existing displays difficult to see clearly.

Porotech says that its next step is to expand its novel approach to integrate InGaN-based red, green and blue (RGB) micro-LEDs for full-color micro-displays, and ultimately create 'smart' pixels that can be controlled independently for responsiveness and accuracy for things such as AR gestures.

www.porotech.co.uk

CSC joins with ICS, VTEC and Aircision in FrOLik

Consortium to develop European source of integrated detectors for 100Gbps, 10km free-space optical telecom links

The Compound Semiconductor Centre (CSC, a joint venture founded in 2015 between Cardiff University and epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK) – which is a partner in the CSconnected compound semiconductor cluster formed in South Wales in 2017 — is to be part of a consortium named 'Free Space Optical Links for telecom networks' (FrOLik) that has received €675,000 in support from Eureka Eurostars to develop innovative free-space optical (FSO) data link technology and an associated supply chain.

The consortium comprises three R&D-intensive SMEs: Integrated Compound Semiconductor Ltd (ICS, a spin out from the University of Manchester, UK); VTEC Lasers and Sensors BV; and Aircision BV (the latter two both of Eindhoven, Netherlands), supported by Cardiff-based CSC.

Currently, point-to-point fiber-optic links are the standard deployment option for high-capacity telecom backhaul as they provide high integrity and high-bandwidth transmission. While FSO is easy and fast to deploy, has very high bandwidth potential and does not require a spectrum license, existing commercial solutions suffer from outages due to adverse weather conditions. The project aims to deliver a novel FSO communication product commercialized by Aircision, using novel components for high bit rates that enable long-range transmission, up to 100Gbps at 10km.

The consortium will leverage this technology with unique high-performance compound semiconductor detector technology (developed by ICS) and new high-speed component integration techniques (developed by VTEC).

A critical outcome of the project will be the demonstration of a new European source of integrated semiconductor detector products specifically designed for FSO systems, enabled by a comprehensive 'materials-to-system' design, manufacture and test capability.

www.csconnected.com/eurostars-frolik

www.compoundsemiconductorcentre.com

US-based ex-Soraa/nLIGHT/Coherent/JDSU veteran appointed as BluGlass president

Gallium nitride laser technical & operations expertise to aid commercialization of laser product portfolio

BluGlass Ltd of Silverwater, Australia — which develops low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs — has appointed expert laser diode executive James (Jim) Haden as president. He will continue to be based in the USA.

Haden has three decades of laser industry expertise and a track record of transforming advanced technology businesses from R&D and early-stage product development to profitable, high-growth commercial entities, says BluGlass. He has held senior executive and advisory roles at several of BluGlass' prospective customers and competitors, including senior technical & operations adviser at Kyocera SLD, chief operating officer at nLight, director of operations & product line management at Coherent, and director of operations at JDS Uniphase.

Haden's appointment follows an extensive global executive search to lead BluGlass through its next growth phase. As president, Haden will oversee all aspects of the business and will be responsible for transitioning the firm from its R&D origins to a technology development and product manufacturing company.

"Jim's unique synergy of deep technical, commercialization and leadership skills, along with his extensive customer and supply chain network, will be invaluable in solving our reliability challenges as we transition BluGlass to profitability and deliver a pipeline of next-generation laser products to market," comments executive chair James Walker.

New president Jim Haden.

"Our ability to attract an industry executive of Jim's calibre is a testament to the quality of our industry-leading technology, which addresses the growing demand for brighter and better-performing lasers. Jim has delivered significant revenue growth and built enviable market-leadership positions throughout his career and has hands-on experience optimizing operations and identifying strategic opportunities, including facilitating successful mergers and acquisitions," Walker adds.

"It is a very exciting time to be joining BluGlass, as we finalize product development and prepare to launch a range of in-demand products into high-growth markets," comments Haden.

In his most recent role at Soraa Laser Diode (now Kyocera-SLD), Haden was responsible for guiding operations and development teams to stabilize, improve and ramp high-power blue gallium nitride (GaN) lasers and associated packaging, which enhanced thermal, electrical and optical performance and greatly improved manufacturing yields. This product development delivered a leading automotive customer (BMW) and rapid revenue growth, assisting in the firm's acquisition by Kyocera in January.

Previously, Haden was chief operating officer at nLIGHT, helping to transform the business from early-stage revenue generation to its current market leadership position. During this time, he more than doubled revenue, delivered a four-fold increase in R&D return on investment, streamlined production management, and improved manufacturing yields and cost margins; ultimately assisting the business to attract expansion capital of US$25m.

Other senior roles include director of operations & product line management at Coherent Inc, director of operations South Bay Operations at JDS Uniphase, and director of operations at Spectra Diode Lasers (acquired by JDS Uniphase for US$41bn). Haden holds a Bachelor and Masters in Electronics Engineering from the University of Southern California.

Interim executive chair James Walker will remain in the role to ensure a seamless transition and support the business' financial and governance requirements as the firm nears commercialization.

www.bluglass.com.au

Sivers Semiconductors establishes US office

VP business development North America appointed for Sivers Photonics

Sivers Semiconductors AB of Kista, Sweden (which supplies chips and integrated modules) has established its first US office, employing its first local employee in California.

Susan Shea has joined the firm as VP business development North America for Sivers Photonics and is the first of four people that Sivers Semiconductors plans to hire in the USA this year. With over 25 years' experience, most recently at optical and photonic product maker Lumentum, Shea has a proven track record of delivering results within the semiconductor industry, the firm says.

"Over 65% of our sales are already in the US, and we believe having local employees will contribute to accelerated US growth," says Sivers Semiconductors' group CEO Anders Storm. "With very important Fortune 100 customers and an exciting silicon photonics market in the US, we are very happy to welcome Susan to Sivers as our first ever employee in the US," he adds.

"We are excited to have Susan on board, bringing with her a wealth of knowledge and extensive experience, as we continue to expand our market presence in the US, particularly in our key growth optical communication and sensing markets," says Billy McLaughlin, Sivers Photonics' managing director.

"The majority of my career has been spent in the semiconductor industry, and I look forward to continuing that tradition by providing photonic device solutions to current and future customers," says Shea.

www.sivers-semiconductors.com

Sivers Semiconductors recruits new chief financial officer

Recruitment follows move to Nasdaq Stockholm's main list and opening of US office

Sivers Semiconductors has recruited Håkan Rippe as chief financial officer (CFO).

Rippe's career spans 27 years in both private-equity-owned and listed technology companies. He has been part of several growth journeys and handled a significant number of acquisitions and capital market transactions. Rippe has previously held the role of CFO at Enea and Clavister as well as senior positions at IBM and Telelogic.

"After moving to Nasdaq Stockholm's main list, we are now entering the next phase of our growth journey," says president & CEO Anders Storm. "Håkans Rippe's many years of experience as CFO from companies on the main list and from the stock market will be a strong addition to the company," he believes. "Håkan has run many M&A transactions and been responsible for business development in the US for many years."

Rippe succeeds Robert Ejermark, who has been CFO for over three years. "Robert has been instrumental in the company's move to Nasdaq's main list by creating a robust and sustainable long-term structure in the company," comments Storm.

www.sivers-semiconductors.com

NSF grants $25m to fund new Center for Integration of Modern Optoelectronic Materials on Demand

Focus on scalable manufacturing processes for devices in applications ranging from displays and sensors to quantum technologies

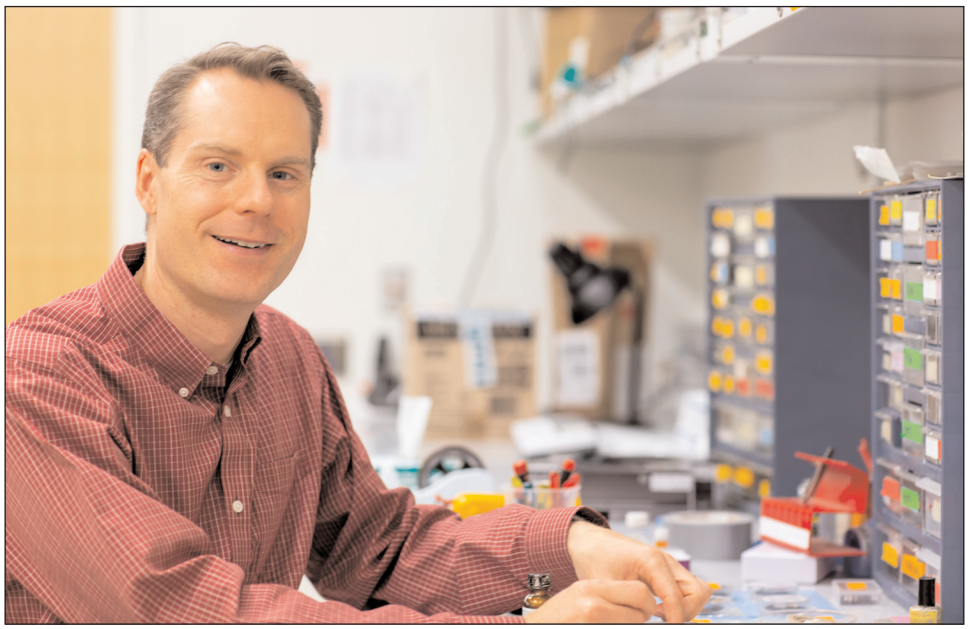
The US National Science Foundation (NSF) is giving a five-year, $25m Science and Technology Center grant to establish the Center for Integration of Modern Optoelectronic Materials on Demand (IMOD), a collaboration of scientists and engineers at 11 universities led by the University of Washington.

IMOD research will focus on new semiconductor materials and scalable manufacturing processes for new optoelectronic devices for applications ranging from displays and sensors to harnessing the principles of quantum mechanics.

"Can we take a quantum optics experiment that fills an entire room, and fit thousands — or even millions — of them on a chip, enabling a new revolution?" questions IMOD director David Ginger, the Alvin L. and Verla R. Kwiram Endowed Professor of Chemistry at the University of Washington, chief scientist at the UW Clean Energy Institute and co-director of NW IMPACT. "Along the way we anticipate IMOD's science will help with a few more familiar challenges, like improving the display of the cell phone you already have in your pocket so the battery lasts longer."

Devices based on optoelectronics such as light-emitting diodes, semiconductor lasers, image sensors and the building blocks of quantum communication and computing technologies (such as single-photon sources) have applications including sensors, displays and data transmission. In particular, optoelectronics is poised to play a critical role in the development of quantum information systems.

But to realize this quantum future, existing research must develop new materials and new strategies to manufacture them. So, building on advances in the synthesis of semiconductor quantum dots and halide perovskites, IMOD will integrate the work of scientists and engineers from diverse backgrounds, including:



David Ginger at the sample preparation laboratory for atomic force microscopy in the UW's Molecular Engineering and Sciences Building. (Photo: Dennis Wise/University of Washington.)

- chemists with expertise in atomically precise colloidal synthesis, characterization and theory, which consist of engineered systems of nanoparticles suspended in a medium;
- materials scientists and mechanical engineers developing methods for the integration, processing and additive manufacturing of semiconductor devices;
- electrical engineers and physicists who are developing new nanoscale photonic structures and investigating the performance limits of these materials for optical quantum communication and computing.

"NSF Science and Technology Centers are integrative not only in the sense that they span traditional academic disciplines but also in the sense that they seek to benefit society by connecting academic research with industrial and governmental needs, while also educating a diverse STEM workforce," says Ginger. "To this end, we are extremely lucky to have had the support of an amazing list of external partners across the fields of industry, government and education."

A partial list of IMOD's external partners includes companies such as Amazon, Applied Materials, Corning Inc, Microsoft, Nanosys and FOM Technologies Inc; government organizations like the US National Renewable Energy Laboratory (NREL), the Pacific Northwest National Laboratory (PNNL) and the Washington State Department of Commerce; and educational partners including GEAR UP at UW, Catalyst @ Penn GSE and the Center for Education Integrating Science, Mathematics and Computing at Georgia Tech.

The center will launch a series of mentorship, team science training and internship programs for partici-

Aerial view of the University of Washington's Seattle campus. (Photo: Mark Stone/University of Washington.)

pants, including students from under-represented groups in STEM and first-generation students. Center scientists will also work with high school teachers on curriculum development programs aligned with the Next Generation Science Standards and act as 'ambassadors' to K-12 students, introducing them to STEM careers.

"In partnership with UW QuantumX and the Northwest Quantum Nexus, IMOD is launching a Quantum Training Testbed facility to provide cutting-edge training and workforce development opportunities for students from across IMOD's participating sites and partners," says Kai-Mei Fu, associate professor of physics and of electrical and computer engineering at UW, who is IMOD's associate director of quantum workforce development. "We're excited to have such strong support from our partners in the region, allowing us to build on the investments that Washington state has already made in the Washington Clean Energy Testbeds to support workforce training and economic development. For example, Microsoft plans to donate a cryostat that will allow our students to cool samples down to within a few degrees of absolute zero to study phenomena such as quantum spin physics and decoherence, and we have plans to do so much more for our trainees. Right now, we're asking the question: 'What is the equipment we wish we had been able to experiment with as students?'"

Research must develop new materials and new strategies to manufacture them... building on advances in the synthesis of semiconductor quantum dots

The 11 academic institutions that make up IMOD are

- the University of Washington;
- the University of Maryland, College Park;
- the University of Pennsylvania;
- Lehigh University;
- Columbia University;
- Georgia Institute of Technology;
- Northwestern University;
- the City College of New York;
- the University of Chicago;
- University of Colorado at Boulder; and
- the University of Maryland, Baltimore County.

Kai-Mei Fu. (Photo: University of Washington.)

In addition to Ginger and Fu, other UW faculty involved with IMOD include Brandi Cossairt, a UW professor of chemistry; Devin MacKenzie, associate professor of mechanical engineering and of materials science and engineering, and technical director of the Washington Clean Energy Testbeds; Arka Majumdar, associate professor of physics and of electrical and computer engineering; and Daniel Gamelin, professor of chemistry and director of the Molecular Engineering Materials Center. Fu and Majumdar co-chair UW Quantum X and are also faculty members with the UW Institute for Nano-Engineered Systems. Ginger, Cossairt, Fu, MacKenzie and Gamelin are member faculty at the Clean Energy Institute. Ginger, Fu, Majumdar and Gamelin are faculty researchers with the UW Molecular Engineering and Sciences Institute.

www.imod-stc.org

TRUMPF launches ViBO VCSEL laser platform

Monolithically integrated micro-optical elements allow 3D sensing with tailored illumination profiles

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 and heating markets, has unveiled the new product platform ViBO (VCSEL with integrated Backside Optics).

The VCSEL array technology supports a new generation of illumination devices that are inherently eye-safe over the whole product lifetime, as the diffusor optics are monolithically incorporated into the laser array. This allows easy interfacing with the new platform and enhances reliability. Also, the form factor is significantly reduced compared with existing hybrid VCSEL package solutions. ViBO can be directly SMD mounted onto a board or driver IC without additional wire bonding. This supports easier integration under smartphone displays, for example.

"ViBO has superior properties as well as cost advantages compared to standard top-emitting devices that are combined with external optics," says Ralph Gudde, VP of marketing & sales. "Using ViBO as light source for 3D sensing applications offers more flexibility and freedom in design for its integration, as the footprint and the height are significantly smaller than hybrid solutions. This is especially interesting for consumer electronics such as smartphones or AR [augmented reality] glasses," he adds. "The smart combination of our high-performance VCSELs with unique, patented lens forms directly etched into the GaAs substrate gives our customers unprecedented benefits in creating tailored illumination profiles needed in advanced 3D sensing applications. Addressable zones allow [one] to create not only flood or spot illumination, but also linear or induvial illumination profiles, as the emitting zones can be flexibly turned on and off."

In the first-generation products, TRUMPF focuses on the realization of illumination devices incorporating various diffusor designs for a wide range of emission angles to support various flood illumination applications for the consumer and automotive sectors. "After having shipped millions of hybrid packaged products containing separate VCSEL arrays and diffusors, these widely used flood illuminators are the logical candidates for our ViBO technolog," says Gudde. "With coplanar contact designs, the devices can be flip-chip mounted, yielding the most compact integration with the shortest electrical path and thus minimum electrical inductance. This design setup allows short pulses, high modulation speed and the flexibility of addressing multiple channels or even selected segments on the chip."

ViBO lays the foundation of a new platform that can be tailored to various customer requirements and optical system designs. Conceivable fields of application could be all areas of proximity sensing — from smart glasses over face recognition to LiDAR applications.

www.trumpf.com/VCSEL-solutions
www.trumpf.com/s/vibo

OSRAM showcases sensor portfolio at Sensors Converge

ams OSRAM of Premstaetten/Graz, Austria and Munich, Germany exhibited its latest sensing technology at Sensors Converge in San Jose (21–23 September) — the first time it had exhibited in the USA following ams' acquisition of OSRAM in March. The firm showcased a comprehensive range of sensor solutions targeted at numerous industries including automotive, healthcare, mobile, industrial and horticulture.

Demonstrations took place in the San Jose Marriott Hotel next to the event. ams OSRAM showcased its 3D sensing and infrared lighting technologies for industrial robots and autonomous vehicles (AVs). The interaction between infrared light and the corresponding sensors is essential to create a 3D view of the vehicles' surroundings. ams OSRAM reckons that it is the only company in the market that provides both vertical-cavity surface-emitting lasers (VCSELs) and edge-emitting lasers (EELs) for infrared light, as well as time-of-flight (ToF) and global shutter image sensors.

The firm also presented its latest technologies in other industries, including:

- a UV-C LED with sensors that can safely disinfect areas by destroying harmful viruses and bacteria, while detecting human presence;
- horticulture sensors that enable spectral balancing of LEDs and daylight harvesting to assure an optimal yield and support energy and cost savings.

In addition, on 21 September, senior marketing manager Joerg Wertli gave a Tech Talk '3D Sensing Enables New Industrial Applications', both onsite at the event in the Tech Talk Lounge and streaming online. Wertli discussed how 3D optical systems, in combination with machine learning algorithms, have significant growth potential in industrial mass markets, increasing productivity of a factory's production system through improved safety, flexibility and autonomy.

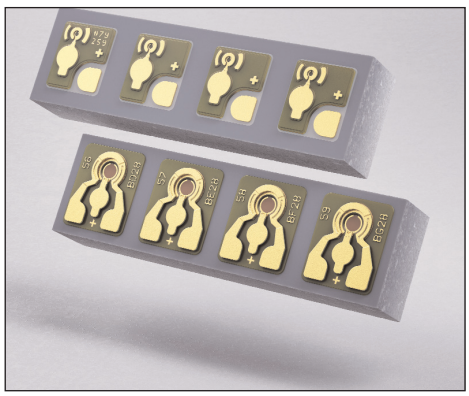
www.sensorsexpo.com
www.osram-os.com

TRUMPF presents new generation of datacom VCSELs and photodiodes at ECOC 2021

Extended temperature range and increased reliability and performance for 56Gbps, with 112Gbps to sample in December

At the European Conference on Optical Communication (ECOC 2021) held in Bordeaux, France (13–16 September), TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) showcased a new generation of vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for data communications applications that have superior performance at higher temperatures due to an extensively upgraded manufacturing platform with enhanced process control and better yields.

The VCSELs feature fully passivated die and extra mechanical protection for the mesa for enhanced reliability. The matching photodiode has low dark current



Trumpf's new 56Gbps VCSEL and photodiode. © TRUMPF.

and an additional ground pad for better shielding, which also provides ground-signal or signal-ground options for mounting. TRUMPF says that these features enables cost savings for data-center and high-performance computing applications due to not only the reduced energy cost (from less cooling) but also fewer device-related failures in the field.

"While we are pleased to offer expanded temperature range on our devices up to 56Gbps today, we are now focusing on bringing our 112Gbps solutions to the market early next year, with first samples targeted for December," says Ralph Gudde, VP of marketing & sales. In addition to the data communication market, the firm also offers solutions for consumer electronics, industrial sensing and industrial heating markets.

www.trumpf.com/VCSEL-solutions

Interoperability demonstrated between TRUMPF's 56Gbps VCSEL and photodiode with MACOM driver and TIA for 200G & 400G datacoms

At ECOC 2021, TRUMPF Photonic Components presented a live showcase of its vertical-cavity surface-emitting lasers (VCSELs) and photodiodes together with the VCSEL drivers and transimpedance amplifiers (TIAs) of MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications).

With the live demonstration over a 70m fiber cable, the component suppliers are providing a live experience of the interoperability of the TRUMPF 56Gbps-per-channel VCSEL and photodiode paired with a corresponding VCSEL driver and TIA for 56Gbps-per-channel applications from MACOM. The demonstrated signal integrity is shown to be better than the bit-error rate (BER) of 1E-11. As well as error-free optical data communication, the demonstration showcases proven, highly optimized optics and PMD solutions for applications in datacom, including 400Gbps QSFP-DD SR8 and QSFP-DD AOC for data centers.

In addition to compliance with the required industry standards, enhanced reliability of TRUMPF's 56Gbps-per-channel VCSEL is provided, as they are featured with a fully passivated die and extra mechanical protection for the mesa. Better shielding of the matching photodiode is reached by a very low dark current and additional ground pad, which also provides ground-signal or signal-ground option for mounting.

"Together, we provide a proven reputable solution for optics and PMDs to our customers," says Ralph Gudde, VP of marketing & sales at TRUMPF. "With 56Gbps-per-channel solutions in place, we are now focused on delivering 112Gbps-per-channel VCSELs and photodiodes towards early 2022" he adds.

"Showcasing interoperability of VCSELs and photodiodes with MACOM's laser drivers and TIAs can deliver customers an excellent bit-error performance at 56Gbps-per-channel for 200Gbps and 400Gbps optical module applications," says Marek Tlalka, senior director, High-Performance Analog, at MACOM. "After successfully proving the high performance and interoperability of these components, we are looking forward to continuing our work towards the next-generation 112Gbps-per-channel solutions."

www.macom.com/opto

Vector appoints business development director for North America

PCSEL firm gains Silicon Valley-based semiconductor communications industry veteran

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd (which was spun off from Scotland's University of Glasgow in March 2020) says that Dr Adam Carter has joined it as business development director for North America, based in Silicon Valley (his home for many years).

"Adam Carter is a semiconductor communications industry veteran, with an impressive, 25-year track record," comments CEO Neil Martin. "He has been instrumental in the growth of some of the world's leading manufacturers of integrated optical components, modules and subsystems, including several successful business exits, turnarounds and acquisitions… He will be a great asset to the business."

Carter was most recently chief commercial officer at Foxcon Optical Interconnects. From July 2014 to December 2018, he was a key executive officer in the team that turned Oclaro from a loss-making manufacturer of optical products to its sale to Lumentum Holdings for $1.85bn. From 2007 to 2014, he was a senior director & general manager of Cisco's Transceiver Module Group, where he led the acquisition of silicon photonics start-up Lightwire. Before that, he held strategic marketing and business development roles at Avago Technologies, Agilent Technologies and Hewlett Packard, having started his career as a process and device engineer at BT & D.

Carter holds a B.Sc. Honours in Applied Physics from Portsmouth University and received a Ph.D. from the University of Wales, Cardiff, for his research on the plasma etching of III-V semiconductor materials.

www.vectorphotonics.co.uk

indie acquiring TeraXion for $159m

TeraXion's lasers complement indie's LiDAR solutions for advanced driver-assistance systems and autonomous vehicles

indie Semiconductor Inc of Aliso Viejo, CA, USA has signed a definitive agreement to purchase optoelectronic component and module designer and manufacturer TeraXion Inc of Quebec City, Canada. The acquisition accelerates indie's vision of becoming a semiconductor and software-level solutions provider for multiple sensor applications spanning advanced driver-assistance systems (ADAS) and autonomous vehicles (AVs). According to a MarketWatch report in March, the global automotive LiDAR segment is expected to rise at a 28% compound annual growth rate (CAGR) off a 2020 base, creating a $3.2bn addressable market by 2027.

Founded in 2000 and underpinned by more than 30 global patents, TeraXion produces low-noise lasers, Bragg gratings and integrated photonic elements to address high-performance applications. More recently, TeraXion was an optical sensing reference design partner of indie, supporting next-generation frequency-modulated continuous wave (FMCW) systems for automotive light detection and ranging (LiDAR).

"Given the critical role LiDAR plays in achieving maximum levels of safety for assisted and self-driving cars, we are excited to welcome TeraXion's world-class design team and integrate their differentiated IP and product portfolio," says indie's co-founder & CEO Donald McClymont. "Specifically, TeraXion has developed leadership laser technologies that, when optimized together with our SoC [system-on-chip] solutions, enable order-of-magnitude improvements in both system performance and cost. Accordingly, this highly synergistic combination, built on a shared vision and strong cultural fit, positions indie to accelerate mass-market deployments of LiDAR platforms," he adds.

"By combining indie's mixed-signal, DSP [digital signal processing], software and power management experience with our laser and sensing technologies, together we intend to enable truly unparalleled solutions for ADAS and autonomous driving as well as adjacent high-reliability applications," says TeraXion's president & CEO Ghislain Lafrance, who plans to join indie's senior management team and continue to lead TeraXion's operations in Quebec.

Based on indie's closing stock price as of 30 August, indie will pay about US$159m for TeraXion, consisting of US$80m in cash plus a fixed number of eight million indie Class A common shares. The transaction has been approved by the boards of directors of both firms and is expected to close in fourth-quarter 2021, subject to customary closing conditions. Excluding any non-recurring acquisition-related charges and amortization of intangibles, indie expects the acquisition to be immediately accretive.

www.indiesemi.com
www.teraxion.com

Vector receives £600k for TITAN project

UK-funded project to develop PCSELs for low-power-consumption hyperscale data-center applications

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd (which was spun off from Scotland's University of Glasgow in March 2020, based on research led by professor Richard Hogg) has received £600,000 for the newly awarded project TITAN ('PhoTonIc CrysTal LAsers for EtherNet applications'), which is developing PCSELs for low-power-consumption optical interconnections between servers in hyperscale data centers.

Of the total project value, £300,000 has come from Innovate UK's Investor Partnership Programme. This has been match-funded by private investment from UKI2S (a specialist, deep-tech seed fund for UK-based research spin-outs); the Scottish Growth Scheme (managed through Foresight Group Equity Finance); and Equity Gap (an angel syndicate investing in emerging Scottish businesses).

"The rising power usage of hyperscale data centers is being driven by escalating demand from network-connected devices, such as smartphones, PCs and the Internet of Things (IoT)," notes Vector Photonics' CEO Neil Martin. "Hyperscale data centers currently rely on high-performance lasers for the optical interconnects between servers. These lasers require so much electrical power to operate that it is the heat they create, and the energy used by the systems which cool them, which has become the limiting factor to any increases in optical performance," he adds.

PCSELs require only half the electrical power of the incumbent lasers, for the equivalent system performance

"The TITAN project will fund the early-stage development of PCSELs, which aim to solve this major heat problem. PCSELs require only half the electrical power of the incumbent lasers, for the equivalent system performance," Martin continues. "Less heat is produced and less energy is used for cooling. Since we anticipate the system optical performance requirements of next-generation, hyperscale data centers increasing in future, it is only low-power-consumption systems using PCSELs that can realistically facilitate this increase."

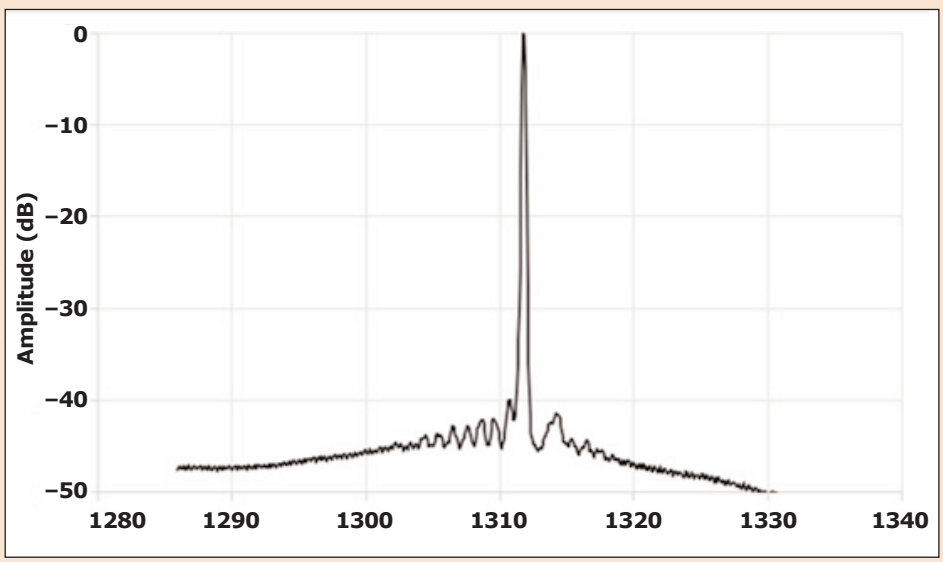
www.vectorphotonics.co.uk

Vector's 1310nm PCSEL demonstrates 40dB SMSR

Side-mode-suppression ratio matches incumbent datacom laser technology

Vector Photonics says that the optical performance test results for its new 1310nm PCSEL show a side-mode-suppression ratio (SMSR) of 40dB, demonstrating that its surface-emitting lasers have achieved a key figure of merit for their performance, on a par with existing market-leading datacom laser technology.

"A 40dB result matches incumbent laser technology performance and shows we are on track with the successful commercialization of this revolutionary new semiconductor laser technology," says David Childs, director of product development.



Optical output of new 1310nm photonic-crystal surface-emitting laser, showing side-mode-suppression.

The 1310nm PCSEL has been developed as part of the project LOCAL (Lasers for Communications Applications), which is funded by Innovate UK's Sustainable Innovation Fund, run in collaboration with the University of Glasgow. The test results demonstrate that the laser should meet the industry specifications for the network processing architecture of next generation hyperscale data centers (the laser's target market).

www.vectorphotonics.co.uk

NeoPhotonics launches tunable, high-power FMCW laser and SOA for coherent LiDAR in AVs and industrial sensing

High output and narrow linewidth in eye-safe 1550nm window enhance safety

NeoPhotonics has launched a tunable high-power FMCW (frequency-modulated continuous-wave) laser module and high-power semiconductor optical amplifier (SOA) chips. Both components are optimized to enable long-range automotive light detection & ranging (LiDAR) and high-resolution industrial sensing applications. The FMCW laser is C-band tunable and can be directly modulated to provide >21dBm (126mW) fiber-coupled power and a narrow-linewidth FMCW optical signal. The SOA chip is designed for integration with PIC LiDAR engines and provides >23dBm of optical output power.

The new high-output-power SOAs and FMCW lasers are based on NeoPhotonics' photonic integration platform and improve sensitivity and range, which enables automotive LiDAR systems to 'see' considerably further than 200m, allowing for enhanced safety. Both products operate in the 1550nm band, which is believed to be more eye-safe, and are currently being sampled to key customers. In addition, tunable FMCW laser sources enable LiDARs with configurable operating wavelength, further enhancing the immunity of coherent LiDARs to external light interference.

Coherent LiDAR (i.e. FMCW LiDAR) uses coherent technology to greatly increase range and sensitivity by measuring the phase of the reflected light instead of relying only on intensity measurements. NeoPhotonics says that it pioneered coherent technology for communications applications and implemented it in PICs using the firm's indium phosphide (InP) and silicon photonics integration platforms. Coherent LiDAR systems require similar chip-scale manufacturing to reduce costs and enable high volume.

Coherent detection, whether for LiDAR or communications applications, uses PICs to extract phase and amplitude information from the optical signal. Narrow-linewidth and low-phase-noise lasers are required for precise phase measurements, and high optical power is required to compensate for optical loss in the silicon photonics optical chips and to provide a sufficient return signal from distant objects for efficient detection. NeoPhotonics' narrow-linewidth laser and SOA can be used together or separately to optimize the LiDAR module performance.

"We are excited to apply our high-volume photonic integration coherent technology, which we have honed for over a decade, to the adjacent market of LiDAR and autonomous vehicles," says chairman & CEO Tim Jenks. "The benefits of coherent technology and the physics enabling it mean we can bring the same benefits to customers in these new markets that we have brought to communications customers for many years."

www.neophotonics.com/soa-sipho-transceivers

NeoPhotonics appoints senior VP of global sales

Communications and semiconductors industry veteran to target new markets and applications

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC) lasers, modules and sub-systems for high-speed communications – has appointed Bradford W. Wright as senior VP of global sales.

Wright has 25 years of experience in the communications and semiconductor industries. Most recently, he was employed as the head of worldwide component sales and applications at Cisco Systems, following its acquisition of Acacia Communications, where he was VP of sales from January 2018.

From January 2016 to January 2018, Wright was director of sales at Intel Corp, following its acquisition of Altera Corp in 2015, where he held a similar role. Before Altera, Wright rose through several commercial roles of increasing responsibility at Analog Devices and Texas Instruments.

Wright holds a Bachelor of Science degree in Electrical Engineering from the University of Wisconsin-Madison.

"Brad's extensive experience in both communications and semiconductors will bring direct benefit to our high-speed optical components, modules and semiconductor device solutions for our rapidly expanding high-speed markets," believes chairman & CEO Tim Jenks.

"There are accelerating demands for high-speed connectivity solutions in hyperscale data centers and in communications equipment companies that demand the technologies and capabilities of NeoPhotonics," comments Wright. "I look forward to leveraging my experience in communications and semiconductors to bring NeoPhotonics' innovative solutions to both new markets and new applications."

NeoPhotonics launches CFP2-DCO module with 0dBm output power for ROADM-based metro, regional and long-haul networks

Coherent pluggable transceiver modules provide solution for multiple cloud and telecom ROADM network use cases

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications – has launched a high-output-power version of its 400G multi-rate CFP2-DCO coherent pluggable transceiver with 0dBm output power and designed to operate in metro, regional and long-haul reconfigurable optical add/drop multiplexer (ROADM)-based optical networks.

The new, high-output-power module is based on NeoPhotonics' vertically integrated indium phosphide technology platform, including its ultra-pure Nano tunable laser and Class 40 coherent driver modulator (CDM) and coherent receiver (ICR). The module operates at up to 67Gbaud, enabling longer-distance transmission and exhibiting superior receiver optical signal-to-noise ratio (rOSNR) performance, it is claimed. A differentiating feature is that the transmitter integrates an optical amplifier to achieve the 0dBm output power, while simultaneously achieving what the firm believes is the best transmitter OSNR and out-of-band OSNR performance in the industry. Higher transmitter OSNR enables longer-distance transmission or more ROADM stages, while higher out-of-band OSNR ensures less crosstalk for colorless ROADMs.

As well as the high output power and superior OSNR performance, ROADM applications also depend on a CFP2-DCO's optical filtering tolerance when its signal passes through multiple ROADMs in a network. This is because each ROADM stage applies optical filtering and causes the signal to lose power at the spectral edges. The CFP2-DCO module is well suited for metro ROADM applications to cover a network distribution of up to 16 ROADM spans, encompassing almost all network scenarios. Also, this module runs at a high spectral efficiency with 75GHz DWDM channel spacing. The same 400G CFP2-DCO module has sufficient performance to cover long-haul applications at 400G and 200G.

"Our newest CFP2-DCO coherent pluggable module, with high output power, robust ROADM filtering tolerance and demonstrated transmission over 1500km, allows customers to use one coherent pluggable solution to cover essentially all metro ROADM use cases, simplifying network design, enabling disaggregation, and lowering inventory costs," says chairman & CEO Tim Jenks. "The key to achieving line-card-equivalent performance in a pluggable module, but with significantly lower power than a line-card, is the vertical integration of our optical solution and Nano tunable laser," he concludes.

Separately, NeoPhotonics conducted a Trends and Technology webinar on 9 September, addressing important issues and new experimental results relevant to the introduction and growth of 400Gbps pluggable modules for data-center interconnect, metro, regional and long-haul applications.

www.neophotonics.com

II-VI joins SmartTunable MSA Group for wavelength-tunable transceivers as founding member

Multi-source agreement targets interoperable self-tuning optics for full C-band wavelength-tunable transceivers

Optical communications component and subsystem manufacturer II-VI Inc of Saxonburg, PA, USA says that it has joined, as a founding member, the SmartTunable Multi-Source Agreement (MSA) Group (STM Group) for wavelength-tunable transceivers.

The STM Group brings together market leaders of full C-band wavelength-tunable transceivers to enable interoperable self-tuning optics (STO).

"The algorithms developed by the SmartTunable MSA will improve OpEx and CapEx for our end users by simplifying the deployment of their systems, reducing technician time in the field, and eliminating the need for tuning equipment," says Dr Lee Xu, senior VP, Transceivers business unit. "Our customers will greatly appreciate the efficiency and streamlined operations achieved through this standardization effort, as they ramp-up DWDM system deployments to support high-speed wireline and 5G wireless broadband services."

www.smarttunable-msa.org

POET ships first optical engine samples to customers

POET Technologies Inc of Toronto, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — has shipped its first 100G transmit (Tx) optical engine sample to a leading European optical systems company. Additional samples will also be delivered to several other interested companies over the next month. Several prospective customers are expected to participate in POET's demonstrations of its Optical Interposer-based optical engine solutions concurrent with the 23rd China International Optoelectronics Exhibition (CIOE 2021) in Shenzhen (16–18 September).

The sample delivered to a leading European optical systems company supports a combined transmit and receive optical engine product, which has been developed for a 400G transceiver application. The Alpha samples are said to demonstrate excellent margin to the transmit link budget at operating temperatures with excellent optical-eye margins. Internal testing shows that only minor improvements are required for a Beta release that would meet all of the requirements for production. These changes have already been incorporated in the Beta designs, which have just been released to the mask shop for production.

"In spite of 20 years of trying, no other company has been successful in developing a versatile hybrid integration platform," reckons chairman & CEO Dr Suresh Venkatesan. "A number of customers and business partners will be taking delivery of samples now and in the coming months — as they gain a full understanding of the simplicity and versatility of the POET Optical Interposer platform, we believe it has the potential to become a new standard for packaging in the photonics industry. The shipment of samples constitutes a completion of over three years of technology and product development culminating in placing market-viable products in customers hands."

The firm demonstrated a 400G transmit engine with a silicon photonics-based modulator from Shanghai-based Silux Technologies Co Ltd (SiluxTek), a 100G CWDM transmitter, a 200G CWDM receiver and other novel remote light source designs during CIOE and the concurrent ICCSZ conference (14–15 September) in Shenzhen.

www.poet-technologies.com

POET teams with Silux to demo 400G optical engine

POET gave a live demonstration of a 400G optical engine to selected customers and business partners during the ICCSZ Conference on 14–15 September and concurrent with the 23rd China International Optoelectronics Exhibition (CIOE) in Shenzhen on 16–18 September.

The 400G optical engine to be demonstrated is based on POET's novel hybrid integration platform, which incorporates four continuous wave (CW) lasers that have been flip-chip bonded to the Optical Interposer. The 400G CWDM4 optical engine has monolithically integrated optical multiplexers, waveguides and coupling structures. The silicon photonic modulator photonic integrated circuit (PIC) of Silux Technologies Co Ltd (SiluxTek) of Shanghai, China is being used to complete the 400G engine, providing high-speed modulation of light for data transmission. The pre-alpha prototype are being demonstrated live to invited guests in the ICCSZ forum and POET's Shenzhen lab concurrent with the CIOE exhibitions.

POET's Optical Interposer is designed with a proprietary optical interconnect layer deposited onto a standard 200mm (8 inch) silicon wafer. The optical interconnect layer contains embedded passive devices such as multiplexers, demultiplexers, spot-size converters and waveguides that allow light to pass among the devices and into connected optical fibers. Active devices (such as lasers, modulators and detectors) communicate electrically at high frequencies through the metal layers that are embedded within the silicon wafer. This unique, patented architecture allows devices of different types to be seamlessly integrated, both optically and electrically, onto a single chip. In subsequent versions of the 400G optical engine, SiluxTek's silicon photonic modulator will be passively flip-chipped onto the Optical Interposer, providing a low-cost, scalable, high-performance 400G solution.

"We are very pleased to have teamed-up with SiluxTek for this important live demonstration, which represents a key milestone for each company," says POET's president & general manager Vivek Rajgarhia. "Beyond proving the combined functions of 400G, we will conclusively demonstrate over the next few months the simplicity and versatility of POET's Optical Interposer design, which allows leading-edge chips, like the SiluxTek modulator PIC, to be rapidly integrated into our platform. In addition, the fully integrated optical engines designed by POET are fabricated and tested at wafer-scale, resulting in lower cost and the ability to rapidly scale production," he adds. "This is a moment, I believe, that will catch the attention of leading module and systems companies based in China, both in and out of the datacom market space, in the potential uses for the POET Optical Interposer across a wide spectrum of photonics applications."

www.cioe.cn/en

Tower and Quintessent partner to create foundry silicon photonics platform with integrated QD laser

New capability to address optical connectivity in AI/machine learning and disaggregated computing

Specialty analog foundry Tower Semiconductor Ltd (which has fabrication plants in Migdal Haemek, Israel, and at its US subsidiaries in Newport Beach, CA and San Antonio, TX, and at TowerJazz Japan Ltd) and Quintessent of Santa Barbara, CA, USA, which specializes in laser integration with silicon photonic integrated circuits (PICs), are collaborating to create what they reckon will be the first silicon photonics (SiPho) process with integrated quantum dot lasers, addressing optical connectivity in artificial intelligence/machine learning (AI/ML) and disaggregated computing (data center) markets. According to market research firm Yole, the silicon photonics transceivers market for data centers is expected to rise rapidly at a compound annual growth rate (CAGR) of 40% to $3.5bn in 2025.

The new foundry process will build on Tower's PH18 production silicon photonics platform and add Quintessent's III-V quantum-dot-based lasers and optical amplifiers to enable a complete suite of active and passive silicon photonic elements. The resulting capability will be an industry first in demonstrating integrated optical gain in a standard foundry silicon photonics process, it is expected. The initial process development kit (PDK) should be available this year, with multi-project wafer runs (MPWs) following in 2022.

"I'm very excited by the prospects for a new class of high-performance lasers and photonic integrated circuits on silicon, leveraging the unique advantages of quantum dot materials," says Dr John Bowers, UCSB professor and Quintessent co-founder.

The co-integration of lasers and amplifiers with silicon photonics at the circuit element level should improve overall power efficiency, eliminate traditional design constraints such as on-chip loss budgets, simplify packaging, and make possible new product architectures and functionalities. For example, a silicon photonic transceiver or sensor product with integrated lasers will be capable of complete self-test at the chip or wafer level. These advantages are further enhanced by employing semiconductor quantum dots as the active optical gain media, which enables devices with greater reliability, lower noise, and the ability to operate efficiently at higher temperatures.

"Bringing the III-V laser diode within our silicon photonics platform will enable single-chip photonic integrated circuit design," says Tower executive director & fellow Dr David Howard. "This means that both III-V quantum dot amplifiers and lasers, and Tower's silicon photonics passive and active elements, will be delivered by a foundry through a single MPW chip run," he adds.

"We are pleased to combine our quantum dot gain functionality with Tower's proven silicon photonics process to enable a disruptive new capability," says Dr Alan Liu, co-founder & CEO of Quintessent. "This platform has great potential to solve the connectivity bottleneck limiting AI training systems and disaggregated computing, among other applications."

The augmented PH18 process is part of DARPA's 'Lasers for Universal Microscale Optical Systems' (LUMOS) program, which aims to bring high-performance lasers to advanced photonics platforms, addressing commercial and defense applications.

www.quintessent.com
www.towersemi.com/technology/rf-and-hpa/silicon-photonics-rf

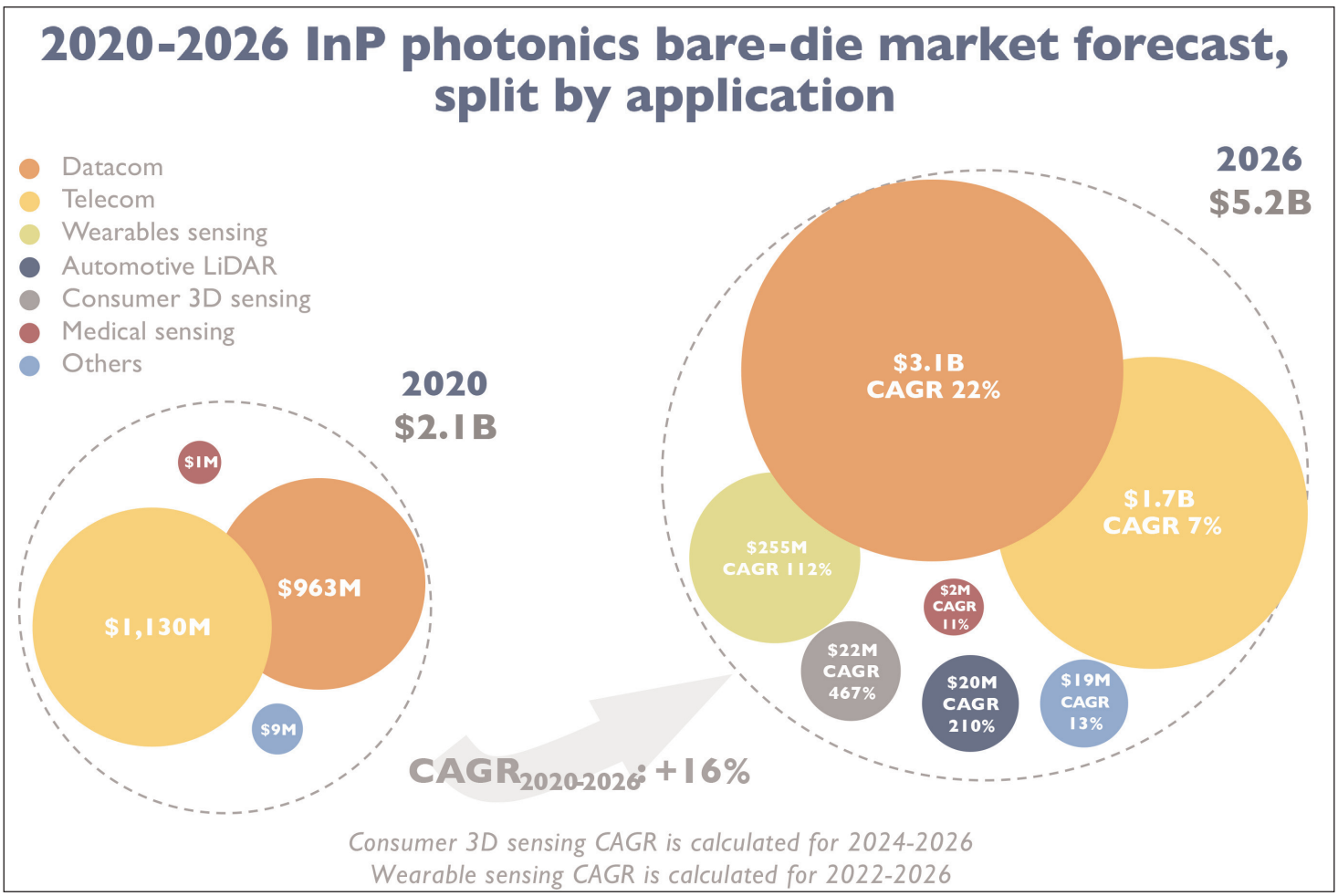
InP bare die market growing at 16% CAGR from $2.1bn in 2020 to $5.2bn in 2026

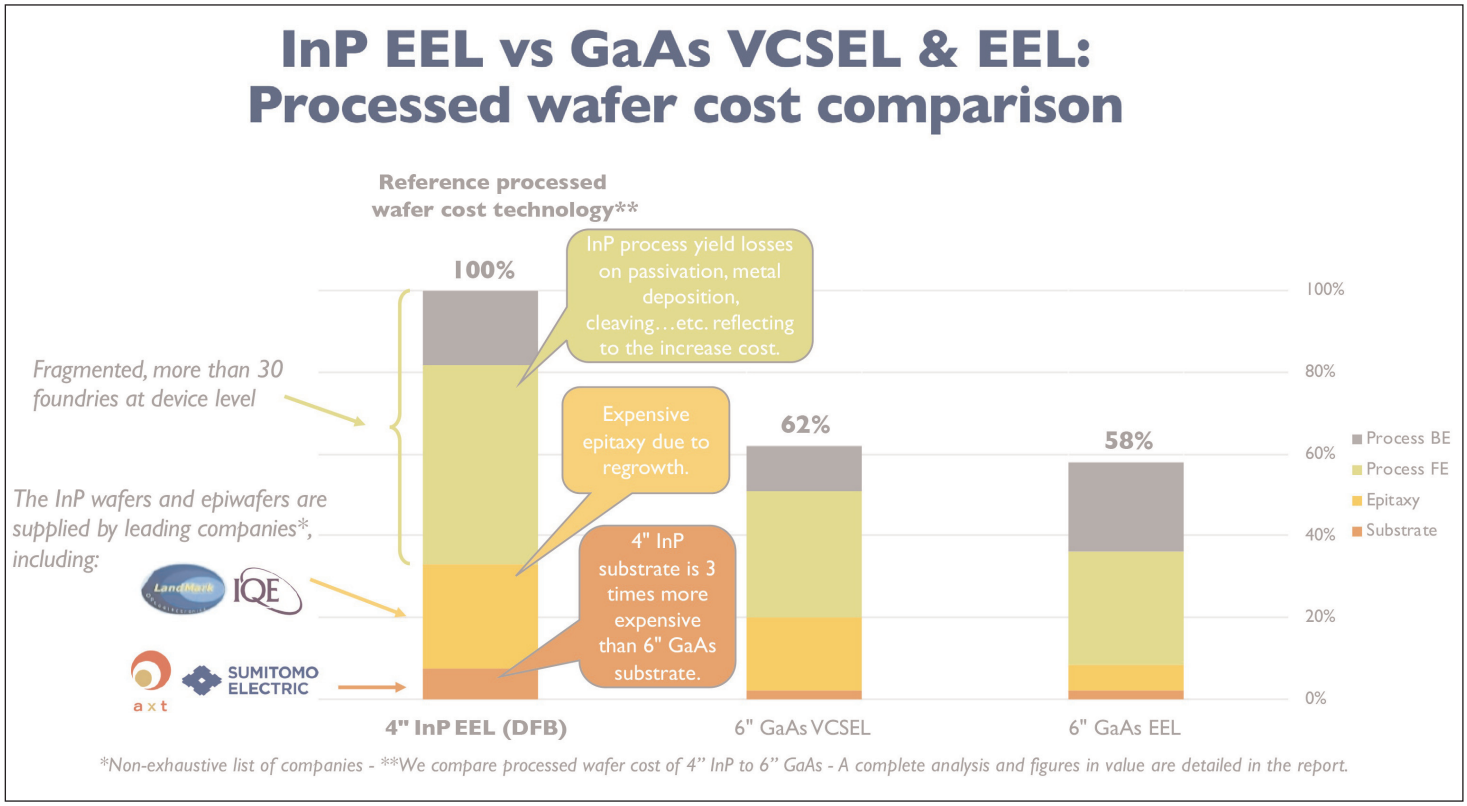
The datacom and telecom sectors are growing at 22% and 7%, while the merging sectors of automotive LiDAR, consumer 3D sensing and wearables are growing at 210%, 467% and 112%, reckons Yole Développement.

In its report 'InP Wafer, Epiwafer and Device Market 2021: Photonics and RF Applications', Yole Développement estimates that the market for indium phosphide (InP) bare die is growing at a compound annual growth rate (CAGR) of 16%, from $2.1bn in 2020 to $5.2bn in 2026.

As an indispensable building block for high-speed and long-range optical transceivers, InP laser diodes remain the best choice for telecom and datacom photonic applications, says Yole. However, following the outbreak of the COVID-19 pandemic and the US–China trade tensions, telecom infrastructure deployment was disrupted (with many laser and photonics companies losing big customers), resulting in a slight slowdown in the InP market in 2020. However, the requirement for more data transfer at higher speed in datacoms is increasing, with technology migrating to single InP lasers targeting state-of-the-art 100Gbps output, making them preferable in 400Gbps and 800Gbps transceivers.

Driven by high-volume adoption of high-data-rate lasers, the bare die market for datacom applications reached about $963m in 2020, and is estimated to be growing at a CAGR of 22% to $3.1bn in 2026.





Meanwhile, due to 5G deployment, the cyclical InP telecom market should continue to grow steadily at a CAGR of 7%, from $1.1bn in 2020 to $1.7bn in 2026, reckons Yole.

Yole expects initial slight market penetration of InP in 2022 in wearables, followed by a significant increase at a CAGR of 112% to $255m in 2026.

"For light detection and ranging (LiDAR) applications, InP could be promising, enabling eye safety at higher wavelengths," says Ahmed Ben Slimane PhD, technology & market analyst, Compound Semiconductors and Emerging Substrates, at Yole. "Leading companies such as Volvo, ZF, Continental, Daimler etc are interested in adopting InP-based LiDAR," he adds. The automotive LiDAR sector is hence forecasted to grow at a CAGR of 210% to $20m in 2026.

For smartphones, organic light-emitting diode (OLED) displays are transparent at wavelengths in the range of 13xxnm to 15xxnm. Original equipment manufacturers (OEMs) interested in removing the camera notch on mobile phone screens and integrating the 3D sensing modules under OLED displays are considering moving to InP edge-emitting lasers (EELs), replacing the existing gallium arsenide (GaAs) vertical-cavity surface-emitting lasers (VCSELs). Even though this trend is currently in an early R&D phase (with process yields still low, hampering the economy-of-scale), Yole sees strong interest from several players, such as ams, Infineon Technologies, STMicroelectronics, and several laser manufacturers and sensor players. The consumer 3D sensing sector is hence forecasted to grow at a CAGR of 467% to $22m in 2026.

Market players in supply chain

As a dynamic market with lots of opportunities for both legacy players and new entrants, Yole notes that the InP market is fragmented, with numerous companies, especially at the device level.

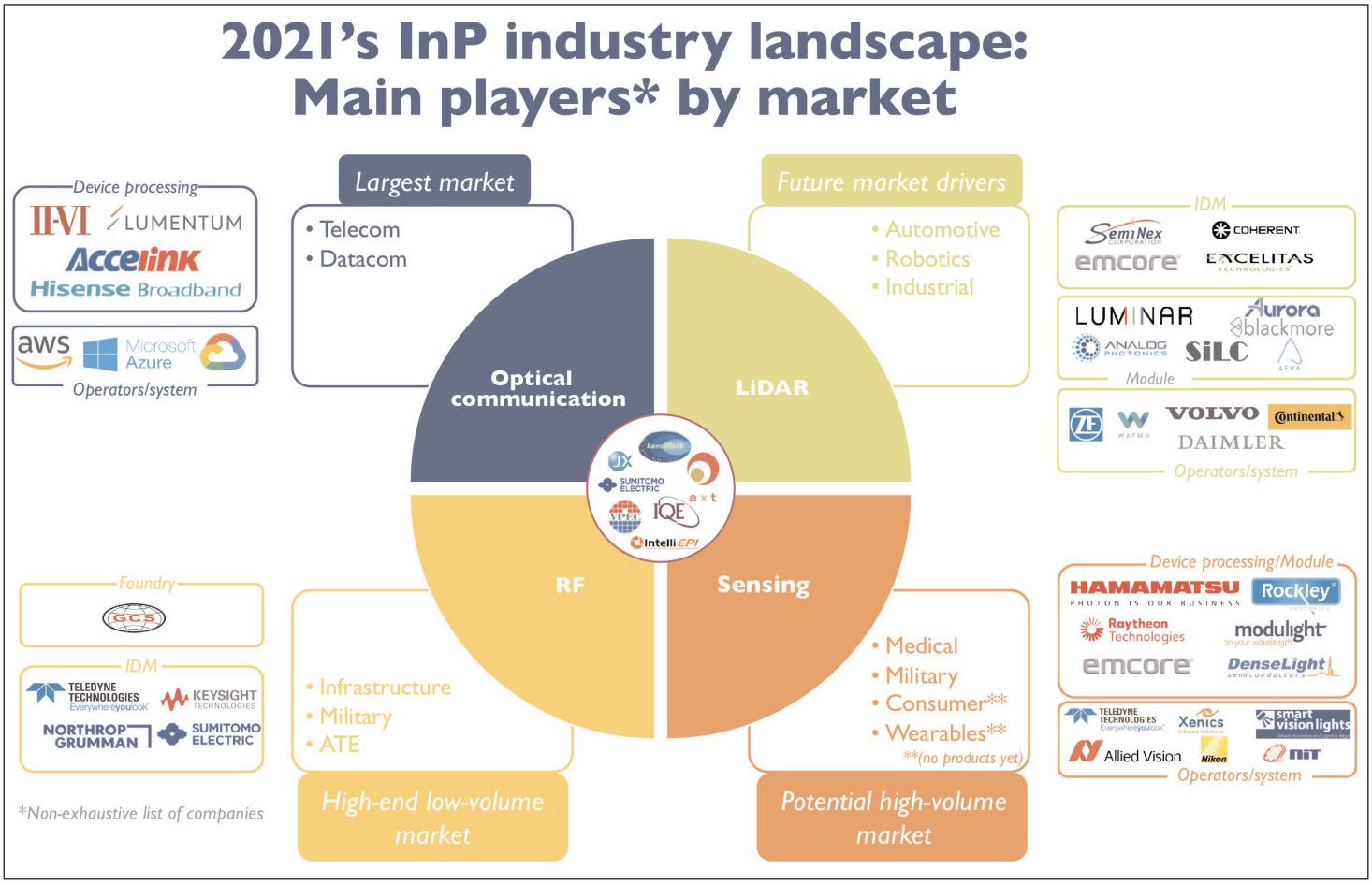
"Two American players are leading the InP market: II–VI and Lumentum," says Ahmed Ben Slimane. "Both have increased their market share and strengthened their position thanks to strategic mergers and acquisitions. Indeed, II–VI acquired Finisar in 2019 and Lumentum acquired Oclaro in 2018."

II–VI and Lumentum both have vertically integrated business models: they generate revenues at bare die, device, and module levels. II–VI also offers epiwafer products. Their combined bare die market share is about 30%.

Facing II–VI and Lumentum, Yole identifies major Chinese players such as Hisense and Accelink. Both these companies are in the global top five and are increasing their market share step by step. The two Chinese firms are taking advantage of the US–China trade tensions and China investing heavily in optical infrastructure (with the massive deployment of 5G transceiver in Asia), says Yole.

Sensing applications targeting the mass consumer and automotive markets are attracting new players. Yole has hence identified several types of player interested in entering this market:

- Vertically integrated InP players with the know-how and an already established structure, as they can easily switch to sensing applications as soon as the market becomes bigger. II–VI and Lumentum are part



of this segment.

- GaAs players with foundry capabilities (e.g. ams and Trumpf) could leverage the existing GaAs tools to switch to similar InP processes.
- Emerging foundries or companies already working on InP-based solutions.

"In the last category, we witnessed an increase in private investments and SPACs [special-purpose acquisition companies] in the last year," notes Poshun Chiu, technology & market analyst, Compound Semiconductors & Emerging Materials. "These include, in Q4-2020, Luminar raised $590m and went public, then acquired OptoGration; in Q2-2021, Aeva went public with an initial valuation of $1.7bn; and in Q2-2021, Rockley Photonics announced its intention to go public at an initial valuation of $1.2bn with an Apple-supported project for smartwatches," he adds.

Yole notes that the InP epiwafer market continues to be dominated by LandMark (with over 60% of the open epiwafer market share). Sumitomo and AXT continue to lead the substrate market (with combined market share of more than 75%). ■

www.i-micronews.com/products/inp-wafer-epiwafer-and-device-market-2021-photonics-and-rf-applications

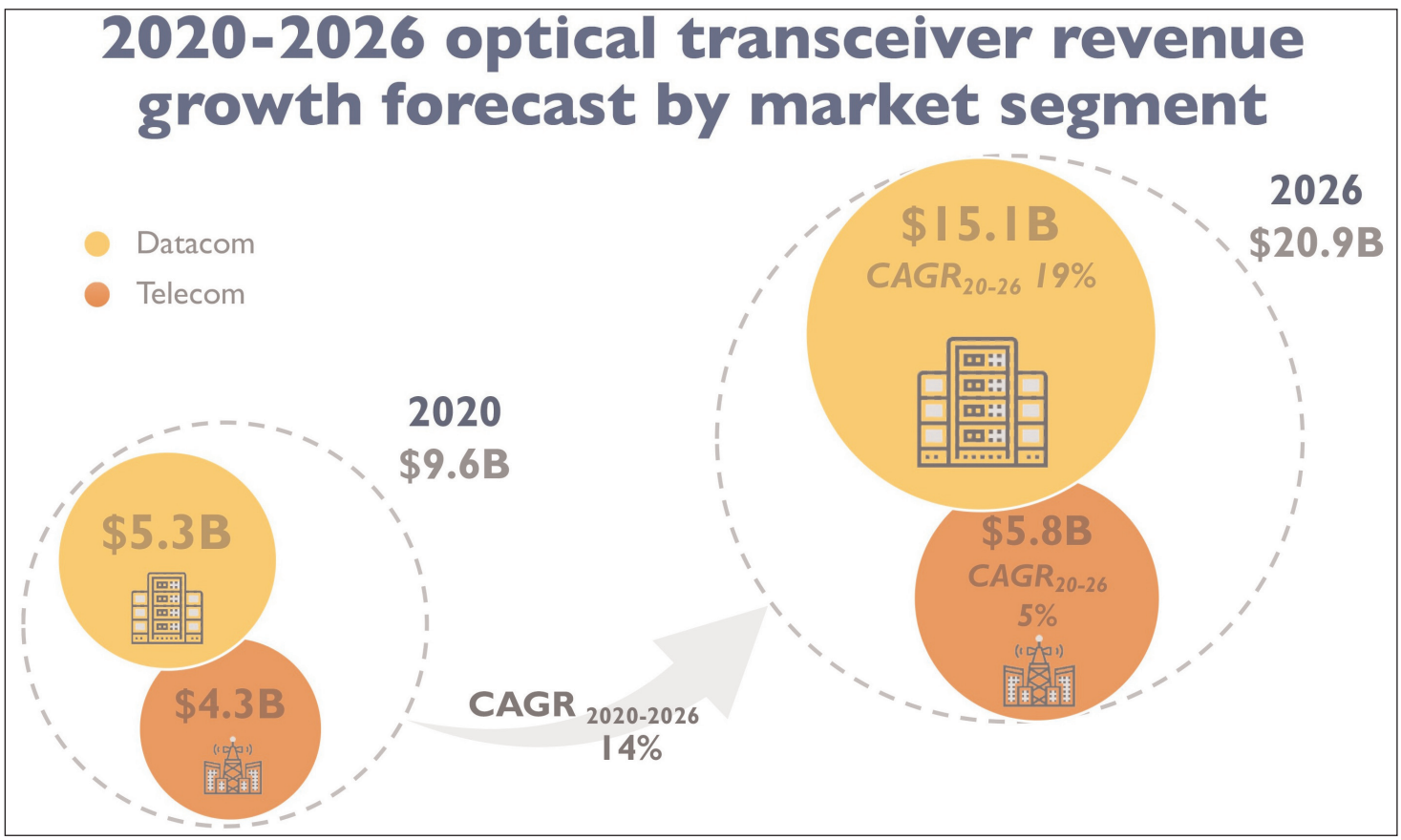
Optical transceiver market growing at 14% CAGR to $20.9bn in 2026

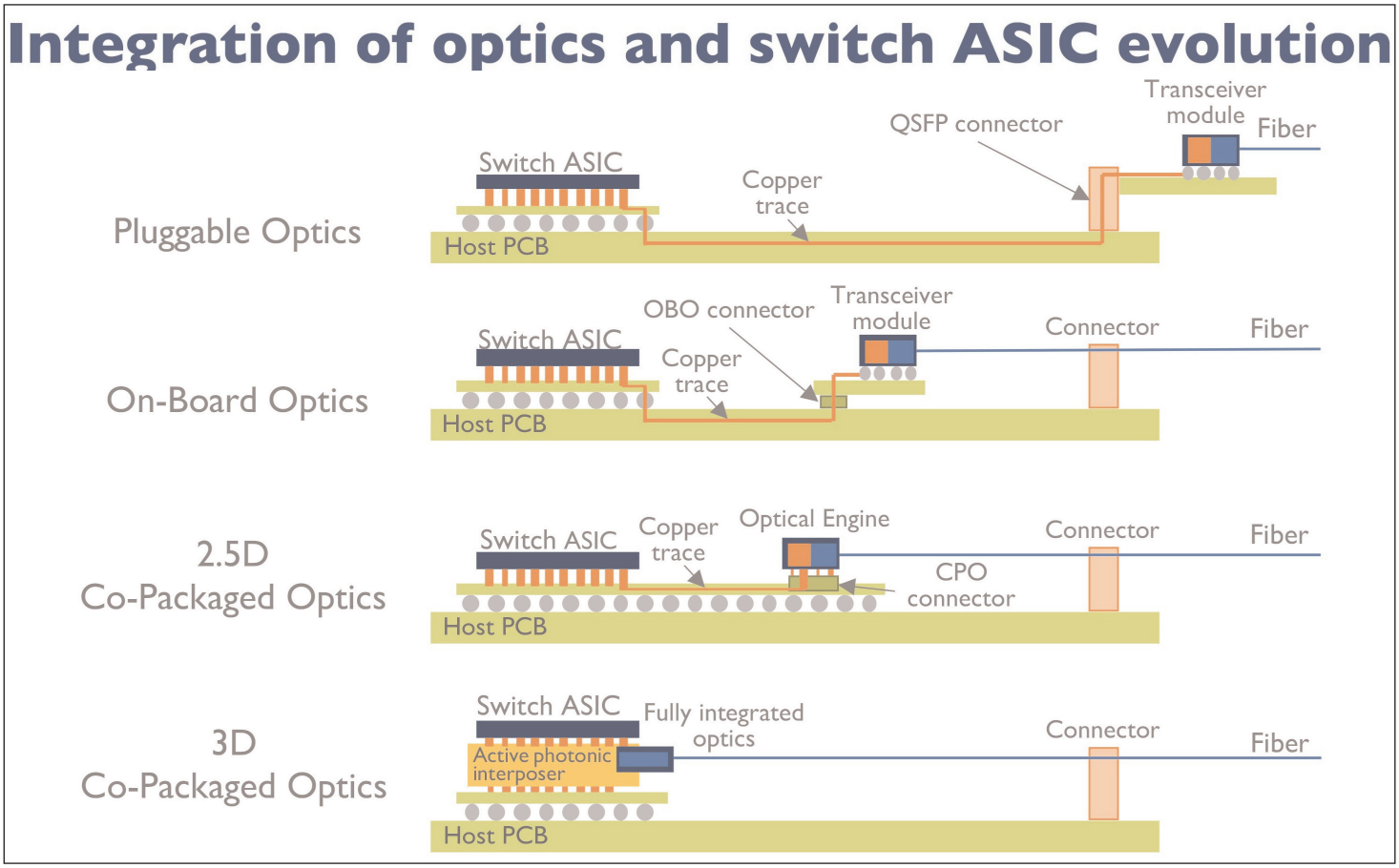
Growth is driven by the adoption of high-data-rate modules by big cloud service operators and national telecom operators, says Yole Développement.

The optical transceiver market was $9.6bn in 2020 and is rising at a compound annual growth rate (CAGR) of 14% to $20.9bn in 2026, driven by high-volume adoption of high-data-rate modules (above 100G) by big cloud service operators and national telecom operators in order to increase fiber-optic network capacity, forecasts Yole Développement in its report 'Optical Transceivers for Datacom & Telecom Market 2021'. The COVID-19 pandemic has affected optics manufacturing globally. However, in the last three years the optical transceiver industry has still grown by 24% in China but only 1% in the USA.

"For the past 50 years, mobile technology innovations have been rolled out each decade," notes Martin Vallo PhD, technology & market analyst, Solid-State Lighting. "Mobile bandwidth requirements have evolved from voice calls and texting to UHD [ultra-high-definition] video and a variety of AR/VR [augmented reality/virtual reality] applications," he adds. "In spite of deep implications of the COVID-19 outbreak for the telecom infrastructure supply chain, consumers and business users worldwide continue to create new demand for networking and cloud services. Social networking, business meetings, video streaming in UHD, e-commerce and gaming will drive the continued application growth".

The average number of devices connected to the Internet per household and per capita is increasing and, with the advent of new digital devices with increased capabilities and intelligence, adoption rates are rising each year, notes the report. Expanding machine-to-machine applications, such as smart meters, video surveillance, healthcare monitoring, connected drives and automated logistics contribute in





a major way to device and connection growth and push the expansion of data-center infrastructure.

The evolution of multiple technologies has enabled data rates of 400G, 600G, 800G and beyond across data-center infrastructure as well as in long-haul and metro networks. While 400GbE deployments are ramping across data-center networks, many cloud providers and telecom operators are now looking to the 800Gbps optical ecosystem to increase bandwidth capacity and keep pace with the growing demand for data: 800G optical modules can support more configurations, for example 2x 400GbE, 4x 200GbE or 8x 100GbE.

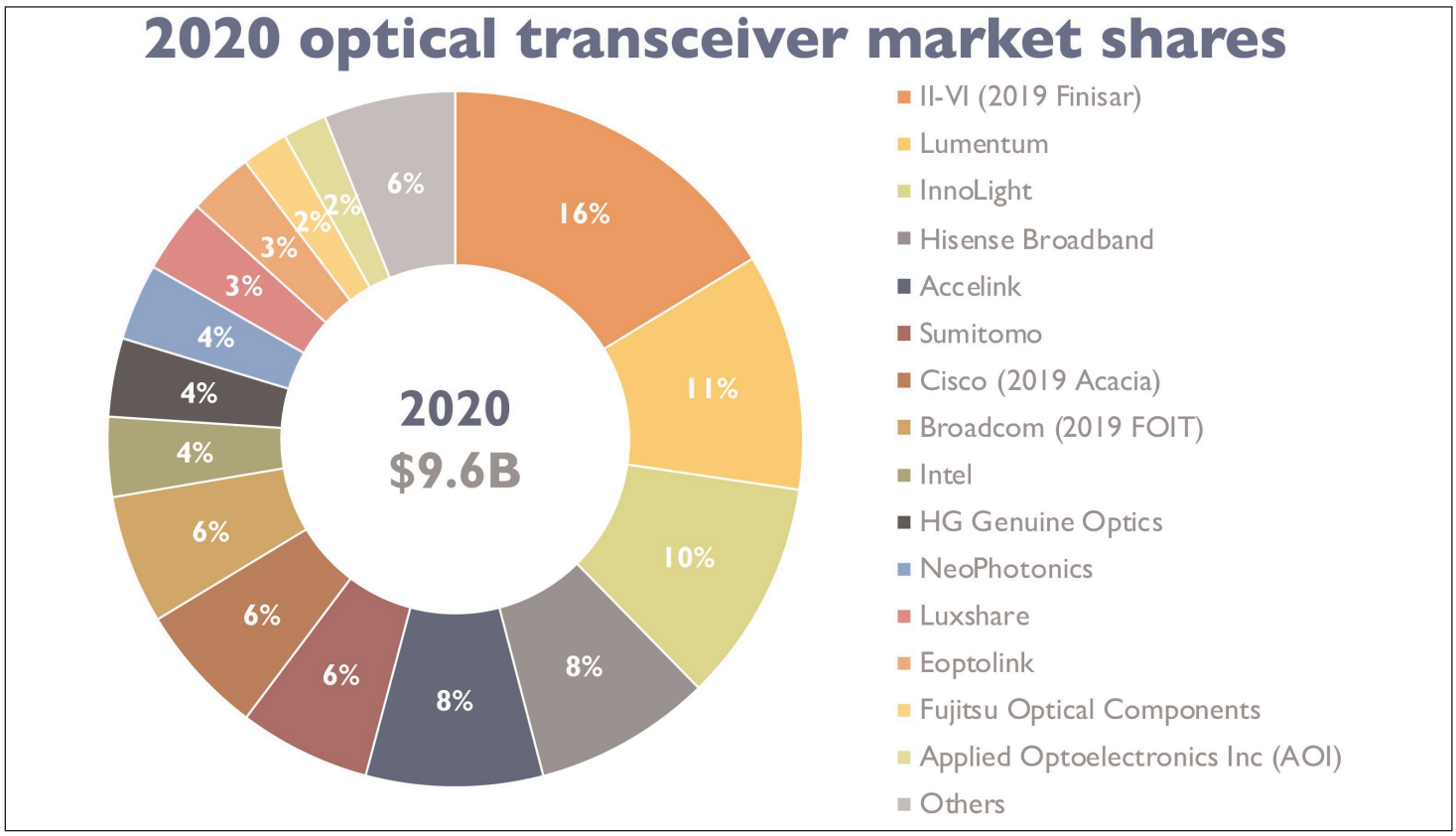
Today's Ethernet switch application-specific integrated circuits (ASICs) are running at a 50Gbps lane rate driven by 50G PAM-4 (4-level pulse amplitude modulation) technology. In line cards, a re-timer is typically needed to synchronize PAM-4 data from the switch to the optical interface. In 400G optical modules, an additional silicon gearbox chip can be used to convert 50G PAM-4 electrical inputs/outputs (I/Os) to 100G per wavelength optical I/Os in order to connect to 100G optics. Depending on the application and transmission reach, 400G offers various optical interfaces, including 400G SR4, 400G DR4, 400G FR4 and 400G LR4.

"We anticipate high popularity of 800G modules as they take advantage of 100G single-wavelength optics already proven in 400GbE systems and thus can be technically and cost-effectively implemented in QSFP-DD [Quad Small-Form-factor Pluggable Double-Density] and OSFP [Octal Small-Form-factor Pluggable] form factors," says Pars Mukish, business unit manager, Solid-State Lighting & Display.

Existing form factors will be limited in their ability to support more than 800G capacity in terms of the required electrical and optical densities and thermal aspects, notes the report. Power consumption is another challenge. The largest contributor is the electrical interface between the switch ASIC and optical module, particularly for QSFP-DD and OSFP. As a result of discrete electrical device implementation, power dissipation and thermal management are becoming limiting factors for future pluggable optics, states Yole.

In this regard, Yole's partner, the reverse engineering and costing company System Plus Consulting, provides insight into the technology data, manufacturing cost and selling price of InnoLight's TDP4CNT-N00 400Gb QSFP-DD optical transceiver in its 'InnoLight's 400G QSFP-DD Optical Transceiver' analysis. "InnoLight's 400G QSFP-DD is one of the first 400G optical transceivers on the market allowing communication up to 2km using PSM4 modulation," notes Sylvain Hallereau, principal technology & cost analyst at System Plus Consulting. "The InnoLight solution is based on the IN010C50 PAM4 DSP [digital signal processor] chipset, four gallium arsenide (GaAs) laser driver dies, and a TIA [transimpedance amplifier] die, all designed by Inphi".

Also, aiming to overcome the challenges mentioned above, co-packaged optics (CPO) is a new approach



that brings the optics and the switch ASIC close together. Furthermore, CPO technology is considered as a new deployment model of the whole ecosystem and alternative to pluggable optics. ■

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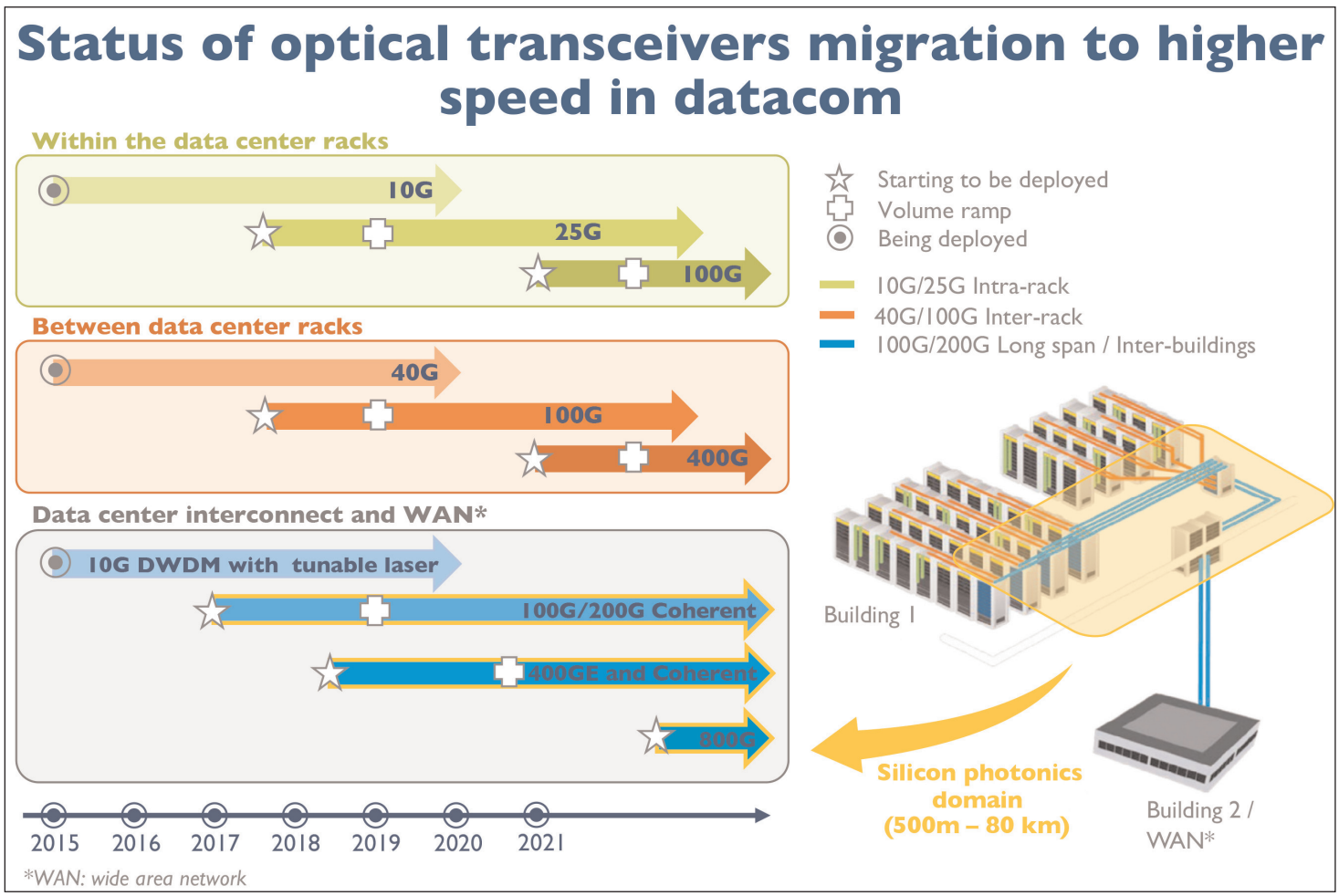

Monolithic InGaAs photo-detectors on 300mm silicon

Researchers at Imec and Ghent University in Belgium have claimed record-low dark current density for nano-ridge waveguide devices.

IMEC and Ghent University in Belgium claim a record-low dark current density of 1.98×10^{-8}A/cm^2 for indium gallium arsenide (InGaAs) photodetectors monolithically integrated on silicon (Si), using metalorganic vapor-phase selective-area epitaxial growth [Cenk Ibrahim Ozdemir et al, Journal of Lightwave Technology, published online 27 May 2021].

The researchers created a range of nano-ridge waveguide photodetectors (NRWPDs) through selective-area epitaxial growth with aspect-ratio trapping (ART) and nano-ridge engineering (NRE).

The devices promise further III–V integration with the silicon photonics platform in the form possibly of efficient light generation and amplification for future O-band (1260–1360nm) and C-band (1530–1565nm) telecom optical fiber applications. Silicon allows for mass production of optoelectronic components on large-diameter wafers at low cost. But silicon is poor at coupling

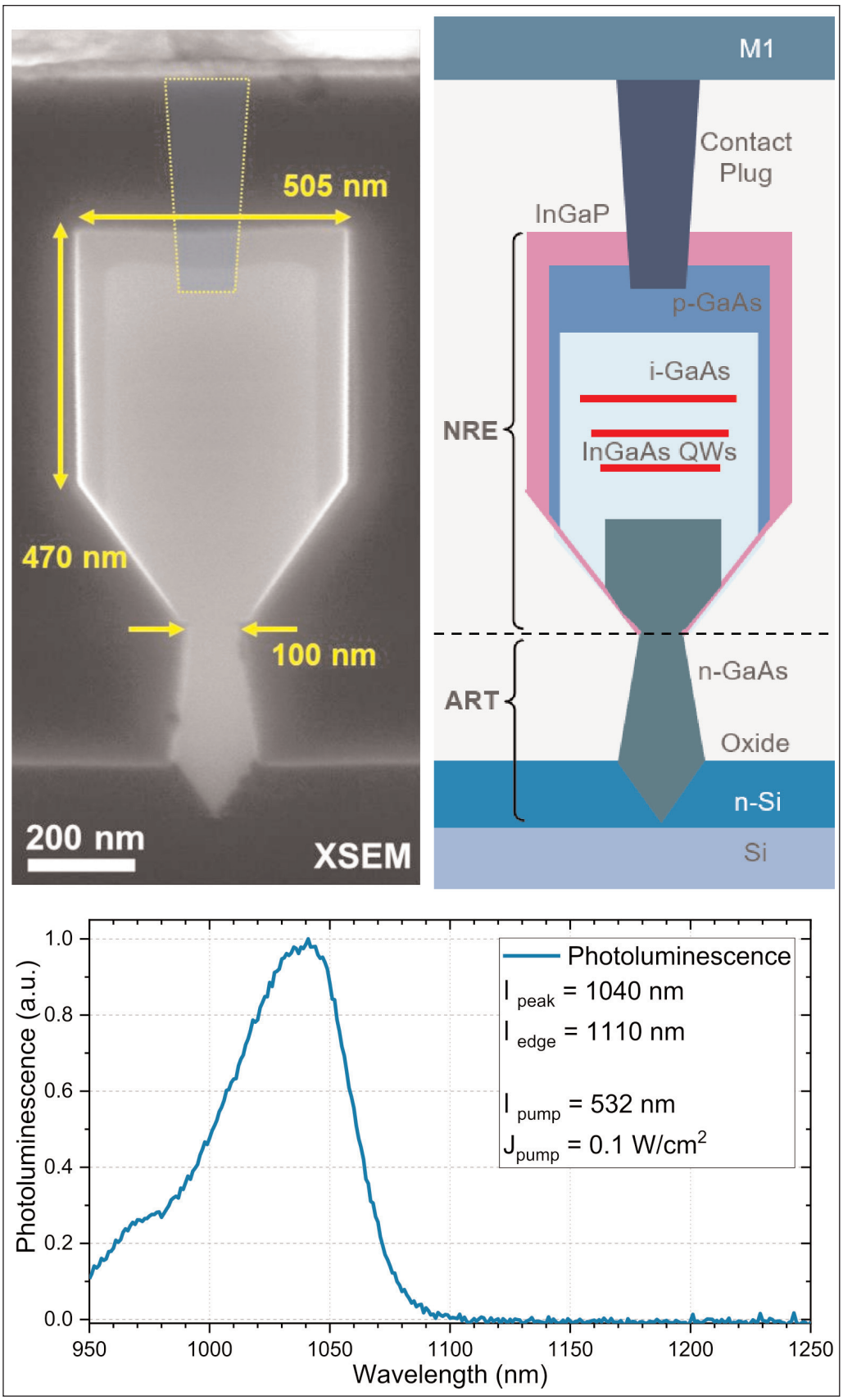

Figure 1. (top left) Cross-section scanning electron microscopy (XSEM) image of GaAs nanoridge with three InGaAs QWs. (top right) Schematic of nano-ridge cross-section. (bottom) Photoluminescence spectrum.

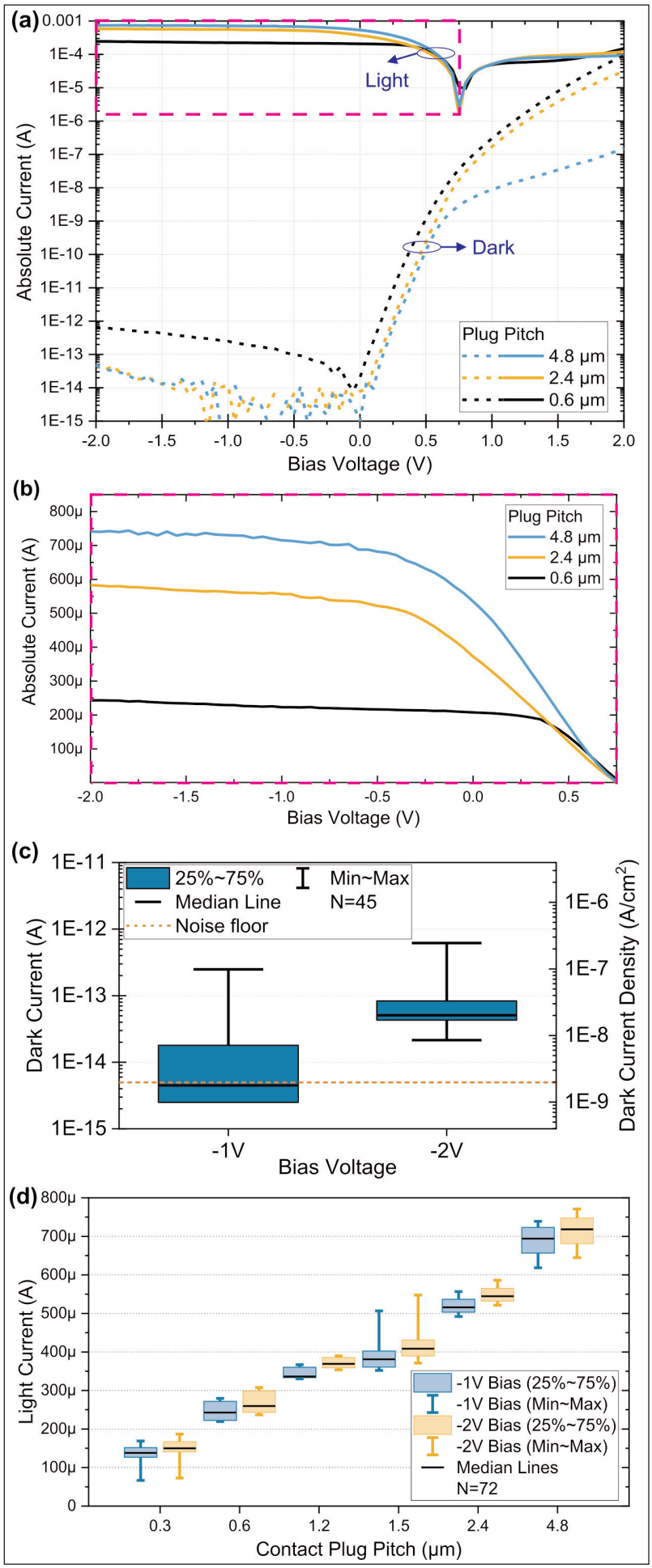

Figure 2. (a) Dark (dash) and light (line) current–voltage curves of devices with different p-contact plug pitches. (b) Light current-voltage zoom-in on linear scale. (c) Dark current statistics at different bias voltages for all devices. (d) Light current statistics of devices with different p-contact plug pitches at different bias voltages, measured at nominal input power.

light and electronics due to its indirect bandgap.

The integration of direct-bandgap materials such as InGaAs has been inhibited by lattice-mismatch problems leading to large defect densities. ART is one method to reduce such defect generation. The IMEC/Ghent work has mainly focused on the shorter 1020nm wavelength range, but IMEC has recently reported NRE InGaAs material growth for operating wavelengths longer than 1200nm, more suitable for silicon and optical fiber photonics.

The 300mm-diameter silicon substrate was n-type doped with ion implantation. Then shallow trenches were formed, 100nm wide and 300nm deep, using a standard 'shallow trench isolation' (STI) process from CMOS electronics processing. After oxide planarization, the trenches were further etched with tetramethylammonium hydroxide (TMAH) solution, forming V-shaped bottoms presenting {111} facets of the silicon crystal structure. These facets inhibit anti-phase domains from forming during GaAs epitaxy.

The nano-trenches were filled with n-GaAs via metal-organic vapor phase epitaxy (Figure 1). Misfit dislocations from the GaAs/Si lattice mismatch were trapped in the trench. Above the ART level, the fully relaxed GaAs had a misfit defect density less than $10^6/cm^2$.

The active region consisted of three 10nm $In_{0.22}Ga_{0.78}As$ quantum wells (QWs) in GaAs barriers. The device material was completed with p-GaAs contact and InGaP passivation.

The resulting nanoridge waveguide structure was 470nm high and 505nm wide. The ridges were encased in planarized silicon dioxide before tungsten plug contacts were made with the p-GaAs and n-Si layers. Further wiring was added using a standard CMOS copper damascene process.

Photoluminescence experiments show a 1040nm-wavelength peak and 1110nm band edge, consistent with the target composition of the QWs. The nanoridge dimension were chosen to support waveguide modes in this wavelength range for strong optical absorption by the QWs.

The median dark current of 500μm-long devices was 0.05pA at 2V reverse bias and 5fA at 1V (Figure 2). The 5fA value was around the noise

floor of the measuring equipment. In terms of current density, the 2V reverse value was 1.98×10^{-8}A/cm^2, described as "the lowest reported dark current for III–V photo-detectors monolithically grown on silicon".

1020nm laser light was coupled into cleaved-facet devices using active alignment controlled to maximize the photocurrent. While the dark current was found to be independent of the plug placement, the photo-response did depend of the pitch between the contacts. For a short 0.3μm pitch, the response was ~0.03A/W at 1V reverse bias, but extending the pitch to 4.8μm increased the response to ~0.14A/W.

On the basis of simulations, the researchers suggest "the drop in the internal responsivities for smaller contact pitch values is linked to the loss induced by the optical absorption at the metal contacts."

Collecting results from devices of various length, the researchers estimate the median internal responsivities and quantum efficiencies of 4.8μm-plug-pitch devices at 0.65A/W and 79%, respectively, at 1V reverse bias. The corresponding values for 2V reverse bias were 0.68A/W and 82%.

The RC bandwidth of the devices was estimated using 1-port S11 measurements from a 50GHz vector network analyzer. Devices with 0.3μm plug pitch and 150μm length had 884Ω series resistance and 91fF junction capacitance at 1V reverse bias, corresponding to an intrinsic RC-limited opto-electrical bandwidth of 1.9GHz. Extrapolating to 4.8μm contact pitch gives a 1.1GHz bandwidth.

The researchers comment: "In future devices, the junction capacitance can be reduced by carefully optimizing the device cross section and eliminating the p-doped GaAs sidewalls, and the series resistance can be reduced by optimizing the contacting and the p-type doping profile." ■

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Author: Mike Cooke

Dislocations in InAs QD lasers on silicon

Misfit trapping layers can significantly improve the lifetime of threshold current and peak output power.

Researchers in the USA have improved the performance of indium arsenide (InAs) quantum dot (QD) laser diodes on silicon by incorporating trapping layers (TLs) to inhibit the movement of misfit dislocations (MDs) during operation [Jennifer Selvidge et al, Appl. Phys. Lett., vol118, p192101, 2021].

The team from University of California Santa Barbara (UCSB), Quintessent Inc., Intel Corp and Stanford University in the USA see the work as contributing to understanding and controlling crystal defects, which "continues to be the most impactful avenue toward integrating light sources on photonic integrated circuits and closing the gap with native-substrate lasers." Producing devices directly on a silicon platform promises to significantly reduce the cost of the optoelectronics technology used in telecoms and other data communication applications.

Although vertical threading dislocations (TDs) have traditionally been seen as show-stoppers for laser diodes, unexpected horizontal misfit dislocations have also been found to impact QD laser performance. The formation mechanism of these misfit dislocations in growth on silicon is described in the paper as possibly

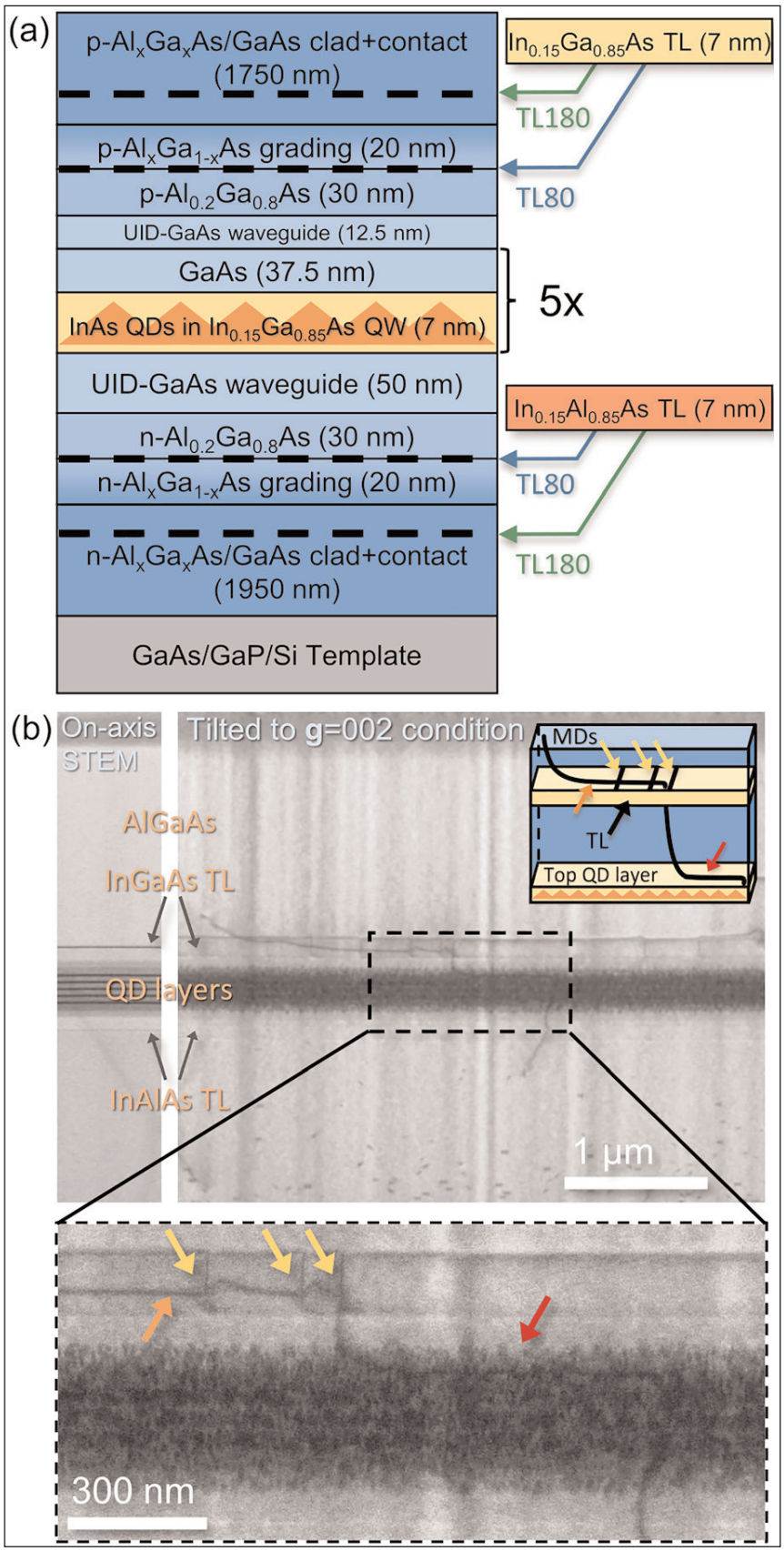

Figure 1. (a) Schematic No-TL laser structure indicating where trapping layers were inserted in TL80 and TL180 structures. (b) Cross-sectional STEM image of TL180 laser structure along [110] zone axis (left) and tilted into a g = 002 diffraction condition (right). Outset: high-magnification image of dashed region. TD rises through QD layers and forms short MD segment (red arrow) and trapped MD (orange arrow) segment at upper TL. Yellow arrows mark several perpendicular MDs lying along upper trapping layer, appearing as short vertical segments in projection, as indicated in the inset schematic.

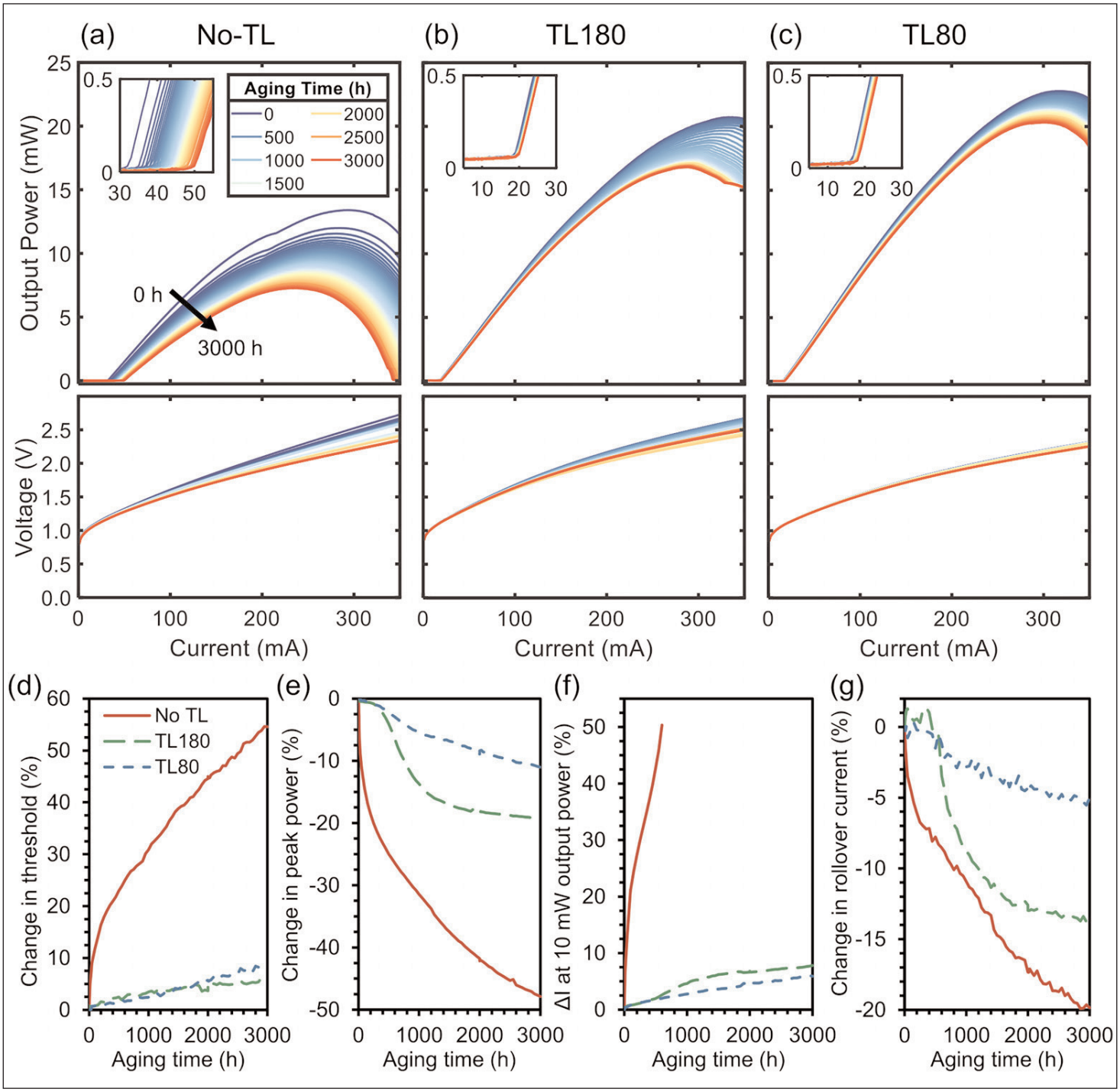

Figure 2. 60°C reliability data from high-performing device of each design. (a)–(c) Light–output and voltage versus current (LIV) measurements at 50h intervals over course of aging for (a) No-TL, (b) TL180, and (c) TL80. (d)–(g) Degradation behavior for same three lasers measured by (d) change in threshold current, (e) change in peak output power, (f) change in current required for 10mW of output power, and (g) change in current at rollover during aging.

"unique", forming after growth as a result of thermal expansion mismatching between the silicon substrate and overlying aluminium gallium arsenide (AlGaAs) layers. Further, "recombination-enhanced dislocation climb" (REDC) can cause shifts of the misfit dislocation layer, generating point defects that further reduce performance.

The researchers produced material for the lasers that incorporated trapping layers (TLs) matching the lattice structure of the quantum wells (QWs) in which the InAs quantum dots were embedded (Figure 1).

The trapping layers in the n-type cladding region were $In_{0.15}Al_{0.85}As$; those in the p-type cladding, $In_{0.15}Ga_{0.85}As$. These trapping layers were placed in the n- and p-type cladding at either approximately 80nm or 180nm from the QD region. The choice of the trapping layer material compositions were made to minimally affect the band alignments.

Laser bars were fabricated with facets coated with silicon dioxide/tantalum pentoxide dielectric layers, targeting 60% and 99% reflectivity of the laser emissions. For testing, the devices were aged for 3000 hours at 60°C under automatic current control at twice the initial threshold current. Some devices were weeded out beforehand if they did not demonstrate low enough threshold current (500A/cm^2) or high enough output power (10mW) at 20°C.

The researchers studied devices with and without trapping layers that were most impacted by the aging process in terms of output power under a scanning transmission electron microscope (STEM). Without trapping, misfit dislocations formed in the outer QD layers. With trapping, the amount of misfit dislocations in the QD layer was reduced to about 5%.

The devices with the trapping layers placed at 80nm (TL80) performed best in terms of maintaining output power and threshold current over the aging period (Figure 2). The drop in peak output power was only 11%, compared with 20% for the lasers with trapping layers at 180nm (TL180) and 48% when there are no trapping layers. At the same time, the threshold for the TL80 device only increased 9%, compared with 55% for the laser diode with no trapping layers.

The team comments that the performance for devices with trapping layers compares favorably with devices grown on GaAs, and "yields reliability results that are nearly as good as those obtained in threading-dislocation-free lasers grown on native GaAs substrates, despite these trapping layer devices still containing a threading dislocation density (TDD) of 2–4x10^7/cm^2.

STEM analysis suggested that one of the effect of aging was to introduce 'wavy'/jagged irregularities into the misfit dislocations as a result of recombination-enhanced dislocation climb. "The energy released in this process allows misfit dislocations to increase their length by emitting point defects (i.e. undergo REDC), which explains the sharp degradation in No-TL laser performance," the researchers write.

Point defects form non-radiative recombination centers, sapping performance and generating heat rather than light. Such heat can lead to thermal runaway, further increasing REDC, and leading to device failure.

The researchers conclude: "As our control over degradation pushes QD laser performance on silicon ever closer to QD lasers on native substrates, we must now look toward implementing this knowledge in advanced integration schemes proposed for photonic integrated circuits. At the same time, it will also be important to revisit other semiconductor materials systems and designs, such as conventional quantum well lasers, where it was once believed that reliable lasers would never be possible in the face of rapid dislocation-based degradation." ■

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Author:
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C- and L-band QDash microdisk lasers on silicon

Researchers have claimed the first continuous-wave demonstration of such quantum dash devices at key optical communication wavelengths.

Hong Kong University of Science and Technology (HKUST) in China claims the first demonstration of room-temperature continuous-wave lasing of quantum dash (QDash) microdisk lasers (MDLs) on silicon in the C (1530–1565nm) and L (1565–1625nm) optical communication bands [Liying Lin et al, Optics Letters, vol46, p2836, 2021].

The devices were optically pumped, but the researchers believe that electrically pumped MDLs could be realized in the future. QDash light emitters are attractive since they are less affected by crystal defects arising from lattice mismatches between silicon and III–V materials. Also, they are less affected by thermal variations.

The team envisages the realization of multi-channel communication through the fabrication of different diameter and thickness disks on the same substrate with reduced light-source volume and complexity, compared with other laser technologies on silicon. The deployment of electrically driven MDLs on silicon would complete the optoelectronic link between low-cost photonics (waveguides and other structures) and CMOS electronics.

The structure was grown by metal-organic chemical vapor deposition (MOCVD) on an 3.1μm indium phosphide (InP) buffer, which in turn was grown on 1.1μm gallium arsenide (GaAs) that bridged the 8% lattice mismatch with (001) Si. The GaAs layer was subjected to five cycles of thermal cyclic annealing to reduce defects. The InP layer included three sets of 10-period 12nm/4nm $In_{0.63}Ga_{0.37}As$/InP strained-superlattices designed to reduce defects. The InP was found to be free of anti-phase boundaries, and the surface roughness was only 2.8nm, according to atomic force microscopy (AFM).

The active region consisted of three layers of InAs QDashes in InGaAs. The cladding material was indium aluminium arsenide (InAlAs). The layers were separated by InAlGaAs barriers, creating InGaAs quantum wells in which the

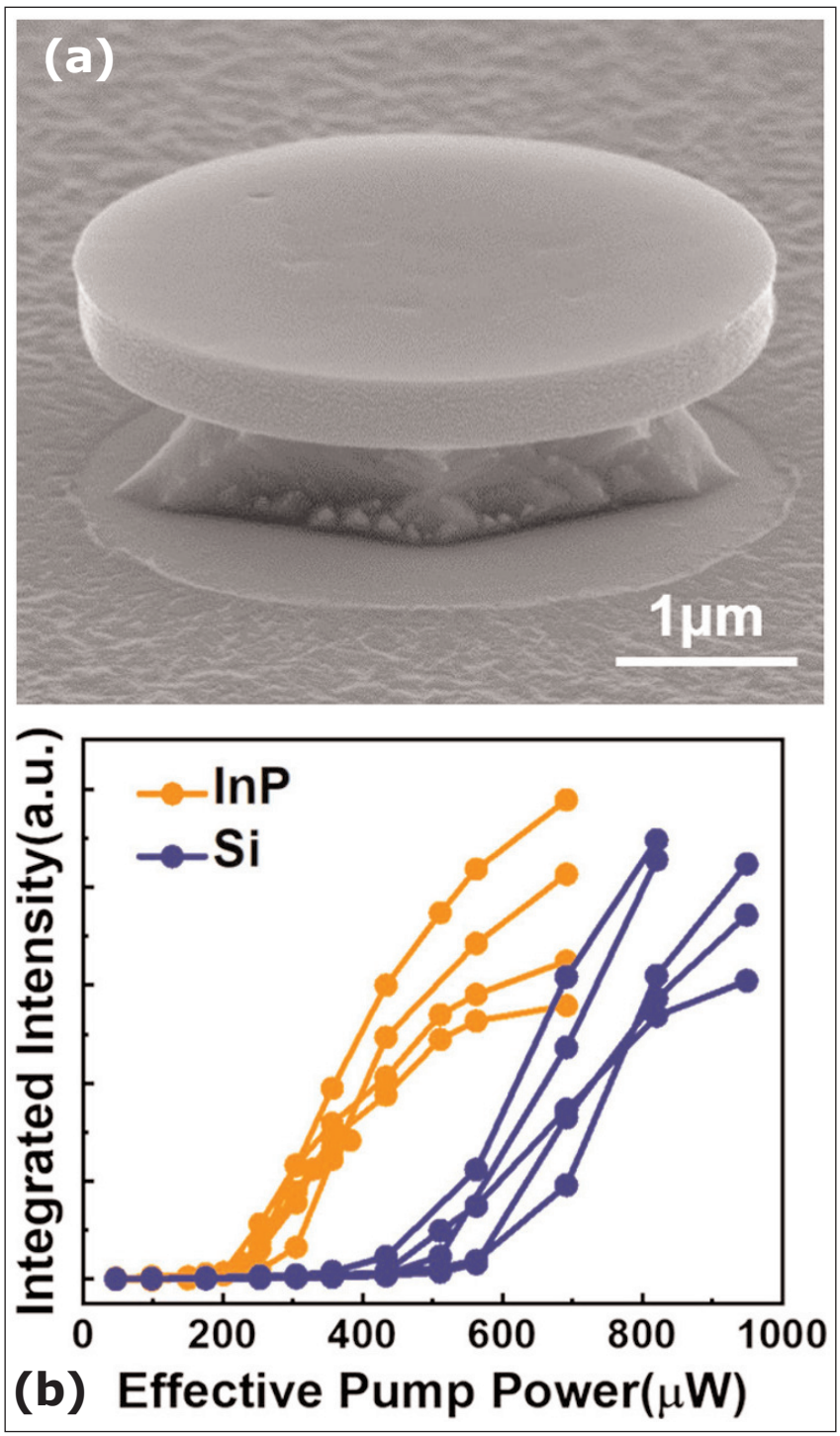

Figure 1. (a) Scanning electron microscope image tilted at 70° of 4μm-diameter microdisk laser. (b) Light intensity versus optical pump power for microdisks on InP and Si, showing thresholds at 200μW and 500μW, respectively.

QDashes were sited. Photoluminescence spectra showed a peak at ~1.5μm, similar to that of a co-grown structure on an InP substrate. However, the material grown on the native InP demonstrated 3x photoluminescence intensity of that on silicon. The lower intensity leads to the expectation that any laser threshold on silicon would by higher than that on InP.

The laser material was fabricated into mushroom-shaped microdisks with the undercut 500nm to form the 900nm-high stem (Figure 1). The researchers focused on creating smooth sidewalls of the disks, since these were designed to reflect the ~1.5μm light, creating a whispering gallery mode resonance. The undercut trapped the light in these modes rather than allowing leakage into the template of the first radial mode.

Continuous-wave pumping on a 3.8μm-diameter 435nm-thick disk produced laser light at 1555nm. Numerical simulations suggest the light came from the transverse electric first radial mode with azimuth mode number 19 (TE19,1). Below threshold a number of peaks were seen in the spectrum, with just one becoming dominant before lasing. The threshold power was as low as 400μW, a value seen as being the lowest reported for such devices so far.

Temperature-dependent studies gave a characteristic T0 for the threshold variation of 65.8K in the range 288–323K. The team comments: "This value is much higher compared with other reported T0 for optically pumped QD MDLs grown on both silicon and III-V native substrates." The researchers also say that 323K is the highest temperature reported for such devices to lase.

Varying the disk diameter between 3.4μm and 4.0μm and the disk thickness between 275nm and 440nm allowed peak wavelength coverage from 1.54μm to 1.61μm, covering the C (1530–1565nm) and L (1565–1625nm) optical communication bands. Optical simulation suggested that different modes were excited in different cases (Figure 2). ■

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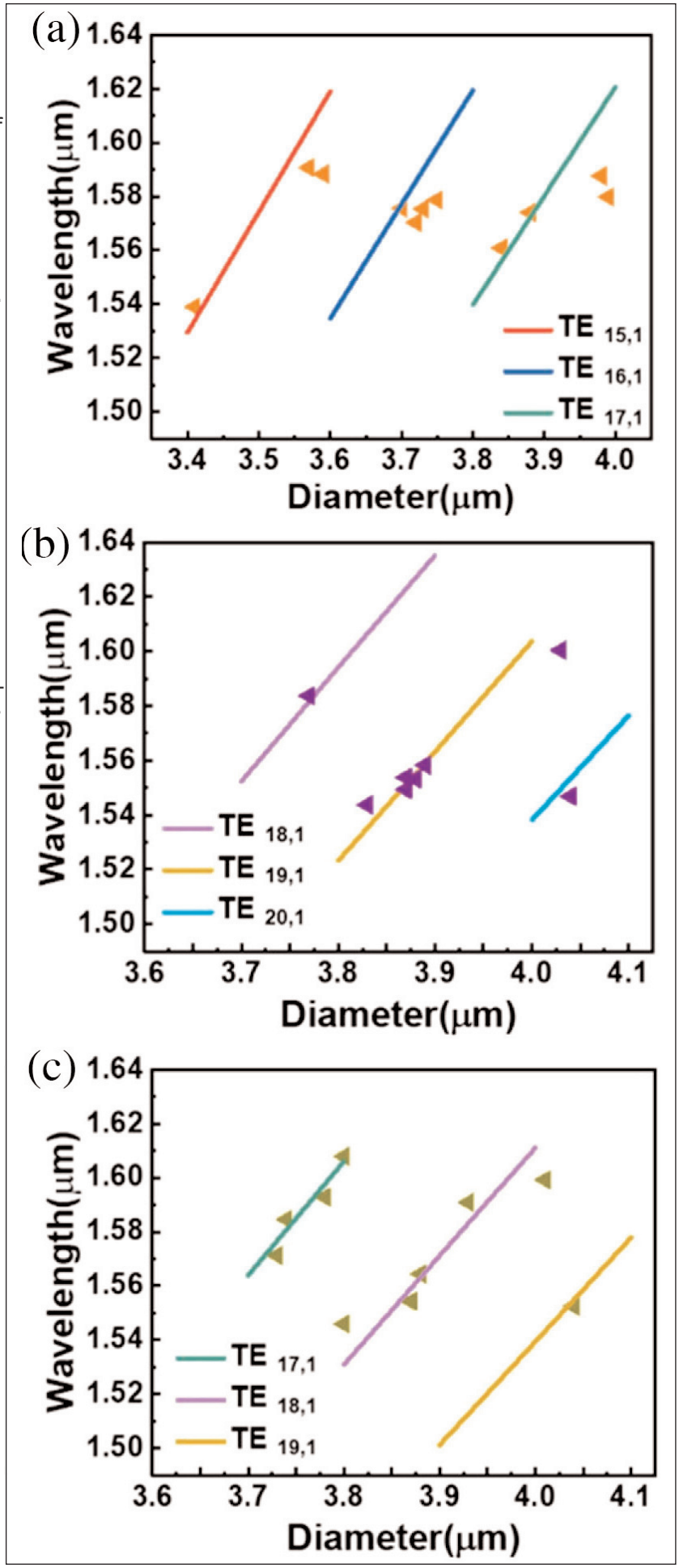

Figure 2. (a)–(c) Experimental data of MDLs with 275–300, 375–400 and 420–440nm membranes, respectively. Lines represent 2D finite difference time-domain (FDTD) simulations based on representative thicknesses of 280, 380 and 435nm accordingly.

Annealed Ni/Al DUV LED p-electrodes

Reflective contacts increase peak EQE by 44% at 277nm wavelength.

Researchers based in China have improved the performance of 277nm-wavelength deep-ultraviolet (DUV) light-emitting diodes (LEDs) by using reflective nickel/aluminium (Ni/Al) electrodes in place of conventional nickel/gold (Ni/Au) [Xianchun Peng et al, Appl. Phys. Express, vol14, p072005, 2021].

DUV LEDs with emission wavelengths shorter than 280nm are being sought as compact, environment-friendly alternatives to mercury lamps for water/surface disinfection and bio-agent detection. Presently, this development is hampered by low energy efficiency and power output.

A number of effects contribute to the low efficiency compared with longer-wavelength LEDs based on III–nitride semiconductors such as aluminium gallium nitride (AlGaN). The best 275nm LED so far achieved 20% external quantum efficiency (EQE). In that case more than half of the power was lost due to low light-extraction efficiency.

Reflective p-electrodes enable more light to be extracted from the sapphire side of the device. The flip-chip configuration with sapphire-side up is generally favored since sapphire is UV transparent, while the apparently unavoidable p-GaN contact layers heavily

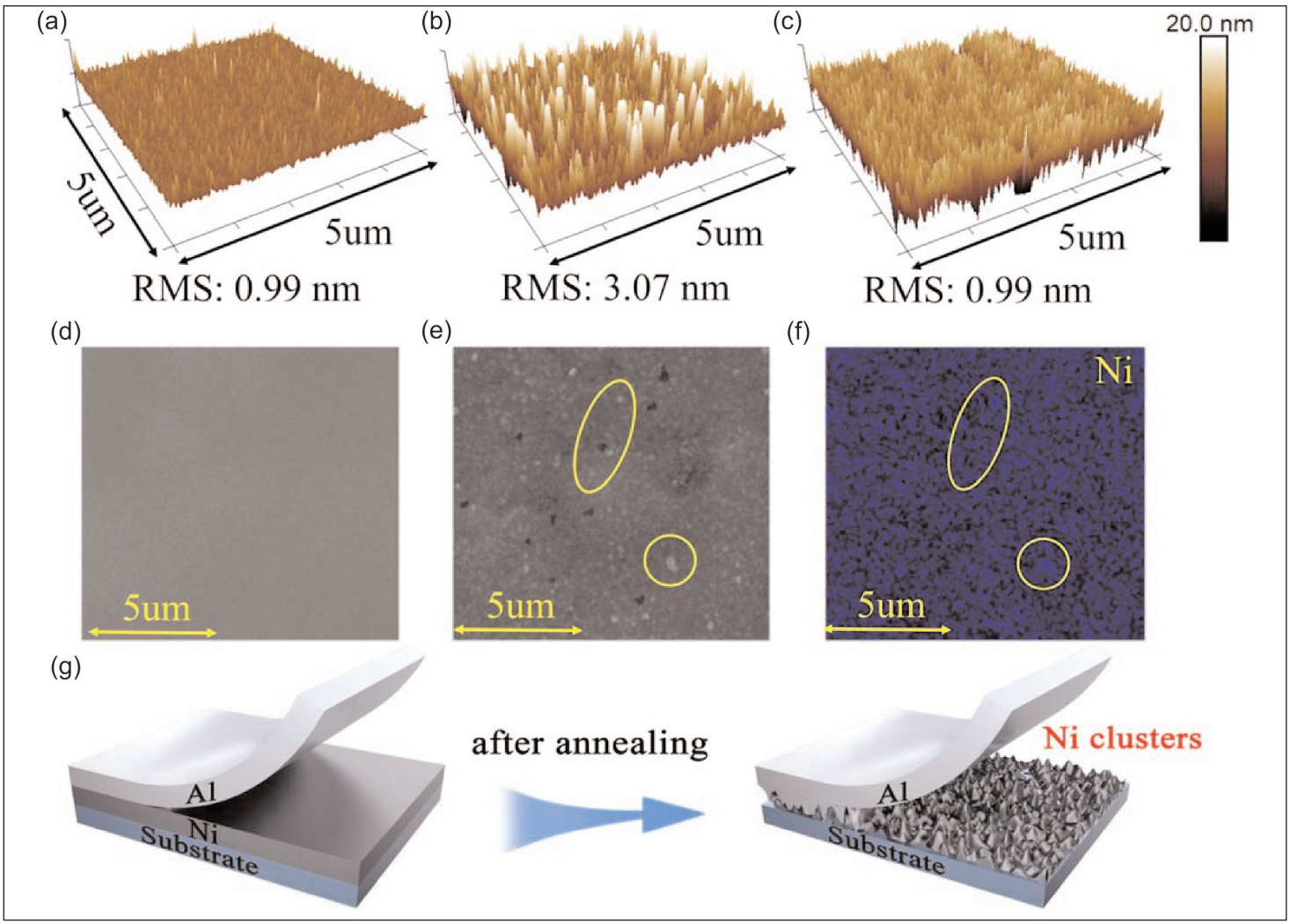

Figure 1. Surface morphologies of Ni/Al on sapphire before (a) and after (b) RTA; (c) surface morphology of single Al layer under same thermal treatment; scanning electron microscope (SEM) images of Ni/Al on DUV-LED before (d) and after (e) RTA; (f) energy-dispersive spectroscopy mapping of nickel composition distribution in SEM field; (g) schematic diagram showing formation of Ni clusters.

absorb wavelengths shorter than the ~3.4eV bandgap, which corresponds to wavelengths ~365nm.

The research team - from Ningbo University, Ningbo Institute of Materials Technology and Engineering, University of Chinese Academy of Sciences, Zhe Jiang Bright Semiconductor Technology Co Ltd, and Advanced Micro-Fabrication Equipment Inc — deposited the Ni/Al electrodes by electron-beam evaporation, followed by rapid thermal annealing (RTA). The Ni and Al thicknesses were 5nm and 300nm, respectively.

The Ni/Al was applied to AlGaN and DUV materials grown on sapphire by metal-organic chemical vapor deposition (MOCVD). The LEDs were fabricated with titanium/aluminum/nickel gold (Ti/Al/Ni/Au) contacts to the n-type layer exposed by mesa reactive-ion etching.

The Ni/Al (or conventional unannealed Ni/Au) p-type electrodes were then deposited after annealing at 800°C for 1 minute. The p-contact layers of the DUV structure consisted of 100nm p-AlGaN and 10nm p^+-GaN. The heavy doping of the final layer improved the ohmic contact with the Ni/Al electrode. The final GaN layer was designed to be thin since it is highly absorbing of DUV radiation. The researchers did not expect the layer to jeopardize the transparency since it was so thin.

To optimize the reflectivity at 277nm wavelength and the contact resistance, the team carried out a series of experiments. The reflectivity was optimized by depositing the Ni/Al on double-side polished sapphire and rapid thermal annealing for up to 10 minutes at temperatures up to 600°C. The annealing is necessary since Ni strongly absorbs DUV radiation.

The most reflective layer was annealed for 10 minutes at 600°C. The researchers suggest that the Ni agglomerates during annealing, allowing some Al to make partial contact with the sapphire substrate. Atomic force microscope and other studies seemed to support this suggestion (Figure 1). The team did not feel that it could go beyond 600°C since Al melts ~660°C, which could result in unwanted surface roughening and/or diffusion effects.

The 600°C, 10-minute layer had a 277nm reflectivity of 78.1% (a 63% increase on the as-deposited layer). However, the presence of Al in contact with p-type III–nitride layers does cause some deviation from ohmic contact behavior. Al tends to form a Schottky barrier with p-GaN due to a mismatch of the work functions of these materials. The researchers comment: "A balance between the electrical and optical properties of the DUV-LED with Ni/Al reflective electrode must be made for the optimum device performance."

The fabricated LEDs produced emissions around 277nm, while a comparison device with Ni/Au p-contact emitted at 280nm (Figure 2). The annealed Ni/Al showed a 28% increase in integrated electroluminescence (EL) over the comparison Ni/Au LED. The unannealed Ni/Al intensity was 14% better than Ni/Au. In terms of EQE, the peak for the annealed Ni/Al LED reached 3.03% (44% higher than the Ni/Au device).

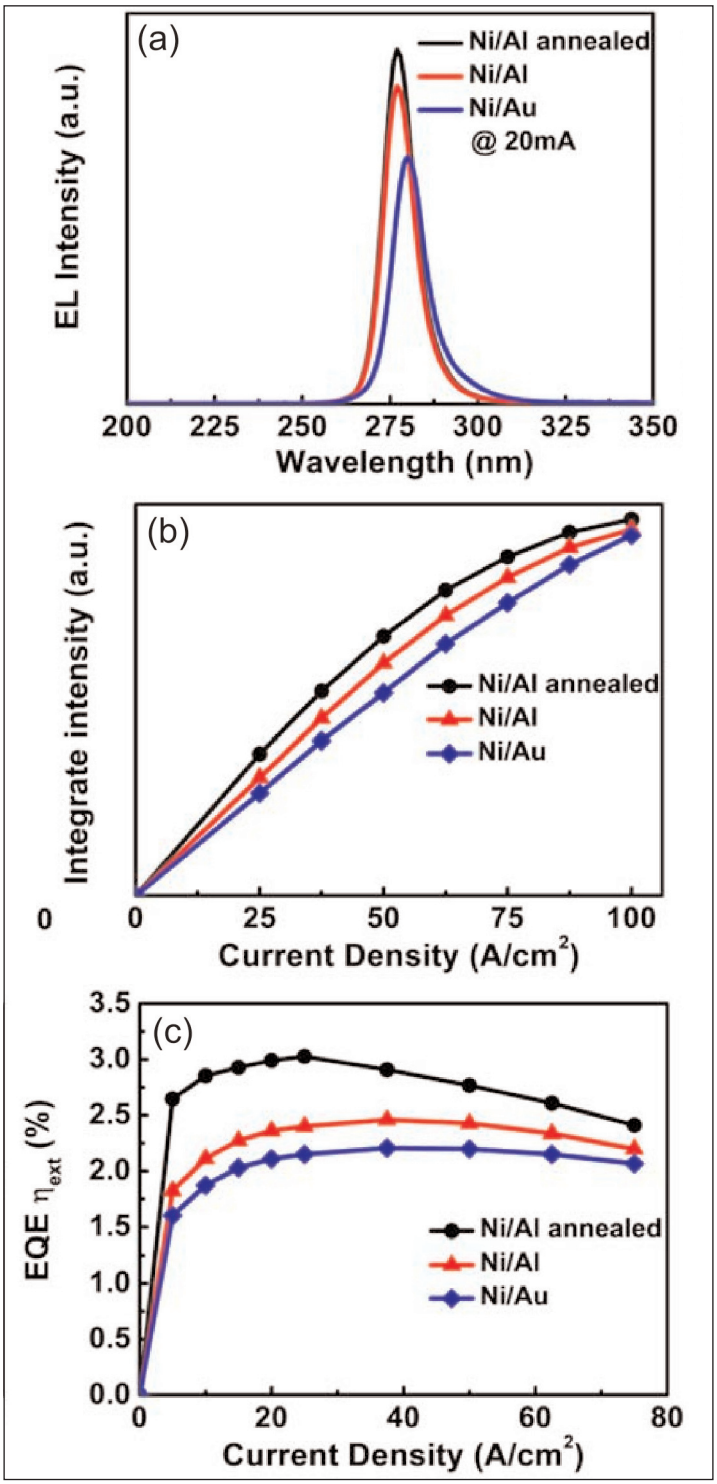

Figure 2. (a) EL spectra of DUV-LEDs with reflective Ni/Al electrode and conventional Ni/Au electrode at 20mA injection; (b) integrated EL intensity at different current densities; (c) EQE curves.

The researchers attribute the enhanced EQE to improved light-extraction efficiency, since the use of the same epitaxial structure should make the internal quantum efficiency the same for all the devices. ■

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Author: Mike Cooke

Tunnel-junction blue/green micro-LED stacks

A cascade structure has been applied as a step towards the objective of color augmented reality/virtual reality/large-area displays and visible light communication.

University of California Santa Barbara (UCSB) in the USA has reported on the use of tunnel junctions (TJs) to stack green and blue micro-sized light-emitting diodes (μLEDs) grown by metal-organic chemical vapor deposition (MOCVD) [Panpan Li et al, Optics Express, vol29, p22001, 2021; Panpan Li et al, Appl. Phys. Lett., vol118, p261104, 2021].

The researchers comment: "The design enables the realization of cascaded blue/green μLEDs in one device with independent junction control, that is, we can control the blue μLEDs, green μLEDs and blue/green μLEDs independently on the same device by injecting current through different pads."

Normally, such cascaded devices suffer from poor performance since buried p-GaN layers are difficult to realize, particularly in MOCVD. The problem is incorporation of hydrogen from the ammonia (NH_3) used as the nitrogen source. Although ammonia is often also used in molecular beam epitaxy (MBE) growth, there is also the potential to use nitrogen gas instead, which avoids the problem. However, MOCVD is the preferred technology in manufacturing due to its faster growth rate, reducing costs and so on.

The incorporated hydrogen passivates the magnesium that is used for p-type doping. Thermal annealing is used to drive out the hydrogen, re-activating the p-GaN. But with buried p-GaN, it is difficult to drive out the hydrogen sufficiently. With μLEDs, however, the sidewall area increases relative to the buried p-GaN volume, potentially allowing efficient escape of hydrogen during annealing.

Tunnel junctions allow current flow through reverse-biased p–n junctions. This is achieved by suitable heavy doping to align the valence and conduction bands of neighboring layers to allow two-way tunneling of electrons and holes through a very thin depletion region.

The team sees potential for cascaded μLEDs from applications such as augmented and virtual reality, large-area displays, and visible light communication systems.

The researchers used standard blue μLED wafers as templates for further MOCVD growth of the TJs and green μLED layers (Figure 1). The first TJ consisted of n-InGaN/n^+-GaN/n-GaN on the p^+-GaN contact layer of the blue μLED structure.

The green μLED structure consisted of n-GaN, a superlattice consisting of low-indium-content InGaN/GaN pairs, five InGaN/AlGaN/GaN quantum wells, a p-AlGaN electron-blocking layer, and a p-GaN/p^+-GaN contact layer.

The final TJ was grown after removal of the wafer from the reactor and cleaning, followed by return to the MOCVD chamber.

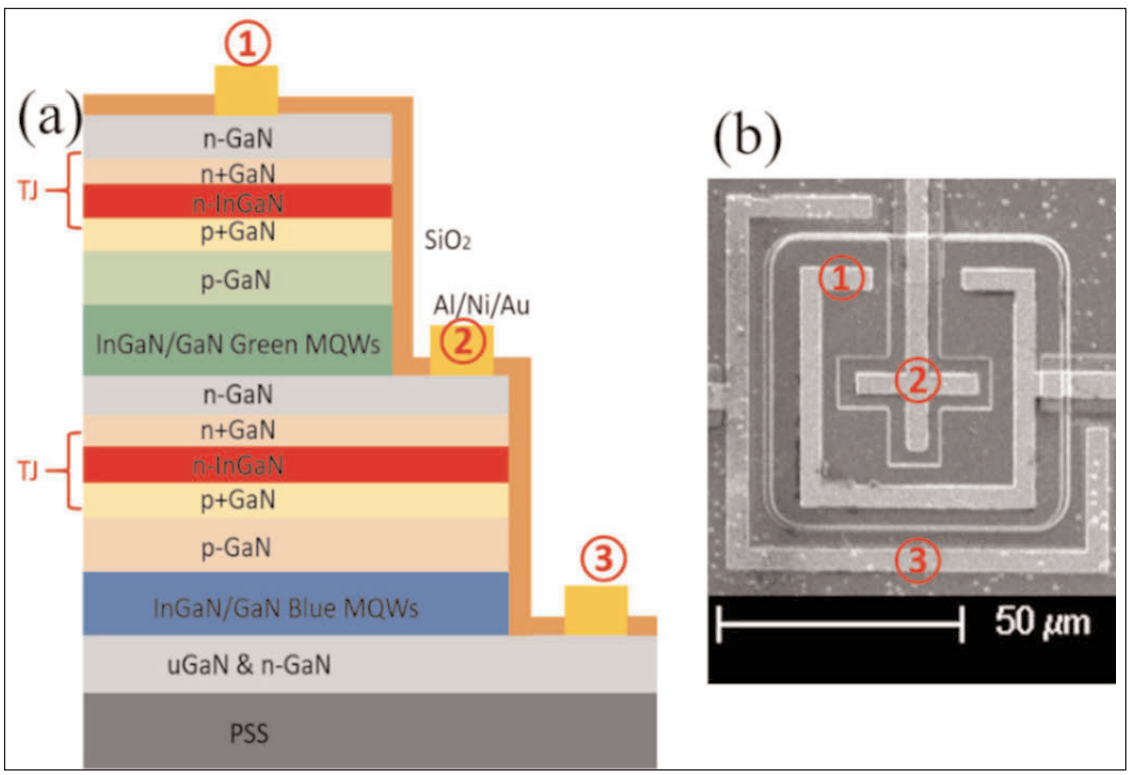

Figure 1. (a) A schematic diagram of cascaded TJs blue and green μLEDs and (b) scanning electron microscope image of fabricated device.

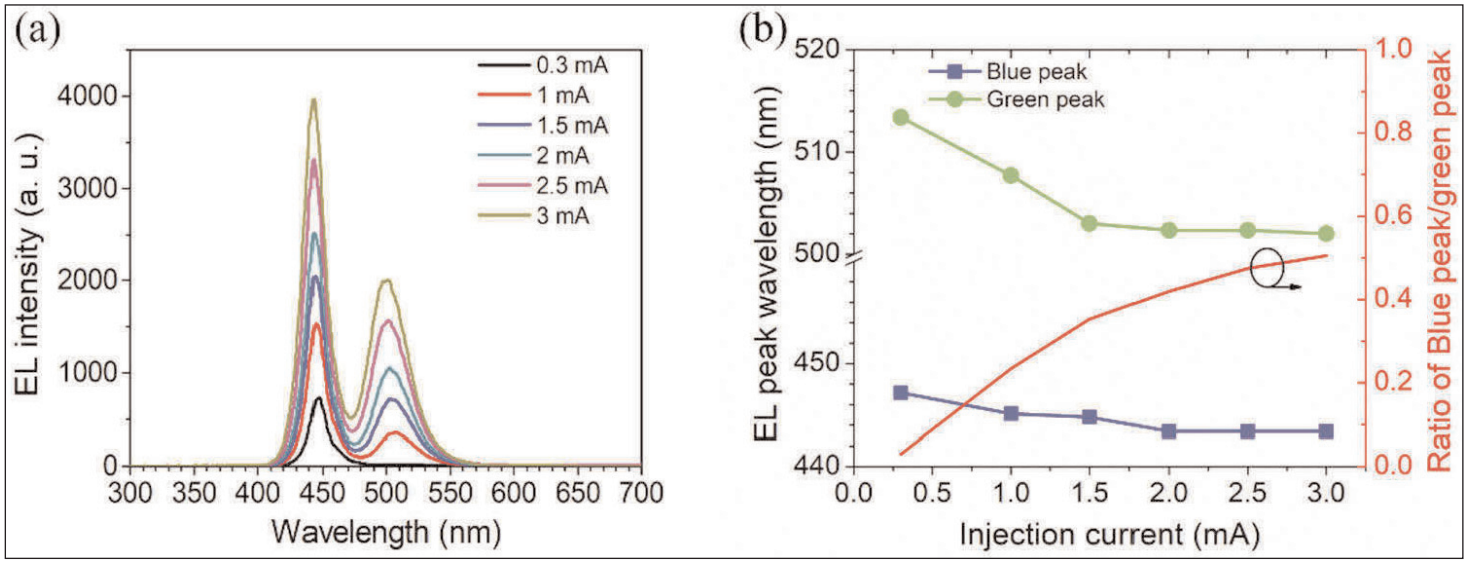

Figure 2. (a) Electrical luminous spectra at various injection currents for blue/green μLEDs with top TJ and (b) extracted blue peak, green peak, and intensity ratio of blue/green peak at various injection currents.

The μLED fabrication began with two reactive-ion etch steps to expose the green and blue n-GaN contact layers. The mesas were small enough to enable rapid thermal annealing (RTA) to drive the hydrogen passivation out of the p-GaN layers through the sidewalls, giving efficient activation of the magnesium acceptors.

Some of the reported μLEDs used indium tin oxide (ITO) as a top contact (Appl. Phys. Lett.) instead of the second TJ (Optics Express). The μLEDs included an omnidirectional reflector layer consisting of five tantalum pentoxide/silicon dioxide pairs and a final aluminium oxide layer, applied using ion-beam deposition. The sidewalls were passivated with atomic layer deposition (ALD) silicon dioxide (SiO_2). The ohmic contact metals were aluminium/nickel/gold (Al/Ni/Au).

The blue parts of the devices emitted around 450nm wavelength (451nm Appl. Phys. Lett., 455nm, Optics Express).There was some difference in the performance of the green sections: with a top TJ the emissions were towards the blue end at 508nm (0.4mA), compared with 518nm with ITO (3A/cm^2). The full widths at half maxima (FWHM) were ~20nm for the blue sections, and ~30nm for the green.

With the top TJ devices the green peak shifted with different injection currents, ranging from 513nm at 0.3mA to 502nm at 1mA (Figure 2). Such blue-shifts are typically attributed to effects such as the filling of higher-energy localized states and charge polarization screening.

The forward voltages for 1mA current were around 4.2V for the blue section and 3.5V for the green with top TJ. Normalized to the mesa areas, the forward

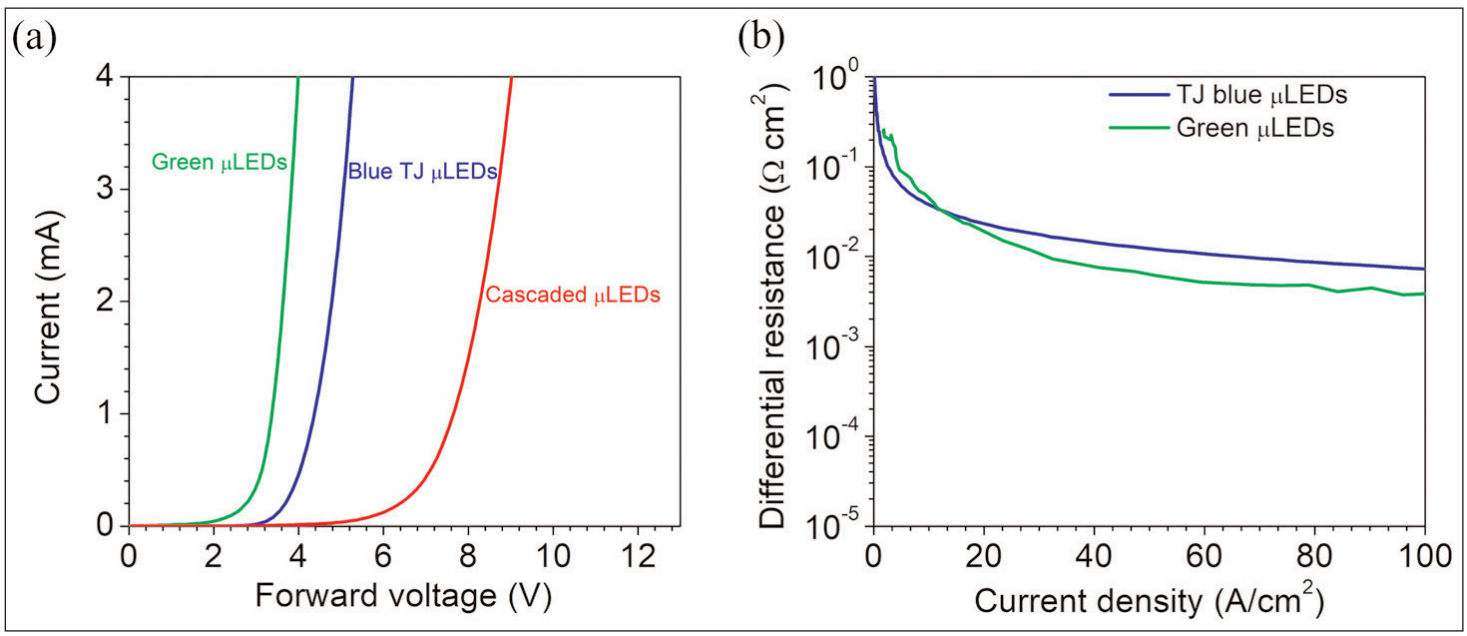

Figure 3. (a) Current forward voltage (I–V) characteristics of blue μLEDs, green μLEDs, and blue/green μLEDs with top ITO contact and (b) differential resistance versus current density for blue μLEDs and green μLEDs.

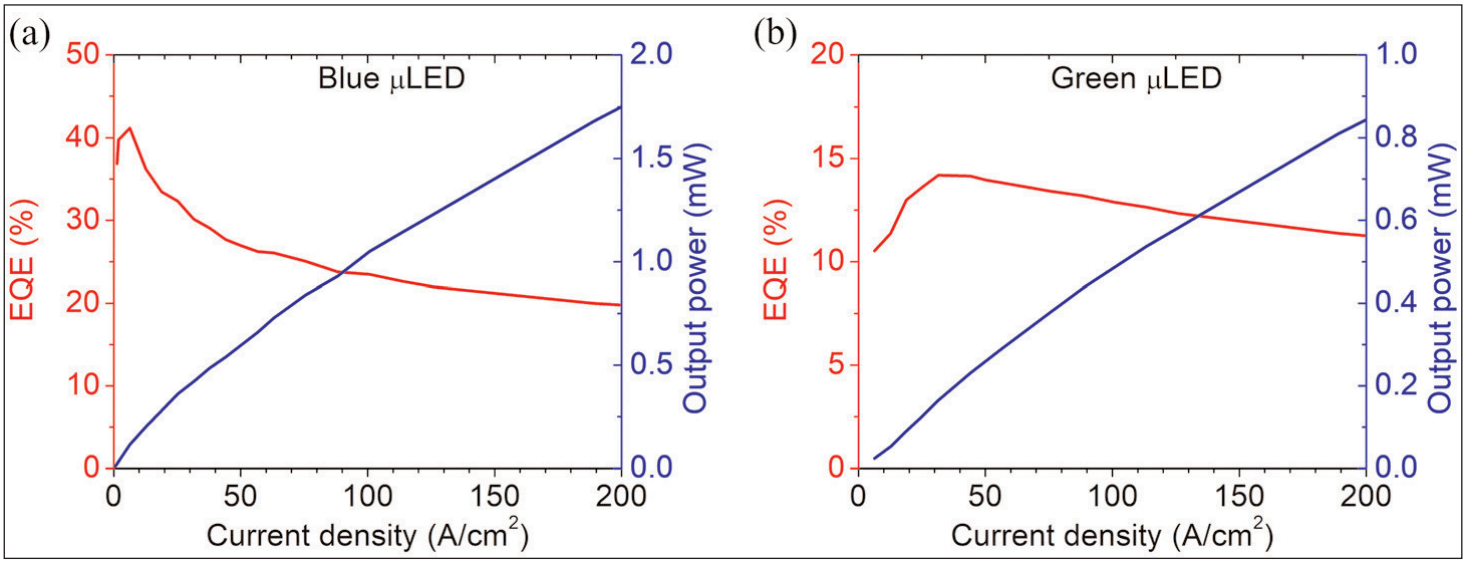

Figure 4. Output power and EQE versus current density for (a) blue and (b) green μLEDs with ITO contact.

voltage was 4.1V for the blue and 3.1V for the green at 20A/cm^2 injection. The researchers see these forward voltages as being among the lowest for green GaN μLEDs with TJ contacts.

In the devices with top TJ the output power increased linearly up to 4mA injection, reaching 0.89mW for the blue, 0.43mW for the green, and 1.41mW combined.

For the devices with ITO contact, the researchers also report peak external quantum efficiencies (EQEs) of 42% for the blue emissions, and 14% for the green. The output powers for these μLEDs reached ~1.8mW blue and ~0.9mW green at 200A/cm^2 injection (~7mA blue, ~3mA green), according to the text (the corresponding graphs suggest significantly lower values, which I am following up). ■

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Boron arsenide thermal management

New substrate material reduces GaN HEMT hot-spot rise by 45% relative to diamond.

University of California Los Angeles (UCLA) and Irvine Materials Research Institute in the USA are proposing the use of boron arsenide (BAs) as a thermal substrate for power electronics devices such as gallium nitride (GaN) channel high electron-mobility transistors (HEMTs) [Joon Sang Kang et al, Nature Electronics, vol4, p416, 2021].

As power densities of electronics systems increase, the need to dissipate waste heat becomes more critical to avoid thermal failure. This needs a combination of high-thermal-conductivity materials and the ability for heat to cross material boundaries.

The GaN material/devices and BAs were bonded using thin aluminium oxide (Al_2O_3) layers on both materials, applied using 10-cycle atomic layer deposition (ALD) at 473K. The surfaces were exposed to oxygen plasma before bonding to activate the interfaces. After bonding, the assemblies were annealed at 773K in vacuum.

The thermal stability of the process was confirmed by cycling the samples between room temperature and 600K, and the relevant properties measured. The researchers state: "All the samples were measured with consistent results and no appreciable degradation."

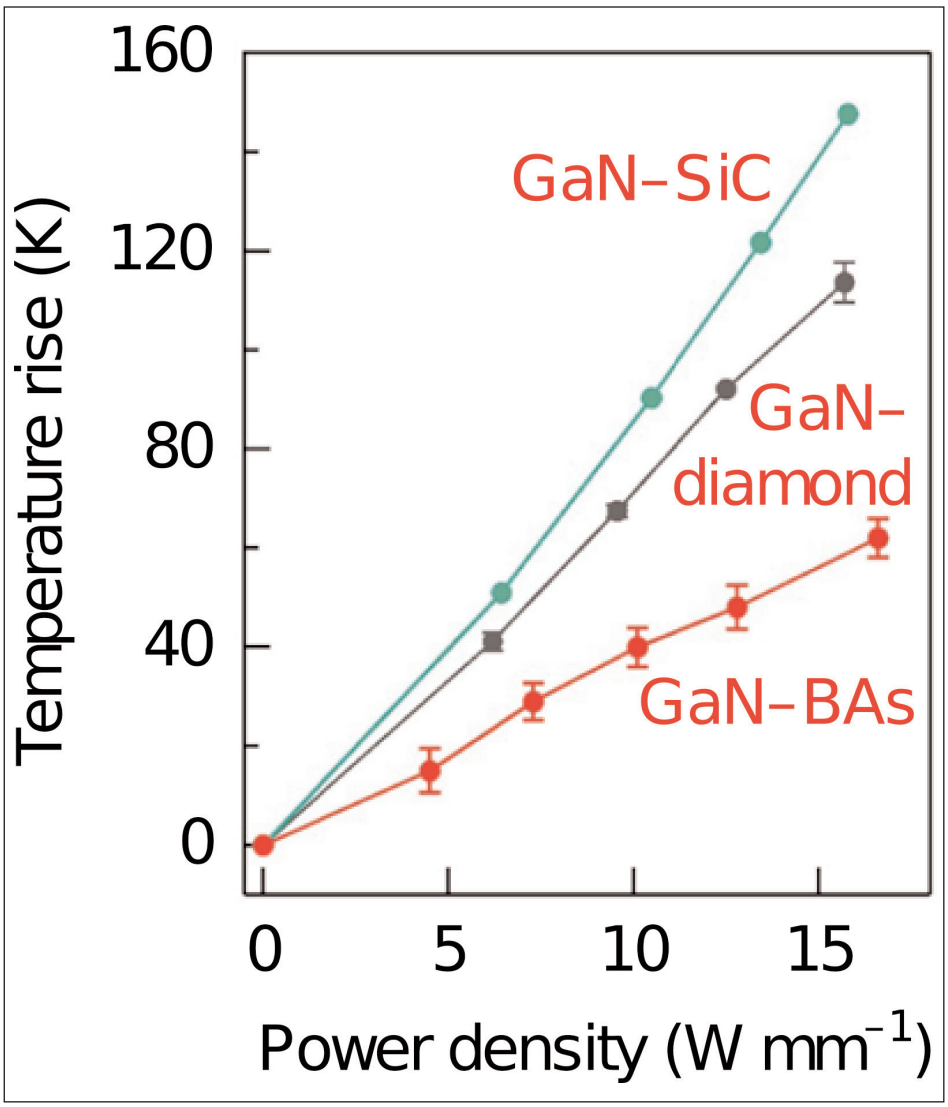

Figure 1. GaN temperature as function of power density, measured using Raman spectroscopy on drain side at lateral distance of 0.5μm from the T-gate edge, for GaN transistors on BAs, diamond and SiC.

The HEMT devices were produced on silicon. The device layers were 1μm GaN channel/buffer and 20nm AlGaN barrier grown on ~1μm AlGaN transition material to the silicon lattice. The 100μm-width HEMTs were two-finger devices at 34μm gate pitch. The devices were prepared for bonding to BAs with selective wet etching away of the silicon substrate and AlGaN transition layers.

The HEMT on BAs showed improved thermal performance over similar devices on silicon carbide or diamond (Figure 1). At a power density ~15W/mm, the GaN–BAs HEMT suffered a hot-spot temperature rise of 60K, much lower than the 110K for GaN-diamond and 140K for GaN–SiC.

The researchers attribute the improved performance of BAs to a combination of high thermal conductivity and low thermal boundary resistance (TBR), relative to the other materials. In fact, the thermal conductivity of BAs is ~1300W/m-K, while diamond's is ~2200W/m-K. The value for SiC is ~400W/m-K. The thermal boundary conductance (reciprocal of TBR) of GaN/BAs was measured using time-domain thermoreflectance,

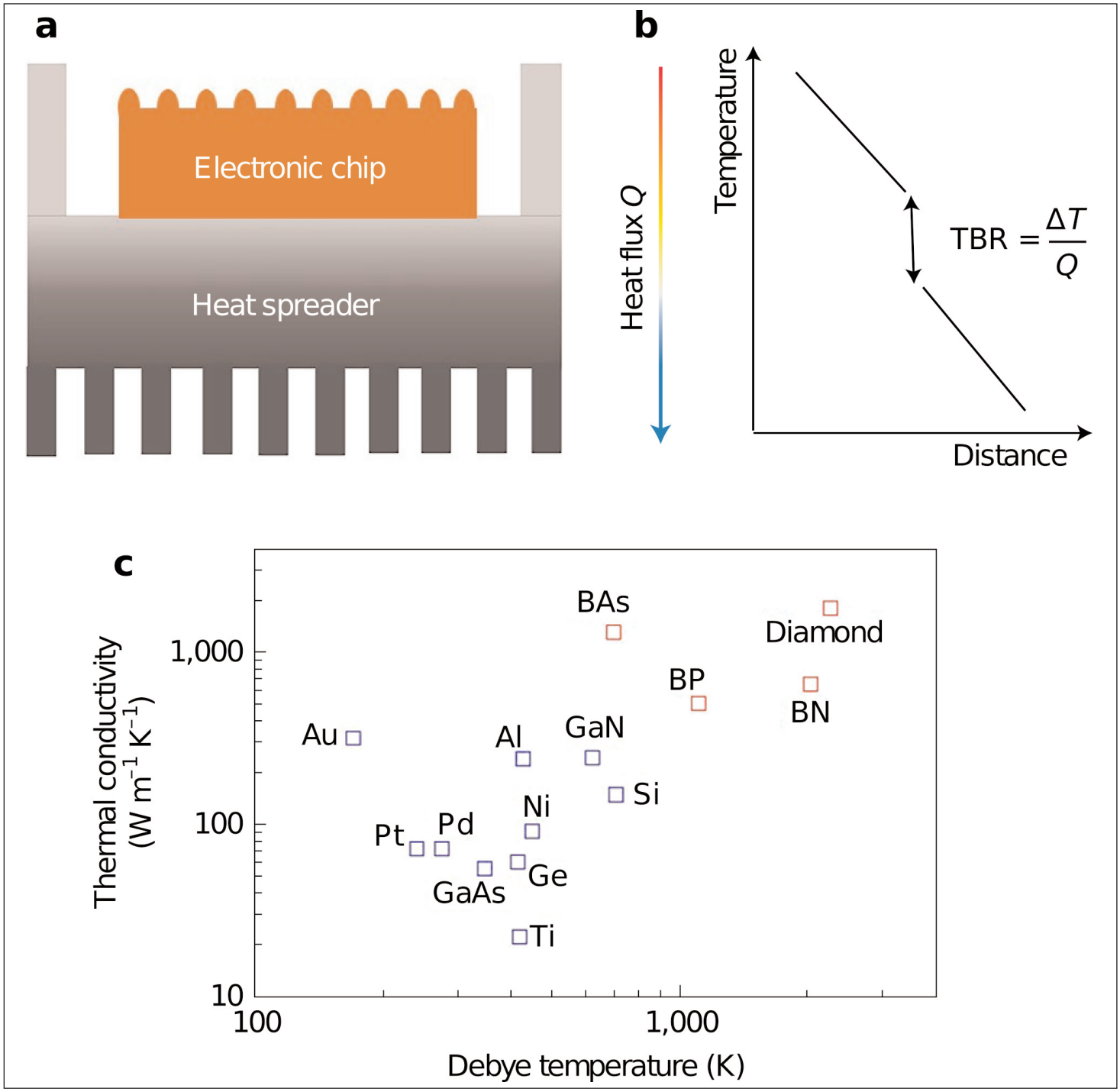

Figure 2. a, Schematic illustrating heat dissipation and thermal boundary resistance (TBR) at interfaces in microchip packaging. b, TBR = ΔT/Q, where ΔT and Q are temperature drop and heat flux across interface, respectively. c, Room-temperature thermal conductivities and Debye temperatures of representative metals, semiconductors and high-thermal-conductivity materials.

giving a value of ~250MW/m^2-K (about eight times higher than that of GaN/diamond). The researchers estimate that around 35% of the thermal resistance can be attributed to the oxide bonding layers.

The team believes that the lower thermal boundary resistance of GaN/BAs over GaN/diamond can be attributed to a better overlap between the properties of the quantized lattice vibrations (phonons) in GaN/BAs. At a simple level, the Debye temperature, derived from the linear spectrum model for specific heat at low temperature, for BAs is much closer to that of GaN (and other common electronic materials) than diamond (Figure 2). The paper details more complicated theoretical work down to the atomic level, aimed at backing up the team's belief. In particular, a better overlap of the phonon spectra reduces the tendency for phonons generated in GaN to be reflected back at the boundary with BAs, reducing the TBR. ■

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Author: Mike Cooke

AlScN project for energy-saving mobile radio base stations wins funding

Fraunhofer IAF and IIS plus Freiburg/INATECH to develop aluminium scandium nitride as power semiconductors for 26–34GHz amplifiers.

In the innovation competition 'Electronics for Energy-Saving Information and Communications Technology' launched by the German Federal Ministry of Education and Research (BMBF), the Fraunhofer Institute IAF (Institute for Applied Solid State Physics, in Freiburg) and Fraunhofer Institute IIS (Institute for Integrated Circuits, of Erlangen), together with the University of Freiburg/INATECH, have won second place (out of ten research teams) with their joint project proposal 'EdgeLimit – Evaluation of Power Electronics in Modern Edge Cloud Systems'. The project consortium is funded by Germany's Federal Ministry of Education and Research (BMBF) to realize their solution for energy-saving mobile radio base stations.

With the aim of promoting innovative solutions for energy-saving information and communication technologies (ICT), the BMBF launched the 'Electronics for Energy-Saving ICT' innovation competition last year as part of the 'Green ICT' initiative in its action plan 'Natürlich.Digital.Nachhaltig.' (a building block of the German Federal Government's Climate Protection Program 2030). After winning second place, EdgeLimit will receive exclusive funding from the BMBF for realization of the project. All three winning teams can now submit their research project designed in the competition to the BMBF for further funding and will receive €12m for this purpose.

"The resource consumption of advancing digitization is taking on ever greater dimensions. We must ensure through research and development that digitization becomes part of the solution in the fight against climate change and not part of the problem," states Federal Research Minister Anja Karliczek. This is particularly true of information & communication technologies, which will have to become much more energy-efficient in the future. New key technologies and a shift in thinking toward demand-based performance requirements are needed for ICT, it is reckoned.

AlScN allows significant advantages over established semiconductors such as silicon, GaAs and AlGaN/GaN. EdgeLimit aims to at least double power efficiency at the amplifier level in new cellular frequencies as well as to halve losses in power converters

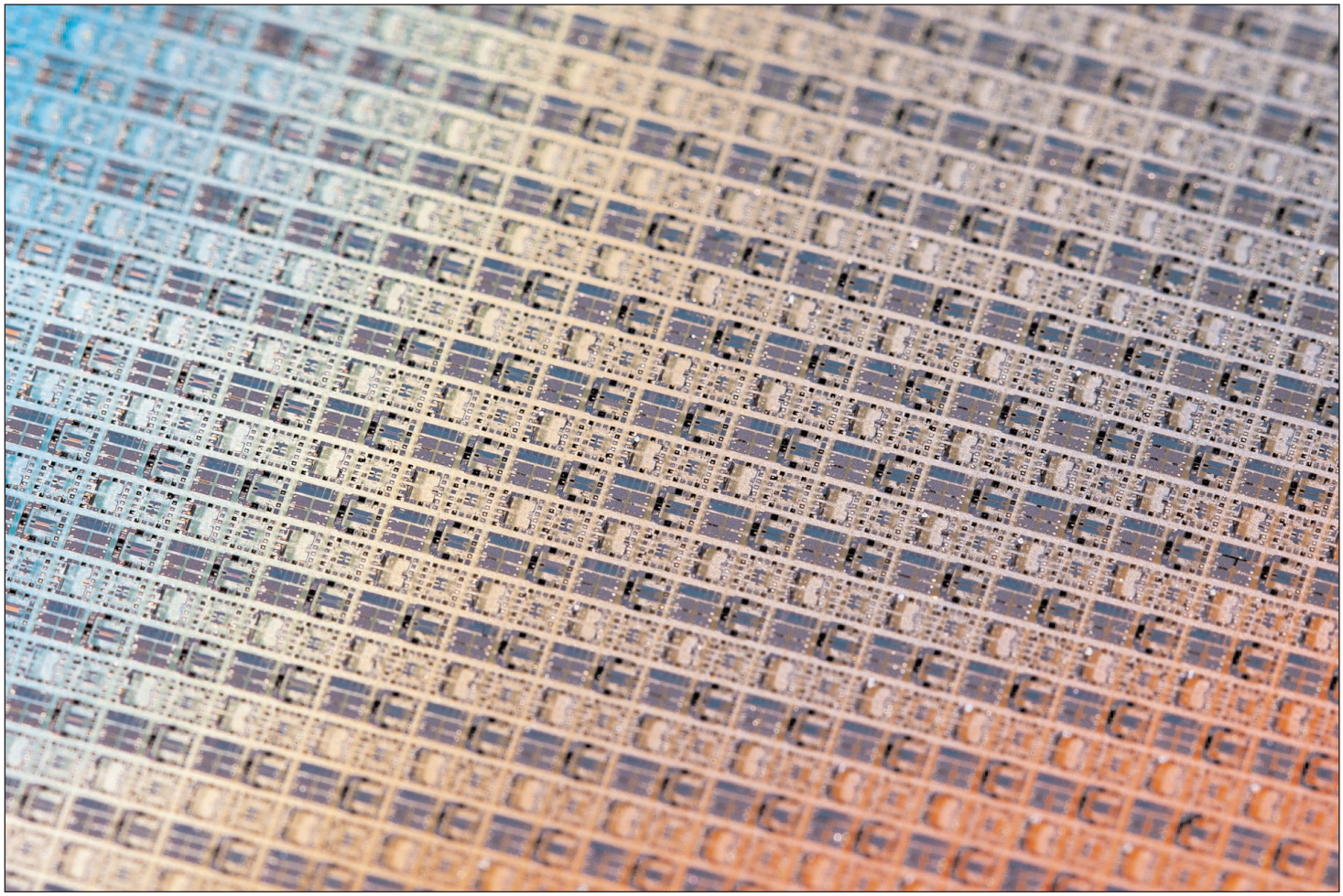
In their prize-winning preliminary project, the EdgeLimit consortium researched innovative semiconductor technologies and approaches towards more energy-efficient mobile communication antenna systems. New mobile communications systems achieve enormous increases in data rates, but the energy consumption of these systems must be reduced at least to the same extent.

EdgeLimit presents a concept for the use of novel power semiconductors for high-frequency amplifiers in 5G base stations for the new millimeter-wave frequency range at 26–34GHz based on aluminium scandium nitride (AlScN). It is reckoned that the project offers not only enormous potential savings in energy consumption and CO_2 emissions but also an extraordinary level of innovation in high-frequency electronics, with major leverage for microelectronics in Germany. This finds expression in the significant participation of industry in the second phase of the project, with a planned cooperation with Nokia Bell Labs, United Monolithic Semiconductors GmbH, Deutsche Telekom AG (associated) and Nokia Solutions and Networks GmbH & Co KG.

More efficient antenna amplifiers

Modern networked ICT systems increasingly have capacities for collecting and processing information at the edge of the network in addition to the central data-processing infrastructures (cloud) as well as systems for transferring data between cloud and edge. "Our goal is to realize a complete antenna system, a so-called remote radio head (RRH), which will enable more energy-efficient transmission in the millimeter-wave range of 5G while halving losses at the same time," says project coordinator Rüdiger Quay, deputy director of Fraunhofer IAF and professor for Energy-Efficient Radio-Frequency Electronics.

"We are working, for example, on intelligent edge solutions that take energy consumption into account during the design phase and reduce it to a minimum,"



High-frequency amplifiers based on aluminium scandium nitride (AlScN) have the potential to significantly improve the power density and efficiency of high-frequency amplifiers in 5G base stations. © Fraunhofer IAF

says professor Albert Heuberger, director of Fraunhofer IIS. By looking at the energy consumption of the radio units (massive MIMO antennas) in the 5G Testbed Industry 4.0 at Fraunhofer IIS, energy-efficient, distributed, secure edge cloud systems can be built and tested.

The project partners are using the novel power semiconductor AlScN to develop pioneering high-frequency components. "The semiconductor technology we are pursuing, with which we have already gained a lot of experience at IAF, has the potential to fundamentally increase power efficiency in integrated circuits (MMICs) through better matching, higher gain and higher power density," says Quay. Due to its high current-carrying capacity, AlScN allows significant advantages over established semiconductors such as silicon, gallium arsenide (GaAs) and AlGaN/GaN. Based on this material, EdgeLimit aims to at least double power efficiency at the amplifier level in new cellular frequencies as well as to halve losses in power converters.

Intelligent and demand-oriented ICT

More energy-efficient electronics alone cannot counter the exponentially increasing energy consumption of ICT. The horizon of physical energy efficiency is closer than that of the realizable data throughput, which is growing faster and thus producing a rebound effect. One solution is the intelligent and adaptive management of mobile communications systems, which ensures that energy is used as needed—an approach with enormous energy-saving potential.

To enable smart ICT, innovative power electronics architectures are required that allow electronics to be switched on and off as needed without compromising the latency of data transmissions. "At the network level, large amounts of energy should be saved by intelligently networking transmission modules and antennas with on-demand control, for example in factory networks such as the new Bosch semiconductor fab in Dresden or for fast video transmission to cars," says Quay. "For this purpose, we are developing the necessary high-frequency electronics in EdgeLimit that are capable of being connected to intelligent network management. Because one thing is certain: in the further development of ICT, we must give resource efficiency at least the same priority as performance enhancement. This is the only way to reduce CO_2 emissions as digitization advances." ■

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Fax: +44 (0) 1480 424900
www.goodfellow.com

PLANSEE High Performance Materials
6600 Reutte, Austria
Tel: +43 5672 600 2422
info@plansee.com
www.plansee.com

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

10 Gas and liquid handling equipment

Cambridge Fluid Systems
12 Trafalgar Way, Bar Hill,
Cambridge CB3 8SQ,
UK
Tel: +44 (0)1954 786800
Fax: +44 (0)1954 786818
www.cambridge-fluid.com

CS CLEAN SOLUTIONS AG
Fraunhoferstrasse 4,
Ismaning, 85737,
Germany
Tel: +49 89 96 24000
Fax: +49 89 96 2400122
www.csclean.com

Entegris Inc
129 Concord Road,
Billerica, MA 01821, USA
Tel: +1 978 436 6500
Fax: +1 978 436 6735
www.entegris.com

IEM Technologies Ltd
Fothergill House, Colley Lane,
Bridgwater, Somerset TA6 5JJ, UK
Tel: +44 (0)1278 420555
Fax: +44 (0)1278 420666
www.iemtec.com

Vacuum Barrier Corporation
4 Barton Lane,
Woburn, MA 01801,
USA
Tel: +1 781 933 3570
Fax: +1 781 933 9428
www.vacuumbarrier.com

VACUUM BARRIER VBC CORPORATION

Vacuum Barrier's vacuum-jacketed dynamic and sealed SEMIFLEX LN2 pipe delivers LN2 at bulk tank pressure in two-phase condition for on-demand supply. Our liquid/vapor phase separators deliver low-pressure LN2 to each use point for on-demand supply. Combine with SEMIFLEX Triax LN2 pipe eliminates two-phase flow to all use points.

Versum Materials
8555 S. River Parkway,
Tempe, AZ 85284,
USA
Tel: +1 602 282 1000
www.versummaterials.com

11 Process monitoring and control

Conax Technologies
2300 Walden Avenue,
Buffalo, NY 14225,
USA
Tel: +1 800 223 2389
Tel: +1 716 684 4500
www.conaxtechnologies.com

k-Space Associates Inc
2182 Bishop Circle
East, Dexter,
MI 48130,
USA
Tel: +1 734 426 7977
Fax: +1 734 426 7955
www.k-space.com

KLA-Tencor
One Technology Dr,
1-2221I, Milpitas,
CA 95035,
USA
Tel: +1 408 875 3000
Fax: +1 408 875 4144
www.kla-tencor.com

LayTec AG
Seesener Str. 10–13,
10709 Berlin,
Germany
Tel: +49 30 89 00 55 0
Fax: +49 30 89 00 180
www.laytec.de
LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

Vacuum Barrier Corporation
4 Barton Lane, Woburn, MA 01801,
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Tel: +1 781 933 3570
Fax: +1 781 933 9428
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WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)
Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald, Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

Bruker
Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187, Germany
Tel: +49 (0)721 595 2888
Fax: +49 (0)721 595 4587
www.bruker.com

KLA–Tencor
160 Rio Robles, Suite 103D,
San Jose, CA 94538-7306, USA
Tel: +1 408 875-3000
Fax: +1 510 456-2498
www.kla-tencor.com

13 Characterization equipment

J.A. Woollam Co. Inc.
645 M Street Suite 102,
Lincoln, NE 68508, USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc
575 McCorkle Boulevard,
Westerville, OH 43082, USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

14 Chip test equipment

Riff Company Inc
1484 Highland Avenue, Cheshire,
CT 06410, USA
Tel: +1 203-272-4899
Fax: +1 203-250-7389
www.riff-co.com

Tektronix Inc
14150 SW Karl Braun Drive,
P.O.Box 500, OR 97077, USA
www.tek.com

15 Assembly/packaging materials

ePAK International Inc
4926 Spicewood Springs Road,
Austin, TX 78759,
USA
Tel: +1 512 231 8083
Fax: +1 512 231 8183
www.epak.com

Gel-Pak
31398 Huntwood Avenue,
Hayward, CA 94544,
USA
Tel: +1 510 576 2220
Fax: +1 510 576 2282
www.gelpak.com

Wafer World Inc
(see section 3 for full contact details)

Materion Advanced Materials Group
2978 Main Street,
Buffalo, NY 14214,
USA
Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

16 Assembly/packaging equipment

CST Global Ltd
4 Stanley Boulevard,
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Blantyre, Glasgow G72 0BN,
UK
Tel: +44 (0) 1698 722072
www.cstglobal.uk

Kulicke & Soffa Industries
1005 Virginia Drive,
Fort Washington,
PA 19034,
USA
Tel: +1 215 784 6000
Fax: +1 215 784 6001
www.kns.com

Palomar Technologies Inc
2728 Loker Avenue West,
Carlsbad, CA 92010,
USA
Tel: +1 760 931 3600
Fax: +1 760 931 5191
www.PalomarTechnologies.com

PI (Physik Instrumente) L.P.
16 Albert St . Auburn ,
MA 01501, USA
Tel: +1 508-832-3456,
Fax: +1 508-832-0506
www.pi.ws
www.pi-usa.us

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara,
CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

Quik-Pak
10987 Via Frontera,
San Diego, CA 92127, USA
Tel: +1 858 674 4676
Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

CST Global Ltd
4 Stanley Boulevard, Hamilton International Technology Park,
Blantyre, Glasgow, G72 0BN,
UK
Tel: +44 (0) 1698 722072
www.cstglobal.uk

United Monolithic Semiconductors
Route departementale 128,
BP46, Orsay, 91401,
France
Tel: +33 1 69 33 04 72
Fax: +33 169 33 02 92
www.ums-gaas.com

19 Facility equipment

RENA Technologies NA
3838 Western Way NE,
Albany, OR 97321, USA
Tel: +1 541 917 3626
www.rena-na.com

Vacuum Barrier Corporation
4 Barton Lane, Woburn, MA 01801,
USA
Tel: +1 781 933 3570
Fax: +1 781 933 9428
www.vacuumbarrier.com

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20 Facility consumables

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6600 Reutte,
Austria
Tel: +43 5672 600 2422
info@plansee.com
www.plansee.com

W.L. Gore & Associates
401 Airport Rd, Elkton,
MD 21921-4236,
USA
Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

21 Computer hardware & software

Crosslight Software Inc
121-3989 Henning Dr.,
Burnaby, BC, V5C 6P8,
Canada
Tel: +1 604 320 1704
Fax: +1 604 320 1734
www.crosslight.com

Semiconductor Technology Research Inc
10404 Patterson Ave.,
Suite 108, Richmond,
VA 23238,
USA
Tel: +1 804 740 8314
Fax: +1 804 740 3814
www.semitech.us

22 Used equipment

Brumley South Inc
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NC 28115,
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23 Services

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2700 Augustine Drive, Suite 110,
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Contact Person: Cathy W. Hung
www.tecdia.com

24 Resources

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7140 San Jose,
CA 95126, USA
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San Jose, CA 95134,
USA
Tel: +1 408 943 6900
www.semi.org

Yole Développement
69006 Lyon,
France
Tel: +33 472 83 01 86
www.yole.fr

event calendar

If you would like your event listed in *Semiconductor Today*'s Event Calendar, then please e-mail all details to the Editor at mark@semiconductor-today.com

10–14 October 2021
27th International Semiconductor Laser Conference (ISLC 2021)
Potsdam, Germany
E-mail: islc@fbh-berlin.de
www.islc2021.org

~~**10–15 October 2021**~~
(postponed to 13–18 February 2022)
24th European Microwave Week (EuMW 2021)
ExCel, London, UK
E-mail: eumwreg@itnint.com
www.eumweek.com

~~**17–21 October 2021**~~ **(postponed to Fall 2022)**
4th International Workshop on Gallium Oxide and Related Materials (IWGO 2021)
Nagano, Japan
E-mail: secretary@iwgo2021.org
www.iwgo2021.org

24–28 October 2021
(postponed from 13–17 September 2020)
13th European Conference on Silicon Carbide and Related Materials (ECSCRM 2020-2021)
Vinci International Convention Centre, Tours, France
E-mail: ecscrm-2020@univ-tours.fr
www.ecscrm-2020.com

7–9 November 2021
8th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA 2021)
Crowne Plaza Redondo Beach and Marina, Redondo Beach, CA, USA
www.wipda.org

16–17 November 2021
Wide Bandgap Devices and Applications Short Course
Virtual, online event
E-mail: rasulliv@ncsu.edu
www.poweramericainstitute.org/shortcourse

16–19 November 2021
SEMICON Europa 2021 (co-located with productronica)
Messe München, Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

6–8 December 2021
PVinMotion conference 2021, Conference & Exhibition on Solutions for Vehicle Integration
virtual event, hosted by Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany
E-mail: info@pvinmotion-conference.com
www.pvinmotion-conference.com

6–9 December 2021
2021 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
~~Monterey Marriott, Monterey, CA, USA~~
Now a virtual, online event
E-mail: cs@cshawevent.com
www.bcicts.org

advertisers' index

11–15 December 2021
67th IEEE International Electron Devices Meeting (IEDM 2021)
Hilton San Francisco Union Square Hotel,
San Francisco, CA USA
E-mail: info@ieee-iedm.org
www.ieee-iedm.org

13–18 February 2022)
24th European Microwave Week (EuMW 2021)
ExCel, London, UK
E-mail: eumwreg@itnint.com
www.eumweek.com

20–24 March 2022
37th annual Applied Power Electronics Conference (APEC 2022)
Houston, Texas, USA
E-mail: apec@apec-conf.org
http://apec-conf.org/conference/sessions/technical

10–12 May 2022
PCIM (Power Conversion and Intelligent Motion) Europe 2022
Nuremberg, Germany
E-mail: pcim@mesago.com
www.mesago.de/en/PCIM/main.htm

15–20 May 2022
2022 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center,
San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

30 May – 3 June 2022
IEEE 72nd Electronic Components and Technology Conference (ECTC 2022)
The Sheraton San Diego Hotel and Marina,
San Diego, CA, USA
E-mail: reg.ectc@gmail.com
www.ectc.net

10–15 July 2022
(postponed from 14-19 June 2020, then 4-9 July 2021)
20th International Conference on Metal Organic Vapor Phase Epitaxy (ICMOVPE XX)
Stuttgart, Germany
E-mail: info@icmovpexx.eu
www.icmovpexx.eu

11–16 September 2022
19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2022)
Davos, Switzerland
E-mail: info@icscrm2021.org
www.icscrm2021.org

19–21 September 2022
48th European Conference on Optical Communication (ECOC 2022)
Basel, Switzerland
E-mail: info@ecoc2020.org
www.ecoco2020.org

25–30 September 2022
25th European Microwave Week (EuMW 2022)
MiCo, Milan, Italy
E-mail: eumwreg@itnint.com
www.eumweek.com

16–21 October 2022
International Workshop on Bulk Nitride Semiconductors — XI (IWBNS-XI)
Lehigh Valley, PA, USA
E-mail: iwbns-xi@gmail.com
www.iwbns-xi.org

15–18 November 2022
SEMICON Europa 2022 (co-located with electronica)
Messe München,
Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

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