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COMPOUNDS & ADVANCED SILICON

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Silicon carbide projects progress amid rapidly changing EV markets

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contents

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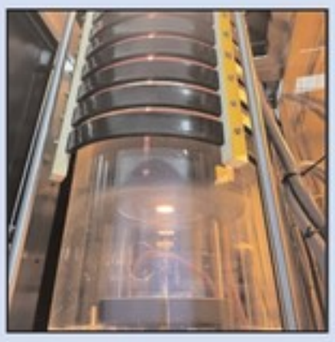
Vol. 19 • Issue 3 • April 2024

p8 Pragmatic Semiconductor has opened the UK's first 300mm wafer fabrication line.

p12 Wolfspeed has topped out construction of the John Palmour Manufacturing Center for Silicon Carbide in Siler City, Chatham County, NC.

p30 The UK's CSA Catapult and Sarawak's SMD have signed an MoU to collaborate on the design, prototyping and manufacturing of chips for the automotive and space industries.



Cover image: Penn State University has launched the Silicon Carbide Innovation Alliance, a coalition of industry leaders, academic institutions and government support with a focus on becoming the USA's central hub for research, development and workforce training in silicon carbide crystal technology. **p13**

editorial

Rapidly developing market for SiC

Driven by industrial and particularly automotive applications, the transition in recent years from silicon to silicon carbide power semiconductor devices has led to huge investment in the silicon carbide supply chain, from substrate growth through epiwafer processing to chip fabrication and module making.

Most recently, in late March, US pioneer Wolfspeed (formerly Cree) topped out construction at its new John Palmour Manufacturing Center for Silicon Carbide, which represents a total investment of $5bn (see page 12). Wolfspeed has since ordered multiple Aixtron G10-SiC CVD systems to ramp up production of 200mm-diameter SiC epiwafers. Likewise, US-based Vishay has ordered G10-SiC systems as it expands from silicon into SiC power device manufacturing at its automotive-certified 200mm-wafer Newport fab in South Wales, UK, acquired in March from Nexperia (see page 41). Indeed, power electronics applications (SiC and GaN) rose from 42% to 75% of Aixtron's total equipment revenue from 2022 to 2023.

Vishay Newport gains support from Aixtron et al in the local eco-system comprising the South Wales-based Compound Semiconductor Cluster. In April, Newport-based Compound Semiconductor Applications (CSA) Catapult signed an MoU with Sarawak's SMD to collaborate on the design, prototyping and manufacturing of chips for automotive and space applications (page 30). CSA Catapult has also opened an advanced packaging facility, as part of the Driving the Electric Revolution Industrialisation Centre (DER-IC) South West & Wales, offering open-access equipment, facilities and expertise to the power electronics, machines & drives (PEMD) manufacturing supply chain (page 28). "The supply chain within the UK is strengthened, helping to protect the industry and fostering job creation," says the UK Government.

Similarly, the EU-funded Chips Joint Undertaking — which aims to "reinforce the competitiveness and resilience of the [European] semiconductor technological and industrial base" — is investing €40m to establish a System-in-Package Fabrication (SiPFAB) pilot line for wide-bandgap (WBG) devices such as SiC and GaN at Finland's Tampere University (page 14).

In the USA, Penn State University has launched the Silicon Carbide Innovation Alliance (SCIA) — centred on the onsemi Silicon Carbide Crystal Center (SiC3) at Penn State's Material Research Institute established in May 2023 — as a US hub for research, development and workforce training in SiC crystal technology (see page 13). Also, SiC substrate maker Coherent has secured $15m in US CHIPS and Science Act funding to "strengthen and revitalize the US semiconductor supply chain" (page 26).

Rapid development of the SiC supply chain drove revenue at test equipment maker Aehr to almost double year-on-year for the quarter to end-August. However, it has since more than halved quarter-to-quarter, due to "delays in orders for SiC devices used in electric vehicles that have created a short-term gap in revenue" (page 27). "We have also seen a recent strengthening in the SiC market for EVs outside the US in what appears to be a shift in the market share of EV suppliers. This includes Asia, where we recently had extensive and very productive and positive visits with a significant number of silicon carbide suppliers and EV suppliers," Aehr adds.

So, apart from the difficulty of predicting trends in demand for a maturing technology (e.g. the recent slowdown in EV sales where consumers are cutting their spending), there are also market-share shifts where, for example, incumbent high-value EV makers in developed markets can be rapidly undercut by new entrants from lower-cost economies.

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***Semiconductor Today* covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices** (e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers and LEDs in wireless and optical communications, etc).

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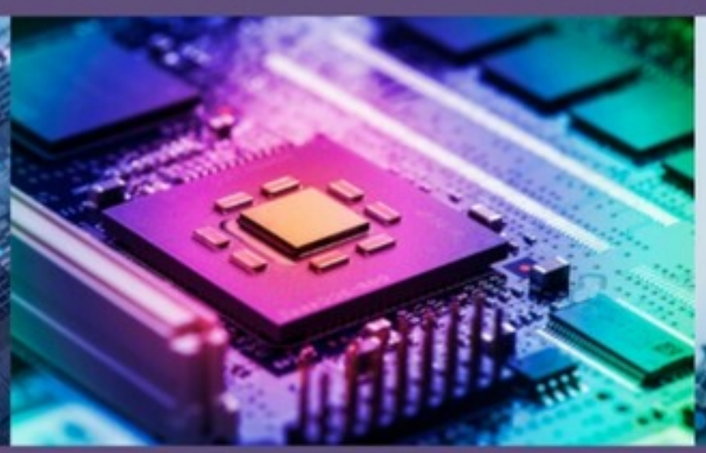

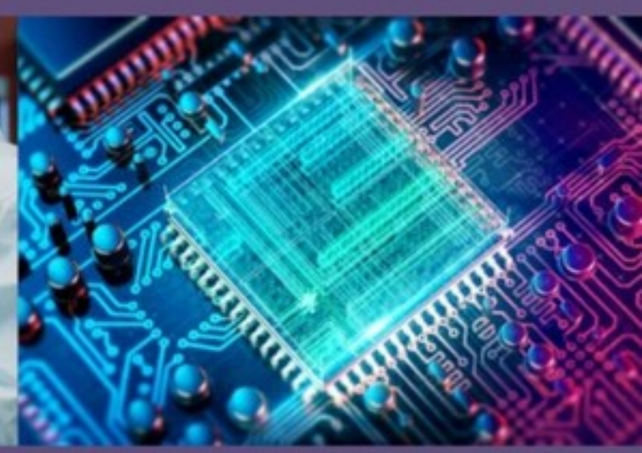

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LED market to rebound by 3% to $13bn in 2024

Automotive LED market to grow to $3.4bn

The global LED market is set to recover in 2024, with revenue growing by 3% year-on-year to US$13bn, forecasts TrendForce. This resurgence is driven primarily by demand across various sectors, including automotive lighting and displays, general/architectural/agricultural lighting, LED video walls and UV/IR LEDs. Additionally, the successful deployment of micro-LEDs in large displays by Samsung and luxury watches by Tag Heuer has played a significant role in this growth.

TrendForce points out that automotive displays present significant growth potential this year. Thanks to momentum from the new electric vehicle (NEV) market, advanced technologies like adaptive driving beam (ADB) headlights, mini-LED taillights, full-width taillights, smart ambient lighting, and mini-LED backlit displays are set to propel the automotive LED market to $3.4bn. Furthermore, micro-LED is making inroads into reading lights and control knobs in European OEMs.

Meanwhile, European, American and Japanese automakers plan to introduce micro-LED transparent displays. With automakers requiring micro-LED heads-up displays (HUDs) to achieve a transparency rate exceeding 70% and accommodate curved designs, the automotive market is set to embrace transparent micro-LED displays for augmented-reality (AR-HUD) or window displays by 2026–2027 as the technology matures and becomes more cost-effective.

The mini-LED video wall market is seeing rapid growth, propelled by leading manufacturers like Samsung, LG Electronics, Leyard, Unilumin, and Absen.

In the UV LED segment, manufacturers continue to roll out high-power sterilization and purification products to meet market demands. The application of UV-C LEDs in air sterilization by Huawei AITO — with orders spanning 2023–2025 — is poised to hasten the adoption of automotive air sterilization applications. Compared to traditional UV lamps, UV LEDs offer a longer lifespan and simpler optical design. Companies such as Nichia, Seoul Viosys, and Violumas have launched comprehensive UV-A/B/C LED product lines to satisfy the demand for UV lamp alternatives.

Agricultural lighting is gaining momentum in Central and Eastern Europe, particularly in Czechia and Poland, where the cost reduction of horticultural lighting end-products has improved the return-on-investment (ROI) of plant factory solutions. Furthermore, investments in horticultural lighting for cultivating vegetables and fodder in high-latitude Asian and Nordic regions aim to mitigate the adverse effects of prolonged winters on food suppliers, promising to boost the horticultural lighting LED market in 2024.

www.trendforce.com/research/led

EV DC charging system market to reach $23.7bn by 2029

Intelligent DC charging heralds burgeoning market for silicon carbide

Due to the continual expansion of charging infrastructure and the coming need for infrastructure replacements, the emergence of electric vehicle direct current (EV DC) charging holds long-term market viability and presents a promising business venture for companies specializing in power electronics, reckons market analyst firm Yole Group. Meanwhile, alternating current (AC) chargers will persist alongside onboard chargers (OBCs) in vehicles until DC infrastructure becomes universally established, a process anticipated to take 10–15 years, says the firm in 'DC Charging for Automotive 2024', an update of its annual report.

The total EV DC charging system market is expected to soar to $23.7bn by 2029. While chargers 50–150kW dominated the market in 2023, there is a noticeable surge in demand for higher-power chargers, particularly those exceeding 150kW. By 2029, the highest market value, estimated at $9.2bn, will be attributed to very high-power chargers (150kW≤x≤350kW).

"The integration of 1000V chargers is expected. The objective is clearly to simplify the charging experience for EV owners, irrespective of their battery pack voltage (400V or 800V), thereby streamlining the process of 'plug & go'," says Milan Rosina Ph.D., principal analyst, Power Electronics & Battery at Yole Group. "This advancement will alleviate concerns for OEMs with EVs utilizing 800V battery systems. Indeed, it will eliminate the need to adapt batteries to 500V chargers. Ultimately, this technological shift promises reductions in volume, weight and cost at the vehicle level."

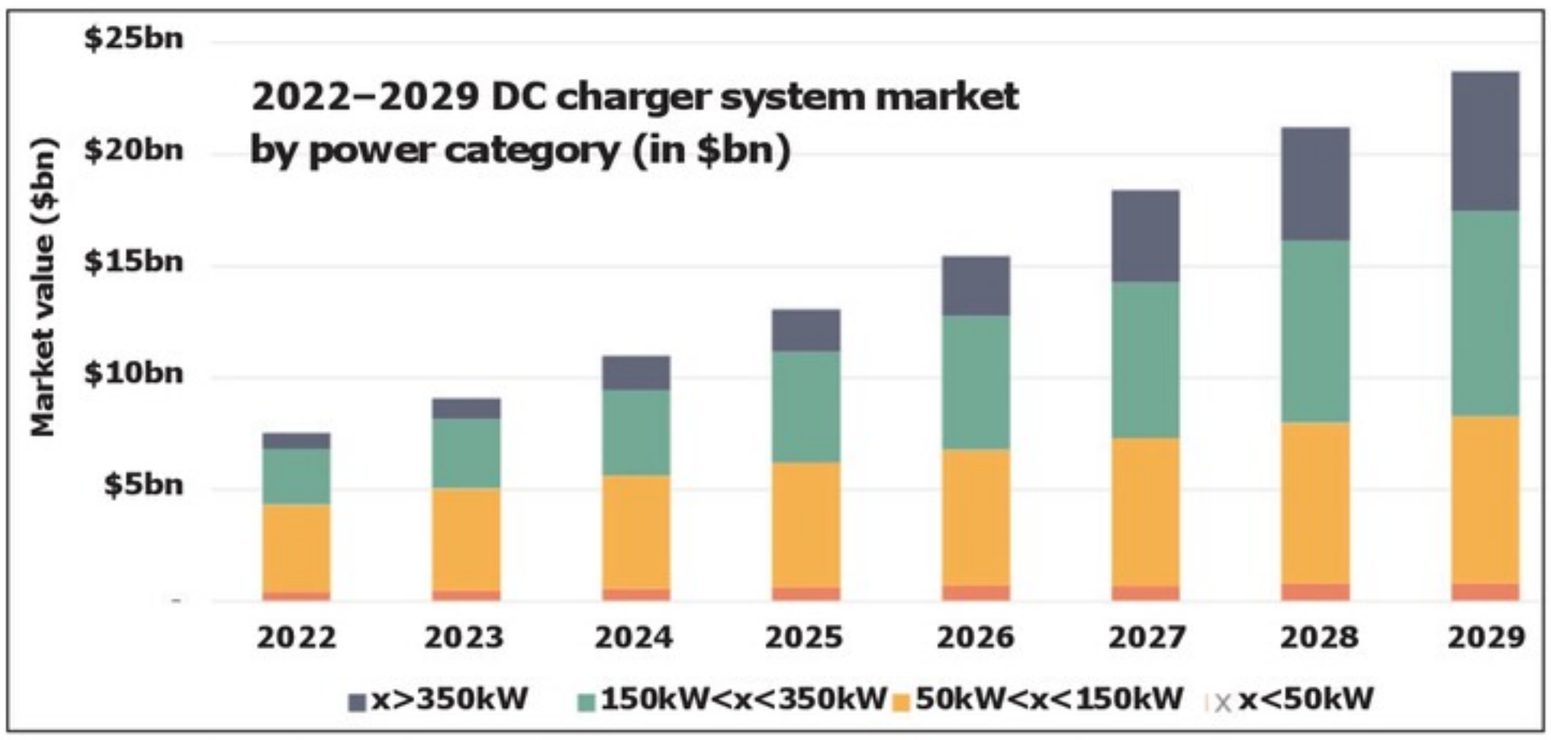
"The primary trends observed in EV DC chargers involve two key advancements: the increase in maximum charger voltage from 500V to 1000V to accommodate both 400V and 800V batteries and an escalation in power levels to above 350kW for exceedingly rapid charging. However, chargers with nominal power exceeding 350kW exceed the current charging capabilities of most electric vehicles," says Hassan Cheaito Ph.D., technology & market analyst, Power Electronics.

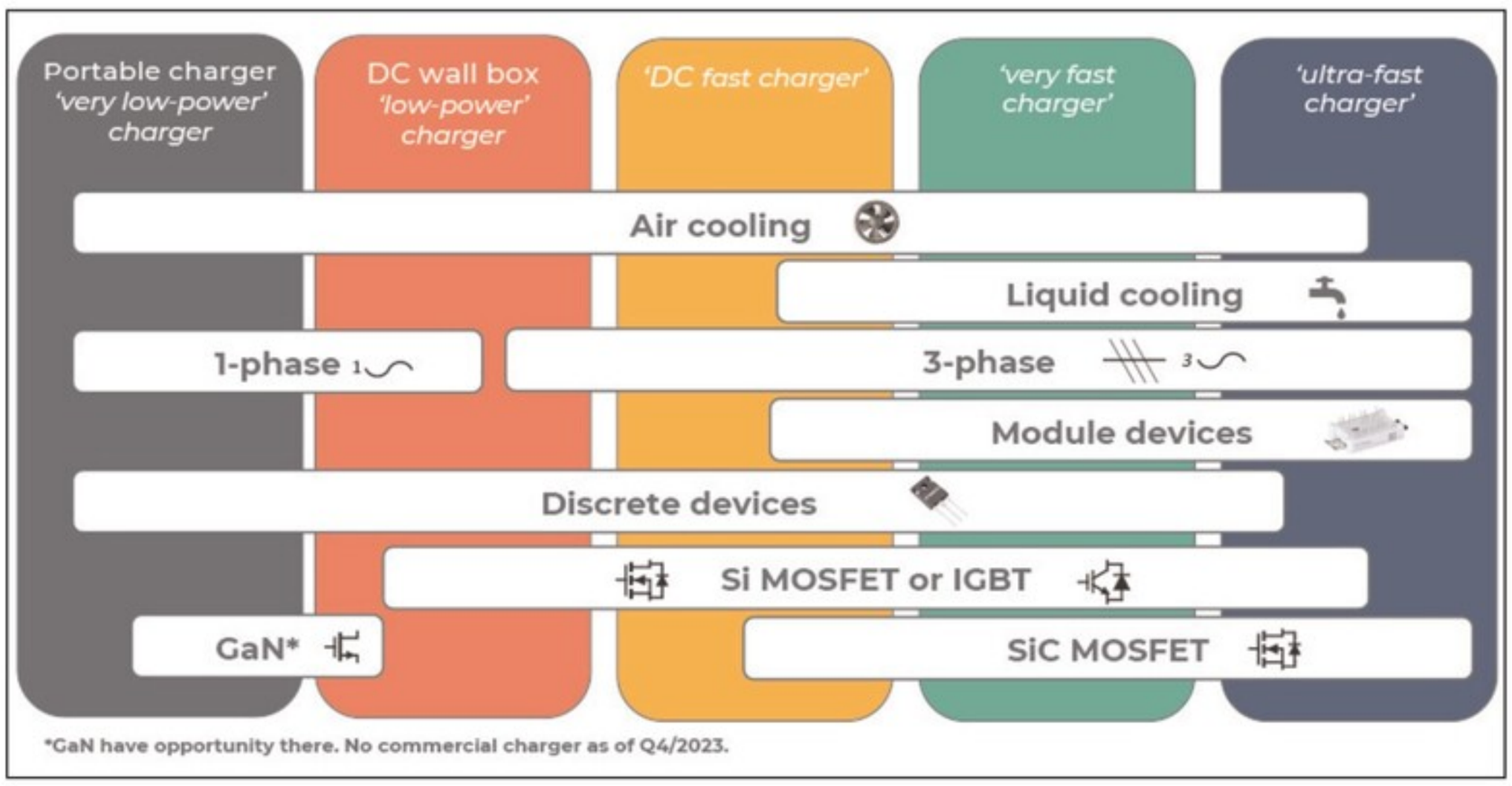
"These ultra-fast chargers are increasingly engineered to charge multiple vehicles concurrently through dynamic power allocation features," notes Yu Yang, Ph.D., principal analyst, Automotive Semiconductors. "Bidirectional chargers are not anticipated to become mainstream until V2G [vehicle-to-grid] technology gains traction."

Silicon transistors, specifically discrete insulated-gate bipolar transistors (IGBTs) and metal-oxide-semiconductor field-effect transistors (MOSFETs), remain prevalent in EV DC chargers. The adoption of silicon carbide (SiC) MOSFET devices is driven by factors such as a smaller charger footprint, enhanced thermal capabilities (resulting in simpler and more cost-effective cooling systems), and a higher breakdown voltage of 1200V. The collective impact of these parameters, coupled with a favorable return on investment particularly in high-utilization charging stations, is promoting the widespread adoption of SiC technology.

In addition, since liquid cooling systems are increasingly utilized in ultra-fast chargers, there is growing interest extending even to lower-power applications in residential or enclosed settings where noise reduction is a critical consideration.

www.yolegroup.com/product/report/dc-charging-for-automotive-2024





Technology trends among different charger sizes.

Pragmatic officially opens UK's first 300mm wafer fab

FlexIC fab in North-East England to create 500 jobs over next five years

In a ceremony attended by HRH The Princess Royal as well as key customers, ecosystem partners, investors and government officials, Pragmatic Semiconductor of Cambridge, UK has officially opened what is the UK's first 300mm wafer fabrication line. The manufacturing facility at the 60,000m^2 Pragmatic Park brown-field site near Durham in North-East England produces chips based on the firm's unique flexible integrated circuit (FlexIC) technology.

Incorporating layers of indium gallium zinc oxide (IGZO), Pragmatic's FlexICs are said to be low-cost, more sustainable alternatives to silicon chips, with an ultra-thin flexible form factor that enables connect, sense and compute capabilities, fuelling the Internet of Things (IoT) across sectors including consumer, industrial and healthcare.

The aim is to provide "item-level intelligence to trillions of smart objects over the next decade across a wide range of applications with significant opportunities in smart packaging of fast-moving consumer goods that will significantly improve levels of reuse and recycling, transforming waste management". Other use cases include wearables, sensors and flexible controllers. "Such intelligence at scale has the power to accelerate the digital transformation across industries," reckons CEO David Moore.

Pragmatic Park has the capacity to host up to nine fabrication lines, each capable of producing billions of chips per year. The firm's sustainable approach extends to manufacturing, using fewer process steps and a more concentrated footprint than standard silicon fabs. The optimized manufacturing process supports rapid production cycles of less than 48 hours, at low cost. It is also said to use significantly less energy and water than typical silicon manufacturing, and fewer harmful gases. "Sustainability is at the very core of our technology and extends to how FlexICs enable our customers to further drive innovations and pathways through their products and services towards global net-zero goals," says Moore.

Pragmatic's manufacturing line in Durham, UK.

Also, Pragmatic's modular 'Fab-in-a-Box' approach supports co-location of end-to-end FlexIC manufacturing at customers sites, rationalizing extended supply chains and providing additional levels of security and resilience. Pragmatic says that the manufacturing facility enables it to meet the growing demand for its technology from customers worldwide. Over the next five years Pragmatic expects to create more than 500 jobs in the North-East of England and Cambridge.

Incorporating layers of indium gallium zinc oxide, Pragmatic's FlexICs are said to be low-cost, more sustainable alternatives to silicon chips

"The bank invested in Pragmatic to support low-carbon domestic manufacturing of semiconductors in the UK," says Simon Little, banking & investments director, UKIB and Pragmatic board member. "The official opening of Pragmatic Park in Durham marks a pivotal next step in its journey," he adds.

"The UK has a very supportive ecosystem for providing early-stage funding, but it becomes challenging for businesses looking for later-stage capital," comments fellow Pragmatic board member Niranjan Sirdeshpande, global head of M&G's Catalyst strategy. "By providing growth equity to enterprising tech disruptors such as Pragmatic, M&G's £5bn Catalyst strategy can help them to scale, provide expertise and partner with them all the way to success. Put to work in this way, patient capital can support economic growth and capture value for peoples' pensions and savings as we transition to a more sustainable economy. We are proud to support Pragmatic's work in Durham with tech advancement in this critical part of the UK's national infrastructure."

www.pragmaticsemi.com

Diamfab raises €8.7m in first-round funding

Semiconducting synthetic diamond startup to set up pilot line to accelerate pre-industrialization phase

Diamfab has raised €8.7m in a first round of funding from Asterion Ventures, as well as from the French Tech Seed fund (managed on behalf of the French government by Bpifrance as part of France 2030), Kreaxi with the Avenir Industrie Auvergne–Rhône–Alpes regional fund, Better Angle, Hello Tomorrow and Grenoble Alpes Métropole.

Based in Grenoble, France, Diamfab was spun off from the Centre National de la Recherche Scientifique (CNRS) laboratory Institut Néel after 30 years of R&D into synthetic diamond growth. Initially incubated within SATT Linksium Grenoble Alpes, the Diamfab project led to the creation of the firm in March 2019, founded by semiconducting diamond researchers Gauthier Chicot and Khaled Driche (PhDs in nanoelectronics).

To address the market for semiconductors and power components for the automotive, renewable energies and quantum industries in particular, Diamfab has developed technology for the epitaxial deposition and doping of synthetic diamond. Protected by four patents, its expertise lies in the growth and doping of thin diamond layers, as well as in the design of diamond electronic components.

Compared with silicon-based components, the components that Diamfab develops are said to be lighter, more resistant to high temperatures and more energy efficient, making them suitable for a wide range of applications including power electronics in electric cars, industry and electricity distribution networks.

This first round of funding will enable Diamfab to set up a pilot line to pre-industrialize its technology, accelerate its development, and meet the growing demand for diamond semiconductors.

Diamfab's aim is to bring semiconductor diamonds to the level of development required by industry.

"In the development of a cutting-edge industry like ours, each stage is essential. The pilot project will catalyze many discussions with our partners and strengthen our relationships," says chairman Gauthier Chicot. "To be accompanied by investors who are committed to the industry and the climate, and above all who understand its constraints and links, is fundamental," he adds.

"Diamfab is at the crossroads of many of today's challenges: industrial relocation, decarbonization, strategic sovereignty... The technology we have developed makes it possible to reduce the historical carbon footprint of semiconductors considerably, and to do so by relocating a key industry for Europe, which is one of our investment priorities with Asterion," says Charles-Henry Choel, the Asterion Ventures partner in charge of the deal. "Industrial deep-tech companies need calm, long-term support, and that's what we provide."

Diamfab fits perfectly into the investment criteria of the brand-new Fonds Régional Avenir Industrie. We are particularly pleased to support the company at the critical stage of building its pilot line, which will enable it to reach the maturity needed to convince semiconductor manufacturers to invest in this new disruptive technology

Since its creation in 2019, Diamfab has built up an ecosystem of international partners and customers that are helping to develop the technology, including Soitec, Murata, STMicroelectronics, CEA and Schneider Electric.

By reaching industrial standards (wafer size and demonstrator components), it is reckoned that deeptech will enable players in the sector to integrate diamond technology into future solutions. The result should be unmatched performance in terms of efficiency, voltage withstand, thermal management and reduced CO_2 impact throughout the process, from manufacture to use.

By supporting Diamfab, the French Tech Seed fund, the Fonds Régional Avenir Industrie and Grenoble Alpes Métropole are acknowledging the importance of this technology, as well as their desire to see it develop in France and in a European ecosystem.

"On behalf of the French government, Bpifrance is actively participating in the re-industrialization of France, and is working to ensure the country's sovereignty in strategic sectors such as semiconductors," says Stéphane Lefevre-Sauli, investment director at Bpifrance. "Diamfab crystallizes these two ambitions," he adds.

"Diamfab, because of its deep-tech nature and the industrial nature of the project, fits perfectly into the investment criteria of the brand-new Fonds Régional Avenir Industrie, launched by the Auvergne–Rhône–Alpes region at the end of 2023," comments Pierre-Antoine Cognard, business manager at Kreaxi. "We are particularly pleased to support the company at the critical stage of building its pilot line, which will enable it to reach the maturity needed to convince semiconductor manufacturers to invest in this new disruptive technology."

www.diamfab.com

SemiQ opens office in Taiwan

Strategic hub enhances regional support for silicon carbide solutions

SemiQ Inc of Lake Forest, CA, USA — which designs, develops and manufactures silicon carbide (SiC) power semiconductors and 150mm SiC epitaxial wafers for high-voltage applications — has officially opened its newest office in Taiwan, underscoring its commitment to providing enhanced ground support to customers in the region while solidifying its presence in the Asia–Pacific market.

As a Product Engineering and Global Sourcing Center, the new office, located near the Taiwan High Speed Rail Hsinchu Station, will serve as a hub facilitating interfacing with key stakeholders including Hsinchu Foundry, Miaoli Test Facility, Far East OSATs, and the Taiwan Sales Office.

"Expanding our presence in Taiwan represents a significant milestone for SemiQ as we continue to strengthen our global operations and better serve our customers," says Michael Tsang, VP, product engineering and operations.

Tsang will lead the Taiwan office. His expertise will be instrumental in managing demand, fostering partnerships, and ensuring service delivery to customers, SemiQ reckons.

The strategic location of the new office near key industry players and transportation hubs is expected to enhance SemiQ's ability to collaborate effectively with its partners, streamline operations and expedite response times to customer needs. Establishing the Taiwan office complements SemiQ's existing wafer processing facilities in the region.

"We are excited about the opportunities that the Taiwan office brings in terms of strengthening relationships with our partners and better understanding the evolving needs of the market," says. Tsang. "This expansion aligns with our vision of driving innovation and delivering value-added solutions to our customers."

www.SemiQ.com

Infineon provides Fox ESS with power semiconductors

CoolSiC MOSFETs 1200V to be used in industrial energy storage

Infineon Technologies AG of Munich, Germany is supplying its power semiconductor devices to inverter and energy storage system maker Fox ESS of Shanghai, China (founded in 2019). Specifically, Infineon will provide CoolSiC MOSFETs 1200V, which will be used with EiceDRIVER gate drivers for industrial energy storage applications. At the same time, FOXESS' string photovoltaic (PV) inverters will use Infineon's IGBT7 H7 1200V power semiconductor devices.

The global market for photovoltaic energy storage systems (PV-ES) has grown rapidly in recent years, notes Infineon. As competition in the PV-ES market accelerates, improving power density has become key, and how to improve efficiency and power density for energy storage applications has attracted much attention. Infineon says that its CoolSiC MOSFET 1200V and IGBT7 H7 1200V series power semiconductor devices adopt the latest semiconductor technologies and design concepts tailored to industrial applications.

"Thanks to the support of Infineon's advanced components, Fox ESS' products have been significantly improved in terms of reliability and efficiency. This has been an important driving force for Fox ESS' growth," comments Fox ESS' chairman Zhu Jingcheng. "Infineon's technical support and product quality have not only strengthened our competitiveness but also expanded our presence in the market."

With high power density, Infineon claims that its CoolSiC MOSFETs 1200V can reduce losses by 50% and provide ~2% additional energy without increasing the battery size, which is especially beneficial for high-performance, lightweight and compact energy storage solutions. Fox ESS' H3PRO 15–30kW energy storage series uses Infineon's CoolSiC MOSFETs 1200V for all models. Due to Infineon's performance, the H3PRO series has achieved an efficiency of up to 98.1% and what is claimed to be excellent EMC performance, leading to the H3PRO series seeing rapid sales growth in the global market.

Infineon says that its TRENCHSTOP IGBT7 H7 650V/1200V series has lower losses and helps to improve the overall efficiency and power density of inverters. In high-power inverter projects, high-current mold packaged discrete devices with current-handling capability above 100A can reduce the number of IGBTs in parallel and replace the IGBT module solution, further improving system reliability and reducing costs; in addition, the H7 series has become an industry benchmark for its high-quality performance and greater resistance to humidity, it is claimed. At present, Fox ESS' main industrial and commercial model, the R Series 75–110kW, redefines the overall design of the 100kW model by using IGBT7 H7 series discretes, and the efficiency of the whole system can reach 98.6%. Due to the low power loss and high power density of the IGBT7 H7 series in discrete packages, technical problems such as current sharing in the paralleling process can be simplified and optimized.

www.fox-ess.com

www.infineon.com/coolsic

ROHM's SiCrystal and ST expand silicon carbide wafer supply agreement

Multi-year deal to supply larger volumes of SiC substrates worth at least $230m

ROHM group of Kyoto, Japan and STMicroelectronics of Geneva, Switzerland have expanded the existing multi-year, long-term 150mm silicon carbide (SiC) substrate wafers supply agreement with ROHM group company SiCrystal GmbH of Erlangen, Germany. The new multi-year agreement governs the supply of larger volumes of SiC substrate wafers manufactured in Nuremberg for a minimum expected value of $230m.

"This expanded agreement with SiCrystal will bring additional volumes of 150mm SiC substrate wafers to support our device manufacturing capacity ramp-up for automotive and industrial customers worldwide," notes ST's executive VP & chief procurement officer Geoff West. "It helps strengthen our supply chain resilience for future growth, with a balanced mix of in-house and commercial supply across regions," he adds.

"We will continue to support our partner to expand SiC business by ramping up 150mm SiC substrate wafer quantities continuously," says Dr Robert Eckstein, president & CEO of SiCrystal.

www.st.com
www.sicrystal.de
www.rohm.com/web/global/sic-mosfet

Wolfspeed tops out construction of John Palmour Manufacturing Center for Silicon Carbide

World's largest silicon carbide facility represents $5bn total investment

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — hosted Senator Thom Tillis (R-NC) and other local officials, community partners and employees at a 'last beam' ceremony to celebrate the topping out of construction at the $5bn John Palmour Manufacturing Center for Silicon Carbide, located in Siler City, Chatham County, NC. By the end of 2024, phase one of construction is expected to be completed on the 445-acre site.

The JP will "unlock significant benefits for our local community by growing the state's economy by more than $17.5bn over the next two decades and creating 1800 good-paying jobs by 2030," says Wolfspeed's president & CEO Gregg Lowe.

The JP represents a total investment of $5bn, complemented by public and private support, to help accelerate the transition from silicon to silicon carbide and ramp up supply of this material recently deemed as critical to the energy transition by the US Department of Energy.

Senator Thom Tillis joined Wolfspeed's president & CEO Gregg Lowe in signing the ceremonial 'last beam' at the Topping Out ceremony for The John Palmour Manufacturing Center for Silicon Carbide.

"I was proud to vote in favor of the CHIPS and Science Act, which provides critical support for domestic semiconductor manufacturing, and I applaud Wolfspeed's commitment to developing technology here in North Carolina that supports our national security and economic interests," says Senator Tillis.

The JP will primarily produce 200mm silicon carbide wafers (1.7x larger than 150mm wafers), significantly expanding Wolfspeed's materials capacity and translating to more efficient wafers and ultimately, lower costs. Wolfspeed already produces more than 60% of the world's silicon carbide materials at its Durham, NC headquarters, and is engaged in a $6.5bn capacity expansion effort to dramatically increase production. The JP's ramp-up will support recently signed customer agreements with Renesas, Infineon and others, while driving meaningful progress towards Wolfspeed's long-term growth strategy.

Wolfspeed says the JP underpins its vision of accelerating the adoption of silicon carbide across a wide array of end-markets and unlocking a new era of energy efficiency.

www.wolfspeed.com

Artist's rendering of The John Palmour Manufacturing Center for Silicon Carbide in Siler City, Chatham County, NC.

Silicon Carbide Innovation Alliance launched by Penn State University

onsemi Silicon Carbide Crystal Center at Penn State's Material Research Institute to be hub of US-wide industry, academia and government coalition

Penn State University has launched the Silicon Carbide Innovation Alliance (SCIA), a coalition of industry leaders, academic institutions and government support with a focus on becoming the USA's central hub for research, development and workforce training in silicon carbide crystal technology.

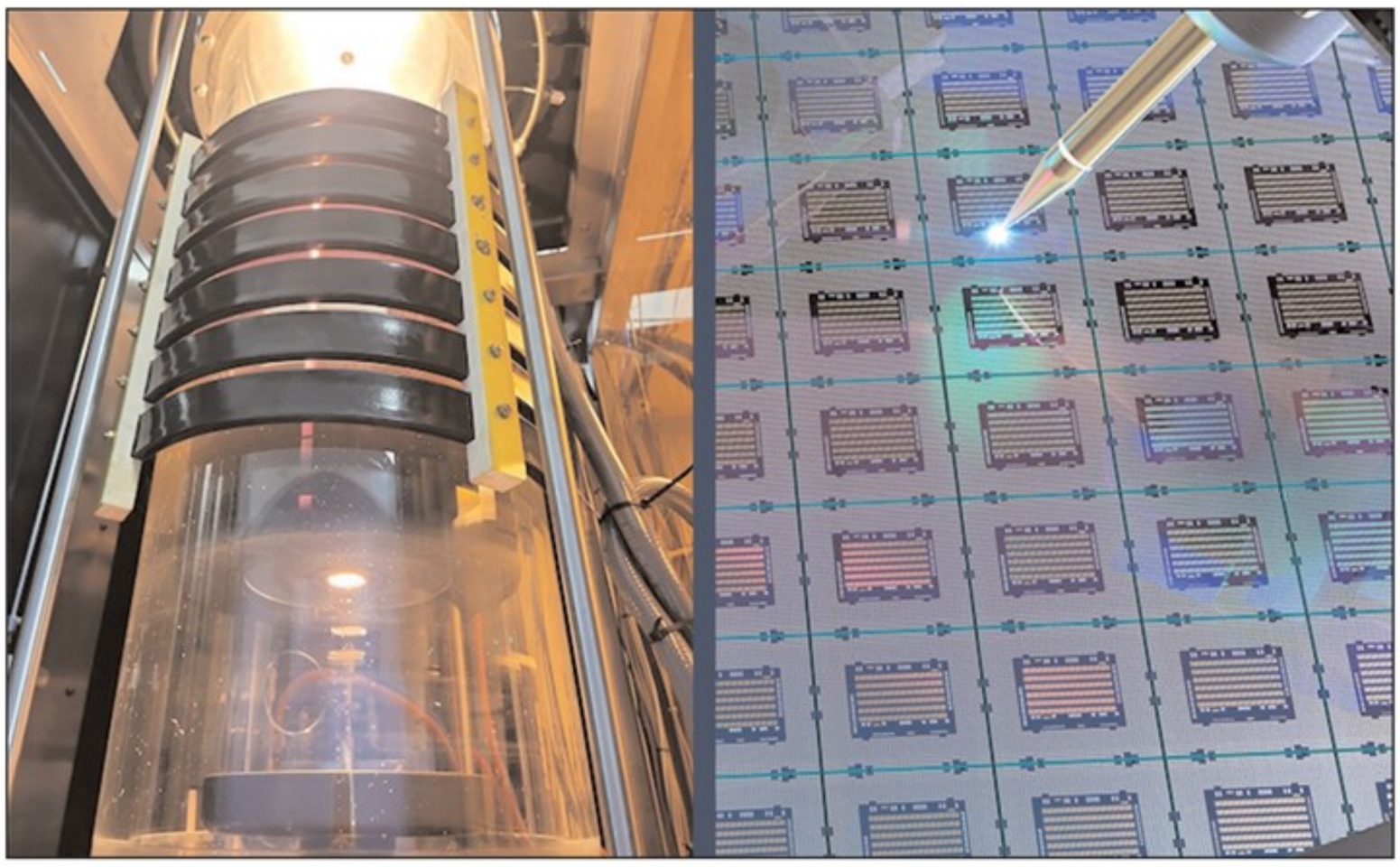
The alliance's flagship will be the recently established onsemi Silicon Carbide Crystal Center (SiC3) at Penn State's Material Research Institute. The SiC3 is funded via an $8m partnership with intelligent power and sensing technologies company onsemi.

Academic research in SiC crystal growth made significant advances 20 years ago, producing materials mainly for the Department of Defense. But, while the application space has dramatically expanded, university education and research in this space has since diminished in the USA, according to SCIA director Joshua Robinson, professor of materials science and engineering.

"Our goal with the SCIA is to put SiC crystal growth and processing research back on the map in the United States," Robinson says. "Our vision is to be the central location for research and workforce development in silicon carbide crystal science for the nation."

The US Air Force also provided key support in making the SCIA possible through a Defense University Research Instrumentation Program (DURIP) award.

"The Air Force provided critical funding for the purchase of essential instrumentation that was key to securing our partnership with onsemi and laying the foundation for SCIA," notes Robinson. "This support also underscores the strategic importance of SiC in national security and defense applications."



A silicon carbide high-temperature growth furnace. Credit: Penn State Materials Research Institute.

SCIA's vision aligns closely with the goals of the CHIPS and Science Act, which aims to revitalize the USA's semiconductor industry and bolster domestic manufacturing capabilities. The alliance will also be key in efforts around the Mid-Atlantic Semiconductor Hub (MASH), an interdependent coalition of top universities and industries founded by Penn State to combine resources and expertise to meet the needs of the semiconductor industry in the USA by strengthening and aligning research, manufacturing and workforce development.

"SCIA's focus on workforce development and fostering collaboration between industry and academia in Pennsylvania and beyond contributes to the realization of the CHIPS Act's objectives," says Clive Randall, distinguished professor of materials science and engineering and director of the Materials Research Institute (MRI) at Penn State. "This will be foundational toward Penn State's leadership of MASH, which aims to accelerate semiconductor innovation."

Our goal with the Silicon Carbide Innovation Alliance is to put silicon carbide crystal growth and processing research back on the map in the United States

The next step for the alliance is growing membership. "We see abundant opportunities for collaboration throughout the SiC substrate supply chain, and we are eager to connect with industry stakeholders to explore potential partnerships," says David Fecko, industry liaison for MRI. "Our focus will be on addressing industry-relevant challenges alongside SCIA members and on nurturing a skilled workforce through hands-on training in a pilot-scale facility. With this approach in mind, we are actively seeking new companies to join us in our endeavors."

www.scia.psu.edu
www.mash-semiconductors.org

EU-funded Chips JU selects four new pilot lines

Wide-bandgap pilot line for system-in-package fabrication at Tampere

Chips Joint Undertaking (Chips JU) has announced the successful evaluation of the submitted semiconductor pilot line proposals and has started negotiations with four consortia, targeting the signing of corresponding agreements later this year. The step aims to catalyse innovation in the region and reinforce Europe's technological leadership on the global stage.

Funded by the European Union (EU), Chips JU participating states and the private members, the Chips Joint Undertaking supports research, development, innovation and capacity building in the European semiconductor ecosystem. Launched by the European Union Council Regulation No 2021/1085 and amended in September 2023 via Council Regulation 2023/1782, it aims to contribute to reinforcing the competitiveness and resilience of the semiconductor technological and industrial base, engaging EU, national/regional and private industry funding of nearly €11bn.

The Public Authorities Board of the Chips Joint Undertaking has now selected the Hosting Consortia that – provided that negotiations are successful – will implement each of the four pilot lines, and will receive grants for the set-up, integration and process development, and for operational activities. The pilot lines will be funded jointly by the European Union, from the Horizon Europe and Digital Europe Programme, the member states and private contributions.

The four pilot lines selected are:

- Pilot Line for sub-2nm leading edge system-on-chip leadership (with technology developed by imec in Belgium);
- Fully Depleted Silicon On Insulator (FD-SOI) Pilot Line (at CEA-Leti in Grenoble, France), with a roadmap towards 7nm, for applications in non-volatile embedded memories, RF & 3D integration;
- Advanced Heterogeneous System Integration Pilot Line (led by Fraunhofer in Germany);
- WBG Pilot Line, with Finland's Tampere University hosting a System-in-Package Fabrication (SiPFAB) pilot line for wide-bandgap devices such as silicon carbide and gallium nitride.

"The selection of these pilot lines marks a pivotal moment for Europe's semiconductor industry, showcasing the collective commitment of European states to drive technological innovation," says Kari Leino, chair of the Chips JU Public Authorities Board.

These calls relate to the operational objectives of the 'Chips for Europe Initiative', the first pillar of the European Chips Act. This initiative aims to "enhance technological capacity building and foster innovation in cutting-edge chip technology on a substantial scale". The Chips JU should play a pivotal role in facilitating a significant part of this investment.

"This decision represents a significant milestone for Europe's semiconductor industry, and we look forward to the realisation of these pilot lines," says Chips JU executive director Jari Kinaret.

The pilot lines will accelerate process development, test and experimentation, and validation of design concepts. Their implementation is expected to bridge the gap from lab to fab and will be available to a wide range of users, including academia, industry and research institutions.

The next steps include negotiations with the consortia to finalize the Hosting Agreements, Joint Procurement Agreements and the related Grant Agreements by end-2024.

www.chips-ju.europa.eu

Tampere secures €40m EU funding for WBG Pilot Line

Finland's Tampere University is a partner in the WBG Pilot Line, which focuses on developing wide-bandgap semiconductors and testing and integrating WBG chips. Applications include motor control systems, battery management systems, fast-charging systems, photovoltaic inverters, power supply systems and 5G base stations.

Tampere University's funding of €40m for the WBG Pilot Line will be provided by both the Finnish government and the European Commission for setting up the System-in-Package Fabrication (SiPFAB) pilot line, providing an environment for testing WBG chips and integrating and packaging chip systems. The grant proposal was prepared in collaboration with the City of Tampere's Chips from Finland initiative.

The EU grant represents one of the largest ever investments in the development of academic research and innovation infrastructures in Finland, according to Tampere University's president Keijo Hämäläinen. "In the next few years, we will continue to expand the university's expertise in semiconductor technology. Tampere will become a major hub of semiconductor expertise in Europe that will attract both academic professionals and new businesses," he reckons.

"The pilot line was an important goal in the Chips from Tampere program," notes Petri Räsänen, director of Business Tampere's Chips from Tampere program. "The pilot line will enable us to create next-generation chip solutions for electrification, safety and data communications. The next step will be the establishment of a competence center for building semiconductor expertise."

www.businesstampere.com
www.tuni.fi

State Governor emphasizes commitment to Vermont's V-GaN Tech Hub

Rapid development of chip design at University of Vermont, prototyping at GlobalFoundries and testing/characterization at OnLogic

Governor Phil Scott has reiterated his support for Vermont's Tech Hub V-GaN by devoting resources to gallium nitride (GaN)-related activities in the State.

"This Tech Hub designation will expand Vermont's expanding tech sector and introduce new and lucrative career opportunities for Vermonters," says Governor Scott. "The State's collaboration with industry and educational partners is an investment in the rural economy and our youth," he adds.

An investment in GaN and GlobalFoundries announced in February as part of the US CHIPS and Science Act reinforces why the region was designated a Tech Hub by the US Department of Commerce, says Scott. GlobalFoundries' Fab 9 plant in Essex Junction is already producing GaN chips in a limited capacity, and is poised to be the first to mass produce this technology in the Western hemisphere.

Building on that, the V-GaN Tech Hub features rapid development of chip design taking place at the University of Vermont and elsewhere, prototyping conducted at GlobalFoundries, and testing/characterization at a new lab at OnLogic.

"The Vermont Agency of Commerce and Community Development and Vermont Department of Labor are working closely with the University of Vermont, the Vermont State Colleges, and GlobalFoundries to support V-GaN and to help it thrive," Scott notes.

Examples of the State of Vermont's commitments, collaboration and investments include:

- WORKFORCE: Vermont's Employment Services will support employee recruitment, training and retention for V-GaN Tech Hub.
- COORDINATION: Direct coordination between Vermont's Workforce Expansion Program and V-GaN.
- APPRENTICESHIP: Creation of the Registered Apprenticeship Program in partnership with the Vermont Manufacturing Extension Center (VMEC) to work with Tech Hub employers to target new occupations for apprenticeship.
- PREPARING STUDENTS: A summer professional development program for teachers on the development of new curriculum to support student learning with skills that support Tech Hub occupations.
- TRAINING AT GLOBALFOUNDRIES: The Vermont Training Program is prepared to award GlobalFoundries a $4.5m grant to train current and future employees for GaN semiconductor mass production.
- MARKETING: The State of Vermont is committing tens of thousands of dollars to help market the V-GaN Tech Hub.

More than 60 businesses, educational institutions and municipalities have already signed on to support and work with Vermont's Tech Hub.

www.vgan.tech
www.gf.com
www.uvm.edu
www.vsc.edu

Infineon receives 'GaN Strategic Partner of the Year' award from Chicony

Taiwan-based power supply maker acknowledges "product selection, application expertise, reliability and cost-effectiveness"

Chicony Power Technology Co Ltd of New Taipei, Taiwan has unveiled the winners of its Annual Partner Awards, honoring Infineon Technologies AG of Munich, Germany as its 2023 'GaN Strategic Partner of the Year'.

Chicony Power is a provider of power electronics systems focusing on power supplies (including switch-mode power supplies) and adapters for applications including notebooks/laptops, desktop PCs, server/cloud solutions, smart home/AIoT products, satellite communication devices, telecom infrastructure, and consumer products.

Infineon has been recognized by Chicony Power as its top partner for gallium nitride-based power supplies, including notebook adapters, plus ICT applications in gaming, storage and servers. Infineon says that the acknowledgment is the result of its high standards for product selection, application expertise, high reliability and cost-effectiveness.

Pooling Infineon's GaN expertise and Chicony Power's capabilities in power supply system design, the firms say that the collaboration has helped to further strengthen both their positions in energy-efficient power solutions. The GaN adoption rate in Chicony Power's high-watt adapters has now reached 20% and is rapidly increasing.

Infineon has played "a pivotal role in driving customer success throughout 2023," comments Chicony Power Technology's president Peter Tseng.

www.chiconypower.com
www.infineon.com

Worksport to incorporate GaN into future versions of COR mobile battery generator system

Worksport Ltd of West Seneca, NY, USA (an automotive accessory manufacturer developing clean energy solutions) has announced a strategic move to integrate gallium nitride in its upcoming product offerings.

Motivated by GaN's potential to provide superior performance, increased efficiency and reduced size and weight compared with conventional silicon-based solutions, Worksport's goal is to integrate GaN into future versions of its COR Mobile Battery Generator Systems, through various partnerships, including one announced in early February with GaN semiconductor maker Infineon Technologies AG of Munich, Germany.

Compared with silicon, GaN-based power switches feature lower overall capacitances, especially considering that they do not have an anti-parallel

body diode. GaN switches therefore allow for faster switching speeds and reduced power losses. GaN can also withstand higher temperatures than silicon. Using GaN can hence boost efficiency, thermal management, and performance. Additionally, since GaN has a wide bandgap energy, devices can withstand much higher voltages than silicon-based devices while also using smaller packages. This can result in power converters with a much higher power density than is typically found in silicon-based switches.

Worksport reckons that, by leveraging GaN technology, its future products will be able to deliver unmatched performance while also consuming less energy, resulting in longer battery life due to higher-efficiency power converters. Also, due to GaN's higher efficiency, GaN-based power converters radiate less heat and have lower cooling requirements and a reduced need for cooling fans, leading the firm to believe that it could yield a more compact size for its power electronics. Moreover, Worksport believes that, by using GaN, it will be able to create more reliable and longer-lasting devices while reducing the risk of overheating and performance degradation.

www.worksport.com
www.infineon.com

Virtual Forest adopts Navitas' GaNFast for 2250W solar-powered irrigation pump

Virtual Forest of Bengaluru, India (an electronics design company specializing in motor control and human interface technologies for consumer appliances, fluid movement and mobility) has adopted the GaNFast power integrated circuits (IC) technology of gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA for a zero-emission, 3hp (2250W) solar-powered irrigation pump.

For farmers worldwide, irrigating remote crops requires powerful pumps to lift water from rivers and streams up to field-level, with most powered by polluting and noisy diesel generators or expensive, lossy long-distance electrical cables, notes Navitas. The Virtual Forest solar pump with maximum power point tracking (MPPT) operates in conjunction with solar panel and energy storage to provide robust, energy-independent and pollution-free performance at the point of use. The 3hp (2250W) pump is remotely accessed via quad-band IoT with low power consumption. It can raise over 50 gallons per minute of water to a height of over 90 feet, enough to water 3 acres of farmland, and help to produce 10 tonnes of wheat. Further, the IoT-enabled solar pump ensures optimal water usage through intelligent analytics, minimizing ground-water utilization.

Navitas GaNSense half-bridge power ICs monolithically integrate two GaN power FETs with GaN drivers, level-shifters, protection features and high-efficiency loss-less current sensing. High-efficiency NV6269 half-bridge ICs, in easy-to-use 8mm x 10mm QFN packages are used in a 3-phase motor inverter, with 3–5x energy savings versus legacy silicon IGBTs, it is reckoned.

"The $450m solar-pump market in India is expected to reach $1.5bn by 2026, calling for a solar revolution on Indian fields," says Virtual Forest's CEO Omer Basith. "Reliable, off-grid systems are critical to overcome food insecurity and achieve energy efficiency. Leveraging Navitas' high-power, efficient GaNSense half-bridge, we seek to deliver a robust solution to the market. We are nurturing our dream to drive gigatons of reduction in carbon emissions," he adds.

"The design team at Virtual Forest adopted the GaNSense half-bridges very quickly, for a fast time-to-market," says Navitas' senior sales director Alessandro Squeri. "With GaNSense 'easy-to-use' features, Virtual Forest comes into the partnership with high efficiency, low component count and a robust design for tough environments."

www.virtual forest.in
www.navitassemi.com/half-bridge-gan

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DSV Global Transport and Logistics

Transphorm and Weltrend add 150mΩ and 480mΩ 650V integrated GaN system-in-packages

SuperGaN-based SiP family now spans three devices, expanding power level support for wider range of adapters and chargers

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 — and fabless firm Weltrend Semiconductor Inc of Hsinchu Science Park, Taiwan (which specializes in the design, testing, application development and distribution of mixed-signal/digital ICs in power supplies, motor controls and image processing) have announced the availability of two new GaN system-in-packages (SiPs). When combined with Weltrend's flagship GaN SiP launched in March 2023, the new devices establish the first SiP product family based on Transphorm's SuperGaN platform.

Sampling now, the new SiPs — WT7162RHUG24B and WT7162RHUG24C — integrate Weltrend's high-frequency multi-mode (QR/valley switching) flyback PWM controller with Transphorm's 150mΩ and 480mΩ 650V SuperGaN FETs, respectively. Like their 240mΩ predecessor (WT7162RHUG24A), the devices pair with USB PD or programmable power adapter controllers to provide a total adapter solution. They also offer several innovative features including the UHV valley tracking charge mode, adaptive OCP compensation, and adaptive green mode control that allow users to design high-quality power supplies more quickly and with fewer components using the simplest design approach.

"When we launched our first GaN SiP last year, it was an important milestone in our company's evolution. It demonstrated a new GTM strategy for the AC-to-DC power market," says Weltrend's VP of marketing Wayne Lo. "We're continuing to serve that space with a wider selection of devices designed to support a wider assortment of product power levels. A total packaged solution with Transphorm's SuperGaN platform delivers design simplicity with unparalleled performance for devices now ranging from low 30W USB-C PD power adapters through to nearly 200W chargers, a unique Transphorm GaN capability," he comments.

End-product manufacturers seek ways to develop new adapters with a reduced bill-of-materials (BOM) that offer versatility, fast charging and higher-power outputs. Additionally, in many cases they seek to deliver 'one-size-fits-all' chargers with multiple ports and/or multiple types of connections. All of this in a smaller, lighter-weight form factor.

Key advantages of Transphorm's normally-off d-mode SuperGaN platform are claimed to include best-in-class robustness (+/-20V gate margin with a 4V noise immunity) and reliability (<0.05 FIT) with the ability to increase power density by 50% over silicon (to 26W/in^3 in the standard 24-pin 8x8 QFN form-factor package, with power efficiency of >93%, allowing for low profile/small system footprint). Other key specifications include: wide output voltage operation (USB-C PD 3.0 and PPS 3.3~21V); and a maximum frequency of 180kHz. Weltrend's SiP designs harness those advantages along with its own technologies to create a near plug-and-play solution that is said to speed design while reducing form-factor size.

"SiPs are an important device option when considering the needs of adapter and charger manufacturers," says Tushar Dhayagude, Transphorm's VP of worldwide sales & FAE (field application engineering). "These systems require effective power conversion that, while simple to use with integrated functionality, also minimize learning curves to ensure quick design-in," he adds. "The first device released validated the performance and versatility of a SuperGaN SiP. The new devices announced today validate both our companies' deepening commitment to arming customers with choice."

Weltrend's SuperGaN SiP family is optimized for use in high-performance, low-profile USB-C power adapters for mobile/IoT devices such as smartphones, tablets, laptops, headphones, drones, speakers, and cameras.

www.transphormusa.com

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DSV Global Transport and Logistics

China's Innoscience refutes Infineon's US lawsuit and questions validity of Infineon patent

Gallium nitride-on-silicon (GaN-on-Si) power solutions firm Innoscience says that it firmly denounces the accusations made on 13 March by Infineon Technologies in a patent infringement lawsuit against three Innoscience entities.

Through its subsidiary Infineon Technologies Austria AG, Infineon Technologies AG of Munich, Germany filed the lawsuit in the district court of the Northern District of California against Innoscience (Zhuhai) Technology Co Ltd of Suzhou, China, and Innoscience America Inc and affiliates. Infineon is seeking permanent injunction for infringement of a United States patent relating to GaN technology owned by Infineon. The patent claims cover core aspects of GaN power semiconductors encompassing innovations that enable the reliability and performance of Infineon's proprietary GaN devices.

Infineon alleged that Innoscience infringes the patent by making, using, selling, offering to sell and/or importing into the USA various products, including GaN transistors for numerous applications, within automotive, data centers, solar, motor drives, consumer electronics and related products used in automotive, industrial and commercial applications.

Innoscience denies Infineon's allegations of patent infringement as well as the validity of the Infineon patent, adding that it will vigorously defend itself.

"Infineon's intention with this litigation is also in question, as it has asserted a patent that has significant defects," says Innoscience. "Even a cursory review of Infineon's patent portfolio reveals that the alleged 'invention' of the asserted patent was already disclosed in Infineon's own earlier prior art patents, raising concerns that it may have committed fraud on the United States Patent and Trademark Office for not making proper disclosures during the prosecution of the asserted defective patent," it adds.

Innoscience denies Infineon's allegations of patent infringement as well as the validity of the Infineon patent. Infineon's intention with this litigation is also in question, as it has asserted a patent that has significant defects

"In addition, contrary to Infineon's wrong characterization that the claims of the asserted defective patent 'cover core aspects of GaN power semiconductors', the lawsuit only concerns a small fraction of Innoscience's packaged high-voltage (650–700V) GaN transistors and does not affect the vast majority of its other products (including unpackaged transistors and wafers, low-voltage transistors, and certain packaged transistors). Therefore, the lawsuit should have little to no effect on Innoscience's current ability to make, use, sell, offer to sell, or import into the United States its products for customers," Innoscience reckons.

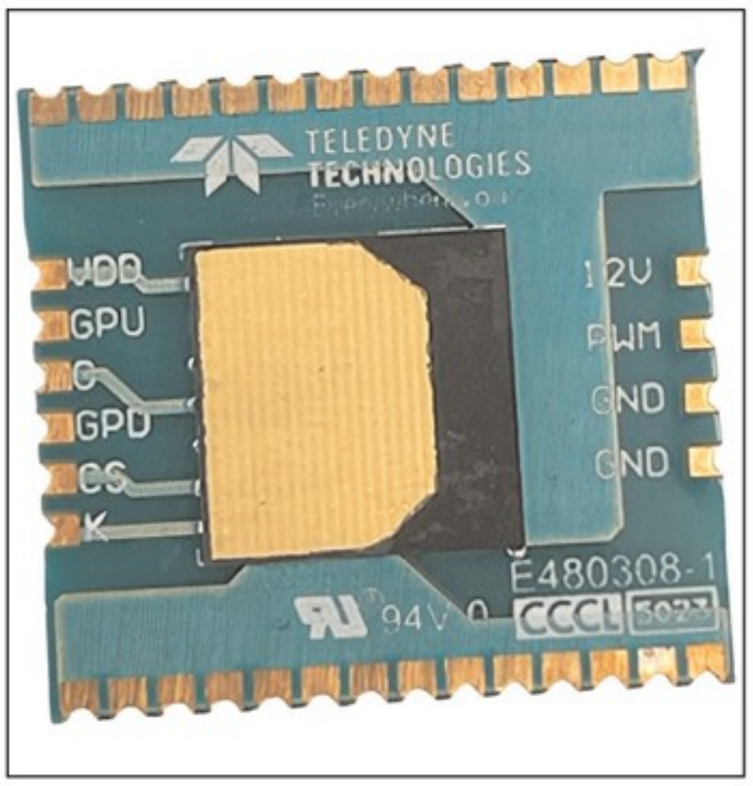
www.infineon.com
www.innoscience.com

Teledyne e2v HiRel releases TDGM650LS60 gallium nitride load switch

First product in new 650V power module family

Teledyne e2v HiRel Electronics of Milpitas, CA, USA (part of the Teledyne Defense Electronics Group that provides solutions, sub-systems and components to the space, transportation, defense and industrial markets) has released the TDGM650LS60, the first product in its new 650V power module family, which utilizes a Teledyne high-voltage gallium nitride (GaN) transistor and integrates an isolated driver in one package.

Designed to act as a load switch or solid-state switch, the TDGM650LS60 is claimed to offer unparalleled performance and versatility. With the driver providing 5kV isolation and a GaN transistor with a minimum breakdown voltage of 650V, the module ensures robust and dependable operation in diverse environments.



Teledyne e2v HiRel's TDGM650LS60 650V GaN load switch.

A feature of the TDGM650LS60 is its fast switching time coupled with the absence of moving parts. This unique combination not only boosts operational efficiency but also greatly boosts device reliability. As a result, the TDGM650LS60 is suitable for high-reliability applications, including but not limited to the space, avionics and military sectors.

www.tdehirel.com

US Patent Office reviewing validity of two EPC patents asserted against Innoscience

Final determination due by 20 March 2025

Gallium nitride-on-silicon (GaN-on-Si) power solutions firm Innoscience (Zhuhai) Technology Co Ltd of Suzhou, China has welcomed two decisions of 20 March by the US Patent and Trademark Office (USPTO) to review the validity of the two remaining US patents, as asserted by Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA against Innoscience. USPTO wrote that "there is a reasonable likelihood that petitioner [Innoscience] would prevail with respect to at least one of the claims challenged in the petition."

In these recent rulings regarding EPC's lawsuits against Innoscience, three judges from the USPTO have initially agreed with Innoscience that the EPC patents that it challenged at the USPTO are invalid. In at least one case, Innoscience argued to the USPTO that the challenged EPC patent was invalid, based on a prior patent of an EPC cofounder/inventor when he was at International Rectifier and, on a preliminary basis, according to the institution decision, the USPTO agreed with Innoscience. In both proceedings at the USPTO, Innoscience has described multiple reasons why the two EPC patents are invalid and, for virtually every argument on invalidity, the USPTO initially agreed. Next, the USPTO will receive additional briefing and make a final determination by 20 March 2025.

In May 2023, EPC initiated legal proceedings against Innoscience in the US International Trade Commission (ITC) in Washington DC, alleging infringement of four EPC patents by certain Innoscience GaN devices. In response, Innoscience denied EPC's allegations of infringement as well as the validity of the EPC patents. Innoscience initiated defenses on multiple fronts, including the filing of inter partes review (IPR) petitions in the USPTO, challenging the validity of all of the asserted patents. During the ITC investigation, EPC withdrew two of its four original patents. The ITC also held a hearing on these two remaining patents in February/March, and the ITC will issue initial determination by 3 June, with a final determination due by 3 October, which may be subject to extensions of time.

Innoscience says that it is confident that it will achieve an eventual full victory in the dispute with EPC. It adds that the USPTO decisions further demonstrate that EPC's accusations against Innoscience lack merit, given that the USPTO has now determined, at least initially, that the last two EPC patents asserted by EPC are likely invalid.

www.innoscience.com

EPC Space launches rad-hard GaN gate driver IC

EPC Space LLC of Haverhill, MA, USA has launched the EPC7009L16SH, a radiation-hardened gallium nitride gate driver integrated circuit (IC) built on EPC's proprietary eGaN IC technology.

The EPC7009L16SH is suitable for power management where size, efficiency and simple design are critical. It integrates input logic interface, under-voltage lockout (UVLO) protection, a 10V-to-5.25V linear regulator and driver circuit within a space-efficient, hermetic 16-pin SMT package to create a high-speed driver that can switch at rates of up to 3.0MHz. The total ionizing dose is guaranteed to 1000kRad and the SEE (single event effect) immunity for LET (linear energy transfer) at 84MeV/mg/cm^2 with the IC's primary supply voltage at 100% of its maximum operating value.

EPC Space says that eGaN transistors are becoming the transistor of choice in space for applications where higher switching frequency, power and radiation hardness are required. With the launch of the EPC7009L16SH driver the full potential of eGaN HEMTs is unleashed, which is not possible with existing silicon-based drivers, the firm claims. Moreover, EPC7009L16SH can drive at least four EPC Space discrete GaN devices.

IC products make it easy for designers to take advantage of the significant performance improvements enabled by GaN technology, says EPC Space. Integrated devices in a single chip are easier to implement, easier to layout, easier to assemble, save space on the PCB, and increase efficiency, it adds.

"Integrated rad-hard GaN-on-silicon offers higher performance in a smaller footprint, while meeting all radiation hardness requirements for space applications" says chief technology officer Max Zafrani.

The EPC7009L16SH is part of a new family of space-level rad-hard ICs that EPC and EPC Space are launching, starting this year. Rad-hard ICs are the next significant stage in the evolution of rad-hard GaN power conversion, from integrating discrete devices to more complex solutions that offer in-circuit performance beyond the capabilities of silicon solutions and enhance the ease of design for power systems engineers.

Applications for the EPC7009L16SH include high-speed DC–DC conversion, motor drivers, power switches/actuators, and satellite electrical systems.

www.epc.space

ASU assistant professor Houqiang Fu receives US National Science Foundation CAREER Award

Fu to develop AlN-based FETs to improve power electronics

Houqiang Fu, an assistant professor of electrical engineering in Arizona State University's Ira A. Fulton Schools of Engineering, has received a 2024 National Science Foundation (NSF) Faculty Early Career Development Program (CAREER) Award to explore the potential of the ultrawide-bandgap semiconductor material aluminum nitride (AlN) for enhanced power electronics.

Fu aims to develop AlN-based power field-effect transistors (FETs) that control power flow with greater efficiency and can handle higher temperatures and more voltage than those made with silicon. AlN is also expected to perform better in power electronics than wide-bandgap semiconductor materials such as silicon carbide and gallium nitride.

"Aluminum nitride power electronics can offer superior performance and significantly impact grid modernization, transportation electrification and greenhouse-gas emissions," Fu says. "The electronics will also dramatically increase the current grid infrastructure's resilience, reliability and efficiency. They will also help mitigate power disruptions' health and economic impact and improve energy security." He adds that, due to the material's ability to better conduct electricity, aluminum nitride can eventually lead to lower electricity costs for consumers and accelerate grid integration of renewable energy sources such as solar and wind power.

Houqiang Fu.

Beyond applications in the power grid, AlN devices can increase the range of electric vehicles on a single charge. With 53% of consumers surveyed by the American Automobile Association citing worries about range as a primary concern discouraging them from adopting electric vehicles, Fu expects that improving range will improve uptake among consumers.

Developing a blueprint for future power electronics

While aluminum nitride has promising properties, a lack of knowledge regarding how to effectively use the material for power electronics prohibits it from reaching its full capabilities.

To better understand how to build power electronics using AlN, Fu will lead a five-year investigation to determine how best to overcome the main problems facing use of the material.

The research, much of which will take place in the semiconductor-focused portions of ASU Core Research Facilities, will focus on how best to grow the crystals needed for manufacturing AlN, refine it, fabricate it into power electronic devices and integrate the devices into electrical systems.

While Fu will serve as the sole faculty member involved in the project, he will have two doctoral students assisting him, as well as master's and undergraduate students through programs such as ASU's Master's Opportunity for Research in Engineering (MORE), the TSMC AZ Fellowship and Fulton Undergraduate Research Initiative (FURI).

"For those who are interested in a career in the microelectronics industry, this research area can equip them with interdisciplinary skills that are highly sought after in the semiconductor field, such as nanofabrication, material characterization, semiconductor device physics, material growth and more," Fu says.

https://engineering.asu.edu

Avnet to distribute EPC Space's rad-hard power devices

Avnet to service high-reliability and aerospace applications

EPC Space LLC of Haverhill, MA, USA says that Avnet has agreed to be a global distributor for its line of radiation-hardened (rad-hard) gallium nitride (GaN) power devices qualified for satellite and high-reliability applications.

EPC Space offers a family of rad-hard power GaN devices including discrete transistors, integrated circuits (ICs) and modules that are said to offer significant performance advantages over competing silicon-based space-level power devices. The firm's GaN devices are smaller, have lower resistance, and have superior switching performance compared with silicon-based components and solutions, it adds.

Critical space-borne applications that benefit from the performance improvements that EPC Space devices offer include satellite's DC–DC converters, reaction and momentum wheels, solar array drive assembly, and micro-pumps for propulsion systems.

"Partnering with Avnet, a global leader in distribution solutions, allows EPC Space to offer timely and reliable service to customers seeking high-reliability GaN power solutions," says CEO Bel Lazar.

www.epc.space

www.avnet.com

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South Korea's RFHIC invests in epiwafer supplier SweGaN

Firms to focus on joint R&D and new product development

SweGaN AB of Linköping, Sweden has entered a strategic partnership with South Korea-based RFHIC Corp, which designs and manufactures GaN RF & microwave high-power semiconductor components and hybrid modules for applications in wireless communications, defense & aerospace, and RF Energy (industrial, scientific & medical). The new agreement encompasses an undisclosed equity investment from RFHIC. The two companies will focus on joint R&D and new product development.

Over the last decade, SweGaN has been developing and producing custom, engineered gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers (based on its unique QuanFINE growth technology) for RF and power devices in applications such as 5G telecoms infrastructure, defense radars, satellite communications, on-board chargers and data centers.

SweGaN says that, in partnership with RFHIC, it gains additional resources to expedite market penetration and to achieve its business goals. "With the accelerating demand for high-performance semiconductor materials to power a multitude of applications and increase the efficiency in an energy-conscious world, the new equity investment will support SweGaN's capacity expansion plan of its best-in-class GaN-on-SiC epitaxial wafers and tap joint product developments with RFHIC," says CEO & founder Jr-Tai Chen.

RFHIC cites the partnership with SweGaN and investment strategy that targets strengthening RFHIC's gallium nitride supply chain and further fortifying the competitiveness of its RF and microwave products within the compound semiconductor arena.

SweGaN says that, as market requirements for high-power, highly efficient semiconductors are spurred by the rapid growth of a wide array of applications such as 5G communications, defense radars and data centers, it is moving to address the growing demand by expanding its in-house manufacturing capacity and R&D capability.

The new strategic partnership with RFHIC has the potential to invigorate its position in key geographical areas as it aims to lead a transition from legacy material solutions to its GaN semiconductors.

"As RFHIC maps its future strategy for GaN semiconductors including accelerated market demand for products in 5G, 6G, satellite communication and more, SweGaN's high-performance 6-inch GaN epiwafers for RF and power semiconductors — with exemplary high power efficiency — provide a strong fit for our technological roadmap and diversification of gallium nitride epitaxial wafer suppliers," comments RFHIC's chief technology officer & co-founder Dr Samuel Cho. "SweGaN's unique epitaxial wafer development and manufacturing technology is a key factor in the high performance of gallium nitride semiconductors that we can tap in developing new products in the 4GHz ultra-high-frequency band increasingly sought after by the market."

www.rfhic.com
www.swegan.se

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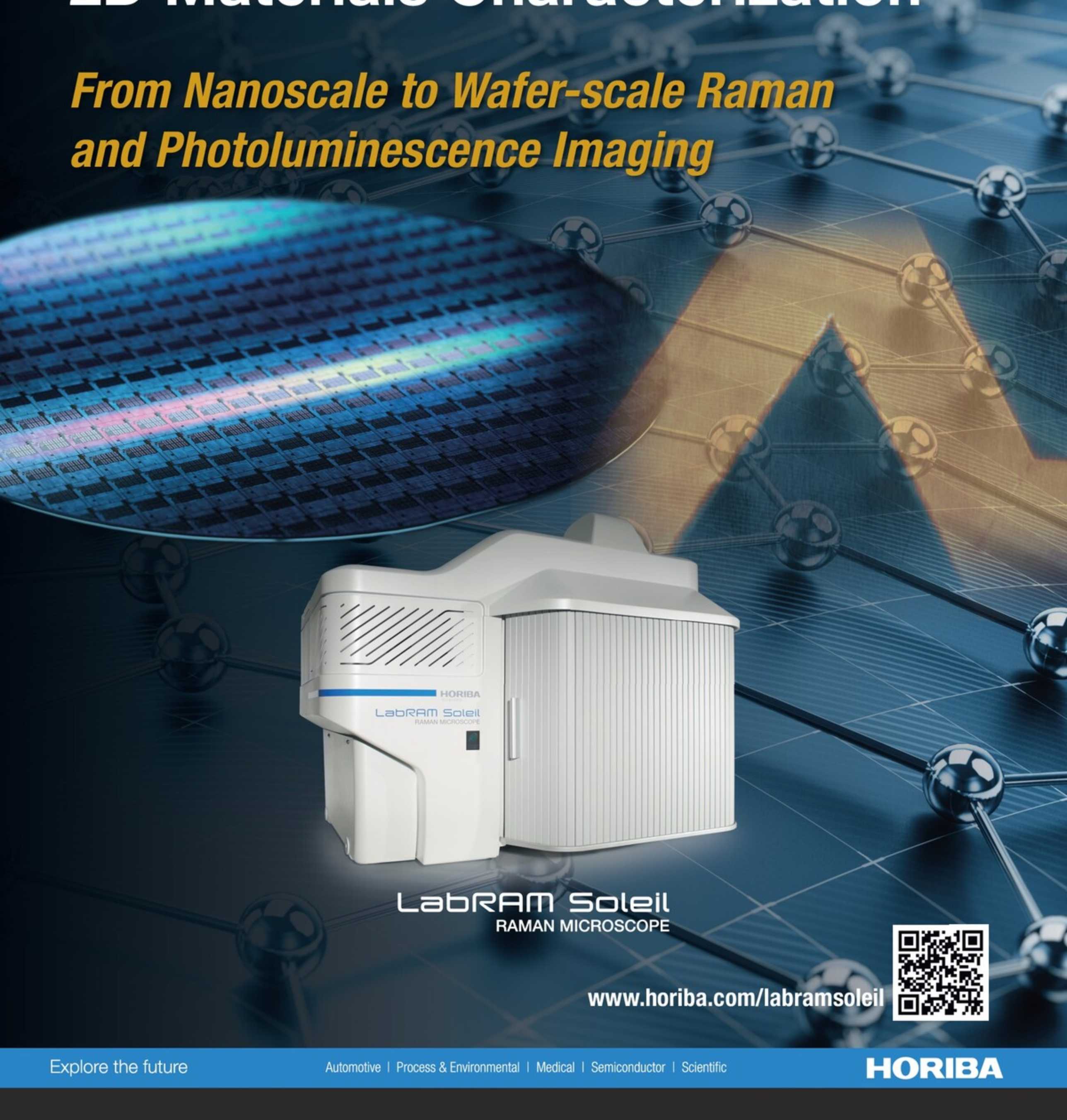

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www.horiba.com/labramsoleil

Coherent secures $15m in CHIPS funds via CLAWS Hub

Funding to accelerate commercialization of wide- and ultrawide-bandgap semiconductors, including SiC and single-crystal diamond

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA has secured $15m in funding from the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 that provided the US Department of Defense (DoD) with $2bn to strengthen and revitalize the US semiconductor supply chain.

A key objectives of the CHIPS program is to nurture ecosystems that reduce risk, incentivizing large-scale private investment in production, breakthrough technologies, and workers. The DoD, through the Naval Surface Warfare Center Crane Division and the National Security Technology Accelerator, hence established eight Microelectronics Commons regional innovation hubs in September, including the Commercial Leap Ahead for Wide-Bandgap Semiconductors (CLAWS) Hub based in North Carolina and led by NC State University. As a member of the CLAWS Hub, Coherent will receive $15m to accelerate the commercialization of next-generation wide- and ultrawide-bandgap semiconductors, namely silicon carbide and single-crystal diamond, respectively.

"Wide- and ultrawide-bandgap semiconductors enable the electrification of transportation, including road vehicles, high-speed trains, and mobile industrial machinery," notes Sohail Khan, executive VP, Wide-Bandgap Electronics. "They also enable smart power grids to efficiently respond to fluctuations in energy demands by regulating the delivery of electricity from conventional and renewable sources to distribution networks, as well as to and from utility-scale power storage and micro-grids."

In addition to DoD requirements for high-voltage, high-power applications and systems including hybrid electric vehicles (HEVs), More Electric Aircraft (MEA) components, directed energy, Navy vessel power systems, and all-electric ships, silicon carbide power electronics are increasingly recognized for their potential to greatly improve the energy efficiency of artificial intelligence (AI) data centers and traditional hyperscale data centers, where power consumption is growing rapidly due to the exploding demand for data- and compute-intensive workloads from AI, cryptocurrency mining, and blockchain applications.

Single-crystal diamond promises to exceed the performance of silicon carbide and greatly expand the applications universe with quantum computing, quantum encryption, and quantum sensing.

www.coherent.com

Axcelis ships Purion EXE SiC implanter to new power device customer in Japan

Purion H200 SiC system to join 200mm Purion EXE SiC at existing customer after successful evaluation

Ion implantation system maker Axcelis Technologies Inc of Beverly, MA, USA has shipped a Purion EXE SiC high-energy implanter as well as a successful Purion H200 SiC medium-energy implanter evaluation closure at power device chipmakers in Japan. The systems will be used for 150mm and 200mm production of silicon carbide power devices supporting automotive, industrial, energy and other power-intensive applications.

"The successful evaluation closure of the 200mm Purion H200 SiC system enables it to join an existing 200mm Purion EXE SiC in production at a leading power device customer in Japan," says Dr Greg Redinbo, executive VP, marketing & applications. "The shipment of an additional Purion EXE SiC to a new 150mm customer in Japan highlights growing customer requirements for even higher-energy ion implant recipes on advanced SiC power devices, which the Purion Power Series provides," he adds.

The shipment of an additional Purion EXE SiC to a new 150mm customer in Japan highlights growing customer requirements for even higher-energy ion implant recipes on advanced SiC power devices

"We look forward to supporting our growing installed base in Japan and remain focused on expanding our market share by providing customers with the most innovative implant technology and support solutions," says president & CEO Russell Low. "The Purion Power Series is the market leader due to its highly differentiated features and process control capabilities that are enabling for power device applications," he claims. "Axcelis is the only ion implant company that can deliver complete recipe coverage for all power device applications."

www.axcelis.com

Aehr quarterly revenue halves due to short-term SiC-related order push-outs following EV market slowdown

Revenue to rebound this quarter; full-year to match or exceed prior year

For its fiscal third-quarter 2024 (to end-February), semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has reported revenue of $7.56m, more than halving from $17.2m a year ago and $21.4m last quarter. The drop reflects delays in wafer-level burn-in system orders for silicon carbide (SiC) devices used in electric vehicles that have created a short-term gap in revenue and profitability.

GAAP net loss was $1.47m ($0.05 per diluted share), compared with net income of $4.15m ($0.14 per diluted share) a year ago and $6.1m ($0.20 per diluted share) last quarter. However, this was slightly better than the guidance of a net loss of $1.5–1.8m ($0.05–0.06 per diluted share) given on 25 March.

During the quarter, cash and cash equivalents fell from $50.5m to $47.6m.

For fiscal fourth-quarter 2024 (to end-May), Aehr expects revenue to rebound, more than doubling quarter-to-quarter to at least $15.4m. Hence full-year fiscal 2024 revenue should be at least $65m (near or above record annual revenue), albeit down from the revised guidance of $75–85m given in early January and the initial guidance of over $100m given in mid-July 2023, before the order push-outs seen since late calendar 2023. The firm expects net income of $11m ($0.38 per diluted share), down from the initial guidance of $28m.

Order bookings for fiscal Q3/2024 were $24.5m, rebounding from just $2.2m last quarter (albeit still down on $33m a year ago). Order backlog has hence recovered from just $3m to $20m at the end of the quarter (still down on $31. 6m a year ago).

"Last week we announced an initial order for our FOX-NP solution from a new customer that is a multi-billion-dollar per year global semiconductor company, and is entering the SiC market to address several applications that include automotive, industrial and electrification infrastructure. This is our third straight new customer for SiC that is primarily focused on applications other than EVs, expanding our opportunity within SiC beyond electric vehicles," says president & CEO Gayn Erickson.

"We are still in continued engagements up to and including on-wafer evaluations with well over a dozen SiC suppliers that are focusing on both EV and other applications and are forecasting production needs for wafer-level test & burn-in of their devices with decision timelines that spread out over the next year. We are focused on the qualification process with as many new customers as possible, as once we have demonstrated our FOX wafer-level test & burn-in solution using their own wafers, we have not yet lost a potential customer," he adds.

"Our discussions with customers indicate that the key markets Aehr is addressing for semiconductor wafer-level test & burn-in have significant growth opportunities that will expand this year and throughout this decade, and we are seeing increased customer engagement in each of these markets. We have also seen a recent strengthening in the silicon carbide market for EVs outside the US in what appears to be a shift in the market share of EV suppliers. This includes Asia where we recently had extensive and very productive and positive visits with a significant number of silicon carbide suppliers and electric vehicle suppliers," Erickson continues.

"According to many market forecasts, including the Semiconductor Industry Association, the semiconductor industry is expected to grow from $600m in 2022 to over $1tr at or around 2030. This acceleration is coming from mega-market drivers including artificial intelligence (AI), green energy and decarbonization, and IoT-based digital transformation. Increased reliability concerns about semiconductors, a growing number of mission-critical applications, and more multi-chip modules or heterogeneous integration with multiple devices being assembled in a single package are driving the need for wafer-level burn-in. At semiconductor industry conferences around the world, we are seeing an increased focus on test & burn-in moving to wafer level before these devices are put into multi-chip packages and modules."

These favorable macro trends are driving the business that drives Aehr Test and include:

- silicon carbide power devices going into high-density modules for power conversion in EVs;
- gallium nitride power semiconductors going into automotive, solar, and other mission-critical industrial applications;
- silicon photonics integrated circuits being put into transceivers for data-center infrastructure and optical chip-to-chip communication of CPU, GPU, and AI processors;
- memory devices for solid-state disk drives used in enterprise and data storage or for AI processors.

"Our continued investments in the FOX platform like the new 3.5kW per wafer FOX-XP multi-wafer production system we began shipping last month also position us well to address the requirements of other new market segments that we believe we will be able to discuss over the next several months," says Erickson.

"As we head toward fiscal 2025, we are encouraged by our increasing engagements with current and potential customers and the long-term growth opportunities of all these markets," concludes Erickson.

www.aehr.com

CSA Catapult in South Wales officially opens advanced packaging facility

New facility is part of Driving the Electric Revolution Industrialisation Centre (DER-IC) South West and Wales

A new £1.6m facility to help accelerate electrification across the UK has officially been opened at the Compound Semiconductor Applications (CSA) Catapult in Newport, South Wales.

Claimed to be the first of its kind in an open-access setting in the UK, the facility's equipment will be used by businesses to improve the performance of their semiconductor and compound semiconductor advanced packaging technologies.

As part of the Driving the Electric Revolution Industrialisation Centre (DER-IC) South West and Wales, the new advanced packaging facility was opened by the Secretary of State for Wales, David TC Davies, at an event attended by industry, academia and government.

DER-IC South West and Wales is part of the UK-wide DER-IC network (established in 2020), which is led by Newcastle University and has four regional centers across the UK (in the North East, the Midlands, the South West and Wales, and Scotland) and offers open-access equipment, facilities and expertise to the power electronics, machines and drives (PEMD) manufacturing supply chain. PEMD comprises underpinning technologies that support electrification and will, in turn, enable net zero and boost the UK economy, it is reckoned.

The new DER-IC South West and Wales facility can be used by manufacturers as a prototype facility for developing semiconductor and compound semiconductor advanced packages using novel 3D printing techniques and materials.

The new 3D printing equipment is the UK's first in an open-access setting. The equipment enables the integration of combination, mixed metal and ceramic printing technologies for chip packages, heat sinks and printed circuit board

(PCB) designs. The equipment includes:

- a multi-material 3D printer that can quickly prototype novel packages using ceramic and mixed material for higher-power and performance packaging;
- a 3D metal printer that can create fast prototypes for embedded packages and modules using copper or other conductive materials;
- an optimized laser system that can dice semiconductors and process ceramic or metal materials for novel package designs.

"The UK Government is proud to support the compound semiconductor cluster in South Wales, which is vital to our ambition for the UK to lead the world in science and technology," said Secretary of States for Wales, David TC Davies at the official opening. "The processes being developed here means that the supply chain within the UK is strengthened, helping to protect the industry and fostering job creation," he added.

"The opportunities this center presents to the PEMD manufacturing supply chain are significant. We're inviting anyone in the PEMD supply chain who is interested in innovation and technology development, manufacturing scale-up and commercialization, as well as skills and workforce development to engage with us," says DER-IC South West and Wales centre lead, Paul Jarvie. "The new DER-IC facility, installed using the funding from the DER Challenge, allows industry to explore what materials it can use to create packaging that allows chips to reach their full potential within electric cars, trains, boats and other modes of transport. Our facilities can support manufacturers to de-risk innovation and attract investment in this area. We can help develop lighter, more energy-efficient components, which can handle more power, are less expensive, and can offer better overall thermal performance," he adds.

"CSA Catapult has significant expertise in advanced packaging, and the addition of this facility will strengthen our offering to UK businesses, helping them to de-risk, improve their technologies and bring their products to market quicker," says CSA Catapult's CEO Martin McHugh. "This new facility is another example of the UK government investing in areas in which it has significant strength, with compound semiconductors and advanced packaging highlighted as key strategic areas that will boost the UK economy and establish ourselves as a world leader in these fields," he adds.

"As key funders of both the CSA Catapult and DER-IC, Innovate UK is delighted to see the opening of the DER Lab in South Wales, a first in the UK. It shows the impact that different areas of the Innovate UK system coming together can have,"

says Mike Biddle, executive director for net zero at Innovate UK. "It's another example of how we are investing in cutting-edge capability in Wales to meet the needs of businesses across the UK, and against the commitments we have made in our collaborative innovation plan for Wales. The Lab is a cutting-edge resource for industry to de-risk innovation and strengthen the supply chain – this will be an invaluable facility for the semiconductor sector and the diverse PEMD community."

The center has already attracted significant interest from major industrial partners across the aerospace and transport sectors. Dycotec Materials aims to develop a 3D printing process to improve performance, reliability and significantly reduce the cost of packages and modules for automotive applications.

Meanwhile, CSA Catapult and Carbon Forest Products are involved in a project to create a 3D graphite heat sink for use in automotive systems.

www.csa.catapult.org.uk

CSA Catapult issues annual report for 2022–23

Progress highlighted in focus areas of Net Zero and Future Telecoms

Compound Semiconductor Applications (CSA) Catapult has issued its annual report for the financial year 2022–23, highlighting progress in its two focus areas — Net Zero and Future Telecoms — and describing how it has helped industry to bring next-generation compound semiconductor technologies to market.

Established in 2018 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a centre of excellence with equipment that specializes in the measurement, characterization, integration and validation of compound semiconductor technology across four areas: power electronics, advanced packaging, radio frequency (RF) and microwave, and photonics. As a not-for-profit organization, it is focused on accelerating the adoption of compound semiconductors. It works across the UK in a range of industry sectors, from automotive to medical, and from digital communications to aerospace.

A significant milestone in financial year 2022–23 was regional expansion to support clusters of compound semiconductor excellence across the UK. With the support of Innovate UK, CSA Catapult opened a Future Telecoms Hub in Bristol and offices in the North East of England and Scotland.

The report highlights the significant impact that the Catapult has had on SMEs in the financial year. New data shows that, on average, since engaging with the Catapult, companies leveraged annual private investment of £85m and secured £26.5m of annual public sector investment. This was compared to a counterfactual group who, on average, raised £46m annually from the private sector and relied on £10m of public sector investments.

A survey of CSA Catapult customers also revealed that 100% would work with it again and 89% would not have been able to progress with their product development if they hadn't worked with the Catapult.

CSA Catapult has won £18.6m worth of collaborative R&D projects to date and has been involved in more than 200 industrial collaborations. It has also been involved in more than 50 academic collaborations and created 10 international partnerships. A total of 2827 jobs have been created or safeguarded within organizations that have worked with CSA Catapult to date.

The report also highlights the initiation of a strategic partnership with Siemens, the first of a kind for both companies in the UK, to accelerate the development of leading-edge power electronics capability.

In the financial year, the Catapult also signed a memorandum of understanding (MoU) with Cardiff University, which was announced shortly after a landmark in which AI was proven to be extremely effective at designing and modelling power electronic converters.

In partnership with UK Electronic Skills Foundation (UKESF), CSA Catapult secured an Innovate UK-funded skills program, 'Spark their Imagination; power their future' for schools and colleges in Wales which will roll out in 2024.

CSA Catapult was also recognised as a 'Great Place to Work' for the second year in row and cemented its continuous commitment to ED&I (equality, diversity and inclusion) by signing the cross-Catapult ED&I Charter in March 2022.

"Our story this year is one of expansion to underpin the growing success of the UK compound semiconductor sector and build for its promising future, with support and collaboration from government, industry and academia," says CSA Catapult's CEO Martin McHugh. "We have continued to deliver at pace against our four strategic areas: our technology centre of excellence, developing supply chains and skills, supporting UK clusters, and growing our own commercial income," he adds. "As we continue to work towards the UK becoming a global leader in developing and commercializing new applications for compound semiconductors, I must acknowledge the continued passion and commitment of everyone at CSA Catapult and look forward to more success in the future."

https://csa.catapult.org.uk/wp-content/uploads/2024/04/Catapult-AR-22-23-FINAL.pdf

UK's CSA Catapult and Sarawak's SMD sign MoU

Collaborations targeted at chip design and manufacturing for automotive and space industries

Compound Semiconductor Applications (CSA) Catapult in Newport, South Wales, UK and Malaysia-based SMD Semiconductor Sdn Bhd (a wholly owned entity of the Sarawak Government founded in September 2022 under the Sarawak Research and Development Council Ordinance 2017) have signed a memorandum of understanding (MoU) that lays the foundation to work together in the design, prototyping and manufacturing of next-generation semiconductor and compound semiconductor chips in the automotive and space industries.

SMD focuses on advanced technology R&D, with an emphasis on chip design and the development of integrated circuit products.

Established in 2018 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a centre of excellence that specializes in the measurement, characterization, integration and validation of compound semiconductor technology across four areas: power electronics, advanced packaging, radio frequency (RF) and microwave, and photonics.

As a not-for-profit organization, it is focused on accelerating the adoption of compound semiconductors. It works across the UK in a range of industry sectors, from automotive to medical, and from digital communications to aerospace.

The MoU also signals SMD's intent to establish an office in the UK to enable the co-creation of ideas and product development while also working with academia, industry and government in the UK and Sarawak to develop a pipeline of talent.

The MoU was exchanged during the AI and Semiconductor Summit held in the UK House of Commons and attended by members of the Sarawak government, UK and Welsh governments, SMD and CSA Catapult. The event was hosted by Stephen Metcalfe MP in collaboration with the All-Party Parliamentary Group on Artificial Intelligence and Big Innovation Centre Ltd (a London-based think-tank and technology consultancy, appointed by the UK Parliament to serve as the Secretariat for the All-Party Parliamentary Group on Artificial Intelligence).

A keynote address was given by Saqib Bhatti MP, Minister for Tech and the Digital Economy. Representatives from the UK and Sarawak discussed opportunities in areas of mutual strategic importance and ways to encourage future collaborations in the development of next-generation semiconductor technology.

The partnership will "allow us to explore new opportunities to develop next-generation technology for critical industries such as automotive and space," says CSA Catapult's CEO Martin McHugh. "The partnership will allow us to call on each other's strengths in the design, prototyping and manufacturing of semiconductor and compound semiconductor technologies to enable new concepts, ideas and products. The MoU also represents a significant landmark for both the UK and Sarawak. By entering into agreements such as this, we are championing international partnerships and helping the UK increase its cooperation with close partners to help build resilience in our supply chains," he adds.

SMD is recognising the potential of compound semiconductor technology and investing heavily in its development and commercialization, says CEO Shariman Jamil. "By harnessing the unique properties of compound semiconductors, we aim to unlock new frontiers in performance, efficiency and functionality across a wide range of applications. SMD is doubling down on its investment in compound semiconductor technology, recognizing its potential to drive innovation, accelerate growth, and create lasting value for our customers and stakeholders," he adds.

"Semiconductors and chips are the hardware driving force of our time. They can unlock AI possibilities and spearhead smart infrastructure development to tackle our productivity and sustainability challenges head-on," notes Big Innovation Centre's CEO professor Birgitte Andersen. "From revolutionizing energy optimization to reshaping our interaction with the environment and each other, semiconductors play a pivotal role. Yet, realising their complete potential demands relentless research and development, and global collaboration," she adds.

"Semiconductors are the backbone of our economy, underpinning our national security and driving advancements in technologies of the future," notes Saqib Bhatti, Minister for Tech and the Digital Economy. "This partnership between CSA Catapult and SMD Semiconductor will catalyse the development of cutting-edge semiconductors, which are essential for our automotive and space industries. As a result, it will not only help fortify our supply of this critical technology, but also drive innovation and economic growth in both of our nations."

www.smdsemiconductor.com
https://csa.catapult.org.uk

UK funding of £14m for open-access power semiconductor test & packaging equipment

UK Semiconductor Strategy via Innovate UK targets net-zero applications in EVs and manufacturing equipment

The UK Government has announced a £16.6m investment to give semiconductor researchers and businesses access to new equipment helping them to test and make chips for use in high-energy machines such as electric vehicles and manufacturing equipment. Of the funding, £14m is targeted particularly at semiconductors used in power electronics.

The new tools, based predominantly in Newcastle and Strathclyde, will help researchers and businesses of all sizes to test applications of new innovations in power electronics and to improve their semiconductor packaging processes.

Made through Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), the investment comes as part of the UK's Semiconductor Strategy, which identified new ways of packaging and testing chips as a key area to drive performance improvements in semiconductors.

Innovations in advanced packaging can help to reduce the power needed to run semiconductors by improving their performance in demanding applications — such as data centers and gaming — while also making sure that chips can cool down more effectively in hot environments, such as manufacturing.

"New innovations in the way we package up semiconductors have the potential to transform whole industries and vastly improve consumer devices, all while driving long-term economic growth," says the UK Government's Technology Minister Saqib Bhatti. "This investment in open-access technology will make sure British researchers have the tools they need to rapidly turn semiconductor science into business reality, all while making hugely energy-intensive sectors more sustainable," he adds.

"The open-access tools will cover a range of processes involved with designing and testing these semiconductors, including slicing silicon wafers into smaller chips and bonding complex materials together to make chips. Funding will also be used to help manufacturers improve the technology used to automate assembly processes, as well as helping build and test drives, which are pivotal in the conversion of energy into motion in electric vehicles, manufacturing equipment and more."

"Innovate UK's investment into supply chains for Power Electronics, Machines and Drives (PEMD) shows the importance of these technologies to the UK economy and the global race to net-zero," says Mike Biddle, executive director Net Zero at Innovate UK. "It is exciting to see the breadth of activity in semiconductor packaging as well as electric machine validation and manufacturing," he adds. "The majority of this investment is strategically aligned with the National Semiconductor Strategy and helps grow the high-value post-wafer capabilities within the UK."

The new funding will help enable and de-risk the scale-up challenge for United Kingdom packaging companies and allow semiconductors to reach their full potential in applications ranging from electric vehicles and renewable energy to manufacturing and data centers

The funding will build on an existing network of machinery open to researchers and businesses across the UK through Driving the Electric Revolution Industrial Centres (DER-IC), originally backed by £33m of funding in 2019. DER-IC has previously partnered with the likes of McLaren Applied to test and develop new ways of manufacturing an electric drive train for use by companies producing automotives and aeroplanes to bring innovative and more efficient electric products to market faster.

"This funding will allow us to help industry invest further in the technologies of Power Electronics, Machines and Drives manufacture," notes professor Matt Boyle OBE, executive chair of DER-IC. "Industry has already invested heavily in these electrification manufacturing technologies since the start of the challenge. This additional equipment is being deployed to areas, capability and sectors where industry has stated that it will grow the UK supply chains for PEMD," he adds.

"This new funding will help us further improve our offering to the PEMD industry and develop innovative new technologies to drive us towards net-zero," comments Paul Jarvie, centre lead for the DER-IC for the South West and Wales and business development manager at CSA Catapult. "The new funding will help enable and de-risk the scale-up challenge for UK packaging companies and allow semiconductors to reach their full potential in applications ranging from electric vehicles and renewable energy to manufacturing and data centers."

www.der-ic.org.uk

www.mclarenapplied.com/solutions/escape-project

Rio Tinto awards Missouri S&T $875,000 to research recovering gallium and germanium from copper refining waste

Project to test new chemical dissolution strategies and purification techniques

A professor at Missouri University of Science and Technology (Missouri S&T) has been awarded $875,000 from global mining group Rio Tinto for a two-year project researching new techniques to recover critical minerals in the waste by-products that come from extracting and refining copper.

"Our project will test new chemical dissolution strategies and purification techniques to produce pure gallium and germanium compounds from these waste materials," says Dr Lana Alagha, a Robert H. Quenon Associate Professor of Mining Engineering. "The new chemicals, or functionalized ionic liquids, we will use were designed specifically for this type of purpose."

Alagha and one of her former Ph.D. students, Dr Mostafa Khodakarami, were recently awarded patents for these chemicals, which Alagha says will work well due to their ability to effectively separate specific components from the materials.

The US federal government considers both gallium and germanium to be critical minerals. The Energy Act of 2020 defines critical minerals as non-fuel minerals vital to the USA's economic or national security.

"There is currently little-to-no production of these two elements in the United States, and we rely to an alarming extent on importing them," Alagha notes. "If successfully implemented, our research could lead to a much stronger domestic supply of these important resources."

She says that recovering gallium and germanium from the wastes created when processing copper is an unconventional approach, but this type of out-of-the-box thinking is necessary for the USA to have a more resilient supply of critical minerals.

Dr Lana Alagha conducts research in a Missouri S&T mineral processing laboratory. (Photo by Michael Pierce/Missouri S&T.)

Both gallium and germanium are more often recovered as a by-product of other metal refining process, such as with aluminium, zinc and lead, but Alagha says it should be possible to recover both of the elements with the chemical compounds that she will develop to dissolve the waste products and with the new purification techniques she will test after that.

Alagha is a member of S&T's mining engineering faculty, but she is an expert in chemistry as well, having earned a Ph.D. in materials chemistry from the University of Texas at Dallas.

"Industry partnerships help bridge the gap between theoretical knowledge and practical application," says Alagha. "They help facilitate the transfer of knowledge, technologies and innovations from academia to industry and vice versa. Working with Rio Tinto will help take my research in this area to the next level," she adds.

"Rio Tinto is constantly looking for better ways to extract critical minerals from our by-product streams," says Dr Saskia Duyvesteyn, Rio Tinto's chief advisor of R&D. "After starting production of tellurium in 2022, we are excited to explore new techniques to produce gallium and germanium compounds in partnership with Dr Alagha and Missouri S&T. Demand for these critical minerals used in high-tech applications is only going to grow, and we are proud to support efforts to increase domestic production."

Alagha's co-principal investigators from Missouri S&T for the project are Dr Michael Moats, chair & professor of materials science and engineering, and Dr Marek Locmelis, associate professor of geosciences and geological and petroleum engineering at S&T and faculty fellow in research and innovation.

Alagha is also involved in other projects focusing on mineral recovery using unconventional sources. One of her projects, with over $700,000 in funding through the Critical Materials Innovation Hub led by Ames National Laboratory, also focuses on extracting gallium and germanium, while another $375,000 project funded by the National Renewable Energy Laboratory focuses on recovering tellurium, as well as gold and silver.

www.riotinto.com
www.mst.edu
www.ameslab.gov/cmi

US DOD awards 5N Plus $14.4m to enhance space-qualified germanium substrate supply

St. George, Utah facility to be upgraded and expanded over four years

The US Department of Defense has awarded $14.4m via the Defense Production Act Investment (DPAI) Program to specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada to sustain and expand the capability to produce space-qualified germanium substrates used in solar cells for both commercial and national security defense satellites. The effort supports the 2024 National Defense Industrial Strategy to continue and expand support for domestic production within the resilient supply chains strategic priority area.

"This effort will feed supply chains that support the space power ecosystem while also helping ensure the long-term business viability of the US defense industrial base for space-qualified germanium wafers," says Dr Laura Taylor-Kale, Assistant Secretary of Defense for Industrial Base Policy (ASD(IBP)).

Based on meeting certain conditions, over the next four years, the award will enable 5N+ to upgrade and expand manufacturing capabilities at its facility in St. George, Utah, while minimizing production variability. Additionally, the initiative will address process integration with solar cell producers' evolving germanium substrate requirements. The effort also includes improvements in germanium sourcing, recovery, and refining. Finally, it supports product diversification to ensure long-term merchant supplier business viability.

This is the latest of 13 awards made by the DPAI program across multiple areas totaling $322m since the beginning of fiscal year 2024. DPAI is overseen by the ASD(IBP)'s Manufacturing Capability Expansion and Investment Prioritization (MCEIP) Program, in the Office of the Deputy Assistant Secretary of Defense for Industrial Base Resilience.

www.5nplus.com
www.businessdefense.gov/ibr/mceip/index.html

Riber's annual revenue grows 41% to €39.3m, driven by systems revenue almost doubling

Full-year income rises from €0.2m to €3.4m

For full-year 2023, molecular beam epitaxy (MBE) system maker Riber S.A. of Bezons, France has reported revenue of €39.3m, up 41% on 2022's €27.8m.

Despite the unstable geopolitical context, Riber achieved its revenue target in 2023, due to significant growth in its MBE system sales.

MBE systems revenue was up 96% from €14.8m to €29m (13 machines delivered, up from just six in 2022).

Services & Accessories revenue fell by 21% from a high €13m (46.8% of revenue) in 2022 to €10.3m (26.2% of revenue) in 2023.

Riber says that the growth in its systems sales reflects its leadership on the MBE market, particularly in the production sector, illustrated by its high order intake in 2023, including seven production systems. Although the services & accessories business decreased, the company's performance shows significant progress, Riber reckons.

Also, Riber moved forward with its innovation efforts, including the launch of the MBE 8000 system, designed specially to meet requirements for the mass production of epiwafers.

Earnings

Gross margin as a proportion of revenue fell from 39.2% to 33.7%, but this was mainly due to the growth in revenue.

Operating income was €3.9m (10% of revenue) in 2023, versus 2022's break-even (which included €1.3m of non-current expenses).

Net income rose from just €0.2m in 2022 to €3.4m in 2023. The cash position hence improved during 2023 by €3.6m, from €6.1m to €9.7m.

During 2023, shareholders' equity rose by €2.4m to €21.2m, driven by the earnings and the distribution of amounts drawn against the issue premium for 2022 to shareholders.

Order book

During 2023, the order book fell by 12% from €29.9m to €26.3m (€20.2m for six MBE systems and €6.1m for Services & Accessories).

However, this does not include the robust new order intake seen since the start of 2024, with five systems ordered to date. These include a major order for three production systems in Asia (announced on 24 January) plus two other orders for research systems (announced on 5 and 20 March, respectively).

Outlook for 2024

Given its current orders and the opportunities that will open up for its systems and services & accessories, Riber expects further growth in revenues and earnings for 2024. The firm will provide a full-year revenue forecast at the end of first-half 2024.

Distribution of amounts drawn against 'issue premium' account

Illustrating its confidence in the firm's outlook, at the general meeting on 19 June the executive board will submit a proposal to shareholders to approve a cash payout based on reimbursing part of the issue premium for €0.07 per share (to be released for payment on 28 June).

Governance

As agreed with the supervisory board, the executive board also decided to propose the transformation of the company's governance structure at the General Meeting on 19 June. Subject to shareholder approval, the existing dual structure based on a supervisory board and executive board will be replaced by an organization with a board of directors.

Riber says that the proposed modification reflects its commitment to simplifying its operational decision-making processes and is in line with its new strategy to support its expansion in a buoyant market environment.

Implementation of share buy-back program

As agreed with Riber's supervisory board, the executive board has decided to implement a share buy-back program based on the authorization granted by the twelfth resolution of the shareholders' general meeting of 20 June 2023. The description of the share buy-back program are being published on 15 April before the stock market opens.

www.riber.com

AXT expects Q1/2024 revenue of $22.4–22.7m, exceeding $20–22m guidance

Growth driven by demand from AI/data-center connectivity, infrastructure, wireless devices, industrial lasers

AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — says that it expects to report revenue of $22.4–22.7m for first-quarter 2024, up from $19.4m a year ago and last quarter's $20.4m, and exceeding its prior guidance of $20–22m.

This reflects growth in demand for both InP and GaAs substrates for a variety of applications, including artificial intelligence/data-center connectivity, infrastructure, wireless devices, industrial lasers, and others.

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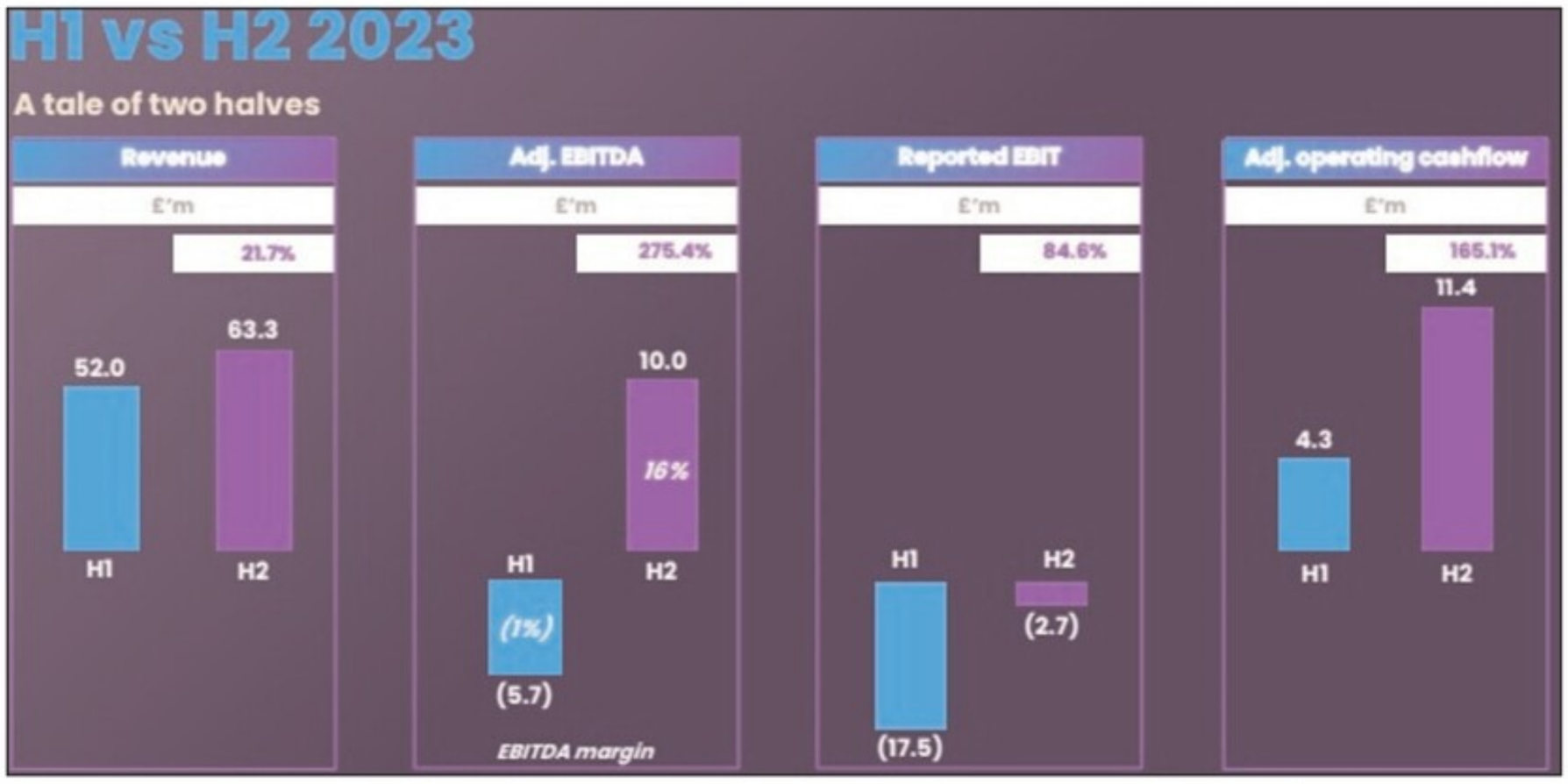
IQE's annual revenue falls 31.2% in 2023, impacted by excess inventory

Return to double-digit growth in H2/2023 a prelude to full-year recovery in 2024



For full-year 2023, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has reported revenue of £115.25m, down 31.2% on 2022's £167.5m.

The global semiconductor industry downturn presented a temporary but significant challenge to sales volumes in Q1–Q3/2023 prior to a gradual improvement in market dynamics and customer demand in Q4/2023 (contributing to second-half 2023 revenue of £63.3m returning to double-digit growth, up 21.7% on first-half 2023's £52m).

Photonics wafer revenue fell by 33.3% from 2022's £88.7m to £59.1m (51.3% of total wafer sales) in 2023. This was due mainly to a slowdown in Asian telecoms infrastructure programs as well as high inventory levels due to weak demand impacting 3D sensing for the handset market, offset partially by a resilient performance in infrared-related products for aerospace and security markets.

Wireless wafer revenue fell by 29.1% from 2022's £76m to £53.9m in 2023 (46.7% of total wafer sales). This was due to a decline in wireless gallium arsenide (GaAs) epiwafer sales (impacted by softness in the global smartphone handset market and build-up of inventory in supply chains) as well as weakness in gallium nitride (GaN) epiwafer sales for 5G infrastructure.

CMOS++ revenue fell by 18% from 2022's £2.8m to £2.3m (2% of total wafer sales) in 2023. This reflected elevated inventory levels caused by weak demand for consumer goods.

Due mainly to the semiconductor industry downturn and the associated reduction in customer sales volumes and revenue, adjusted operating loss rose from £3.6m in 2022 to £20.2m in 2023.

Photonics adjusted operating margin fell from 12.6% in 2022 to –16.9% in 2023, reflecting the significant under-utilization of manufacturing capacity.

Despite the declines in volume and revenue, Wireless adjusted operating margin rose from 6.2% in 2022 to 8.6% in 2023. This primarily reflects the reduction in manufacturing capacity and cost linked to the closure of the Singapore site in 2022, the cessation of manufacturing activities at the Pennsylvania site in 2023, and the positive impact of working capital actions that resulted in the consumption of old inventory and the cash collection of previously impaired trade receivables.

Due to the under-utilization of manufacturing capacity, adjusted EBITDA (earnings before interest, tax, depreciation and amortization) fell from 2022's £23.4m (14% margin) to £4.3m for 2023 (4% margin) on a reported basis. Positive EBITDA margin was maintained following decisive action to reduce costs, says IQE.

To mitigate the semiconductor industry downturn and reduction in customer volumes and revenues, IQE took "strategic actions to reshape our cost base as part of our ongoing commitment to improving margins and profitability," says CEO Americo Lemos. Cost-rationalization actions implemented during 2023 include:

- discretionary expenditure savings in areas including travel, marketing, legal and professional;
- the optimization of manufacturing asset utilization (including idling reactors to reduce cost and align capacity with lower customer volumes);
- a restructuring program and associated reduction in headcount (of more than 10%) and hence labour cost; closure of IQE's Pennsylvania molecular beam epitaxy (MBE) operation and consolidation into its North Carolina manufacturing facility (with customer qualifications now complete and production ramped) and the sale of excess tools; and
- continuing to work with key customers to optimize global footprint.

As part of the cost rationalization

and global footprint optimization plan, restructuring costs of £4.7m were incurred. Other significant infrequent costs incurred relate to the new starter bonus, payable over three years, for the CEO and severance and recruitment fees following the departure of the former chief financial officer.

Despite the decline in trading performance and profitability, reported net cash generated from operations rose from £8.9m in 2022 to £10.1m for 2023. This mainly reflects the strong working capital management, particularly in inventory and trade receivable management.

Cash capital expenditure on property, plant and equipment (PP&E) rose from £9.4m in 2022 to £12.2m in 2023 in order to support IQE's strategic diversification and growth strategy (including strategic investment in GaN capacity). This was focused mainly in Taiwan, Newport and Massachusetts to support future growth opportunities, intangible asset expenditure of £3.1m focused on a combination of intellectual property and IQE's multi-year strategic IT transformation program, and investment in targeted capitalized technology development of £2.8m.

Cash & equivalents have hence fallen from £11.6m to £5.6m.

During 2023, adjusted net debt was cut from £15.2m to £2.2m. This was after IQE took steps to strengthen its balance sheet including:

- an equity fundraise (completed on 18 May 2023) of £31.1m (£29.8m net);
- refinancing (on 16 May 2023) of HSBC Bank plc's £27.3m ($35m) multi-currency revolving credit facility, which has been extended to 1 May 2026 (with quarterly leverage and interest cover covenant tests applicable to the facility, commencing December 2023), with an undrawn balance of $30m (£23.4m) available at end-2023.

These steps, combined with cost rationalization and cash preservation actions, provide the necessary liquidity to navigate the semiconductor market downturn and allow IQE to continue investing in its growth and diversification strategy, reckons the firm.

"We made good progress against our diversification strategy following our investment into GaN capacity, with new customer design wins in the Power Electronics and Automotive sectors," says Lemos.

Strategic highlights

Specifically, IQE is making strategic progress to maintain and grow its position in the Connect and Sense markets alongside diversifying into higher-growth Power and Display markets:

Connect

- protected existing Wireless business while expanding the Connect customer base, engaging tier-1 OEMs in Asia serving the Android ecosystem;
- successful qualification of products for WiFi and 4G & 5G handset applications for emerging markets;
- launched new vertical-cavity surface-emitting laser (VCSEL) capability for high-speed optical interconnects used in artificial intelligence (AI) data-center applications.

Sense

- High-volume production ramp of new VCSEL for advanced 3D sensing applications with a tier-1 handset maker;
- successfully qualified second-generation VCSEL products with consumer smartphone leaders, developing new high-performance 3D sensors;
- expanded 3D sensing portfolio to include new longer-wavelength products for higher-performance imaging applications in handset and AR/VR platforms.

Power

- deployed GaN power capacity in the USA and UK to serve the global power electronics market utilizing proceeds from the placing in May 2023;
- expansion of diverse customer pipeline, consisting of market leaders across fabless, foundries and OEMs serving automotive and emerging data-center server power markets, with qualifications ongoing.

Display

- continued development of RGB micro-LED portfolio through engagement with multiple tier-1 display manufacturers;
- developed new disruptive 8-inch germanium-based platform for use as a red emitter in micro-LED displays;
- delivery of the first display-grade 8-inch GaAs- and silicon-based wafer products will commence in first-half 2024, complementing engagements with customers developing AR/VR format displays.

IQE says that it remains committed to executing its growth and diversification strategy as it builds on the good progress made in 2023 by expanding the customer pipeline and focusing on GaN power product qualification with tier-1 suppliers into automotive OEMs.

There are increasingly positive signs that the global semiconductor industry is recovering from what has been an unprecedented cyclical downturn in terms of both its extent and duration, notes IQE.

The firm saw recovery in second-half 2023, which has continued into Q1/2024, with inventory levels beginning to normalize and customer demand recovering. Trading during Q1 has been in line with expectations and the order book for the remainder of first-half 2024 is strengthening. "We expect to see this improvement continue through 2024, despite persisting uncertainties in the global economy," says IQE.

"Buoyed by the ongoing industry recovery, IQE is well positioned within the global value chain to deliver sustainable growth and capture opportunities in 2024 and beyond," reckons Lemos.

Full-year 2024 results are expected to be within the range of analyst forecasts of £133.7–153.7m for revenue and £11.1–16.6m for adjusted EBITDA.

Market dynamics and customer demand is expected to continue to improve, aligned with external market views, in 2024, ahead of a full market recovery by 2025.

www.iqep.com

IQE expands customer partnership with AWSC with multi-year supply agreement

GaAs wafers for smartphone power amplifiers to be used by China's Lansus for Android ecosystem

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has announced an expansion of its partnership with Taiwan-based compound semiconductor wafer foundry Advanced Wireless Semiconductor Company (AWSC) with a multi-year supply agreement.

As part of its strategic partnership, IQE will supply AWSC with gallium arsenide (GaAs) wafers for the manufacture of smartphone power amplifier devices to be supplied to its key customer Lansus, the Chinese RF technology supplier. This will supply tier-one China-based OEMs in the Android ecosystem, in a market that is expected to return to growth following a period of inventory build-up.

AWSC has been a partner of IQE for over 20 years. IQE says that the expansion of this previously announced agreement demonstrates the strength of the partnership and reflects its expertise in GaAs wafers for power amplifier products. This supports IQE's expectations for the coming year, while delivering on its strategy to defend its position in wireless markets. "IQE is expanding its wireless addressable market into the Android ecosystem," says the firm's CEO Americo Lemos.

www.awsc.com.tw
www.iqep.com

Keysight introduces next-gen RF circuit simulator

Keysight Technologies Inc of Santa Rosa, CA, USA has introduced RFPro Circuit, a next-generation radio frequency (RF) simulation tool targeting the complex, multi-physics requirements of RF integrated circuit (RFIC) designers. Wireless, automotive and satellite designers can now deliver robust designs that overcome performance challenges in dense 3D packaging, taking advantage of interoperability and automation to form complex workflows, says the firm.

The W5600E RFPro Circuit features a new modular architecture that ensures a consistent, streamlined environment for multi-physics co-design across Cadence, Synopsys and Keysight electronic design automation (EDA) platforms. Optional electro-magnetic (EM) and electro-thermal simulators also plug into this new environment, enabling faster design and troubleshooting of wireless RFICs.

Typically, RFIC designers perform sequential, single-domain verifications using expert tools, but have a difficult time identifying and troubleshooting multi-domain design issues until the end of the design process. Designers are often required to become domain experts, shouldering the overhead of setup and database manipulations for each tool. With the new RFPro Circuit simulator, these tools are more tightly integrated into highly automated and efficient workflows.

As well as EM and electro-thermal simulators, Keysight provides RF-aware analyses for stability, system-level modulation and waveforms, and simulator settings. For example, designers can optimize a sophisticated 5G-Advanced power amplifier for error vector magnitude (EVM) while loaded with EM package parasitics. As 3D designs become denser and move into new millimeter-wave frequencies, Keysight now offers a path to efficient design flows that are not only robust but reliable enough to be used for training future artificial intelligence and machine learning automation in leading-edge microwave applications.

RFPro Circuit features include:

- standard DC, AC, S-parameter, Harmonic Balance Transient, and Envelope Transient simulation modes;
- high-accuracy modulation analysis; Winslow stability analysis; optimization; and faster one-time netlist parsing;
- compatibility with Keysight's extensive catalog of silicon and III-V compound semiconductor foundry process development kits (PDK); advanced support for III-V processes, mixed hierarchies for 3D heterogeneous integration and packaging, and validation against system-level modulation.

Beyond RFPro Circuit's technical improvements, Keysight offers a flexible licensing model that gives RFIC designers greater simulation freedom and instant access to the latest features, in order to adapt to changing workflows on a daily basis. RFPro Circuit is available for immediate download for the Cadence Virtuoso and Synopsys Custom Compiler environments. The Keysight ADS environment is expected to be available in late 2024.

"On top of speed and robustness, we've built RFPro Circuit to be the EDA industry's most designer-centric RFIC simulation tool, striving for flexibility, application orientation, and context awareness between multi-physics, high-performance compute, and integration into the major vendor workflows," says Joe Civello, director of RF/μW Products, Keysight EDA. "Designers using RFPro Circuit can accelerate their engineering cycles and shift left more of their verification effort from physical into virtual prototyping where it's easier and less costly to fix problems."

www.keysight.com/us/en/products

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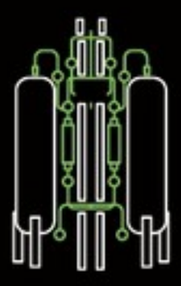

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Aixtron wins German Innovation Award

Deposition equipment maker first among 'large companies'

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has won the German Innovation Award.

Organized by WirtschaftsWoche, Accenture, EnBW, and O_2 Telefónica under the patronage of the Federal Ministry for Economic Affairs and Climate Action, the prize was handed over to the winners in the three categories — large companies, medium-sized companies and start-ups — at a ceremony in Munich. Aixtron came first among the large companies.

Since 2010, the German Innovation Award has been given to companies whose innovations and technologies ensure that Germany's competitiveness and significantly contribute to solving major global challenges.

"With our latest G10 product family, we are setting new productivity and performance standards in the semiconductor industry so that energy-efficient devices and sensors can be used more broadly in our daily lives, contributing to CO_2 emission reduction overall while enabling the digital society of tomorrow with even faster and broader data exchanges between individuals," said Aixtron's CEO & president Dr Felix Grawert, who received the award.

"This award is a testament to the excellent achievements Aixtron has realized in close collaboration with its customers — not only in terms of performance but in particular in terms of productivity and cost that opens up the widespread use of new applications," says Aixtron's VP Advanced Technologies professor Michael Heuken, who accepted the award together with Grawert. "The foundation for this is the excellent work of our colleagues in Aixtron worldwide — from simulation, the laboratory, and the engineering of new system components to sales and customer service."

www.german-innovation-award.de
www.aixtron.com

Aixtron receives Gold Supplier Award from BOE HC SemiTek

Honor awarded for outstanding collaboration on micro-LEDs

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has received the Gold Supplier Award from China-based chipmaker BOE HC SemiTek for their collaboration on micro-LED technology. The partnership spans more than 19 years, evolving since 2022 into a close collaboration focusing on 150mm gallium nitride (GaN) and arsenide-phosphide (AsP) materials for the development of micro-LED technologies.

BOE HC SemiTek operates multiple Aixtron GaN and GaAs (gallium arsenide) tools worldwide, specifically tailored for display LED applications and crucial in producing displays for OEM partners worldwide. Aixtron systems have been instrumental in accelerating the development of micro-LED products, which has led to multiple repeat orders for Aixtron's GaN and GaAs tools in preparation of a volume ramp of micro-LED products at BOE HC SemiTek.

Micro-LEDs are key for next-generation displays, from large displays to automotive applications or enhanced AR/VR. However, the complexity of micro-LED technology and the pressure for cost reduction demands end-to-end cooperation between suppliers and end-users, says Aixtron.

Aixtron says that its technology is engineered specifically to meet the stringent requirements. Solutions include an ultra-low-defect process and wafer-level binning control, all while maintaining a low cost of epitaxy per wafer, aided by highly efficient large-batch reactors and full automation.

"The collaboration with BOE HC SemiTek is very significant for us as a company and for the development of micro-LED technology in general. For more than five years, we have focused on further optimizing our solutions for micro-LED," says Aixtron's CEO & president Dr Felix Grawert. "Our gratitude extends to our dedicated technology teams at our headquarters, whose tireless efforts have fueled our success. Equally deserving of recognition is our exceptional team of Aixtron China, which translated all the latest developments into productivity and therefore cost gains for our partner BOE HC SemiTek," he adds.

"The Gold Supplier Award is given to companies who had a unique contribution towards the industry development while maintaining an exceptional day-to-day service response," notes BOE HC SemiTek's chairman Zhaohong Zhang.

"We are very grateful for our partnership with Aixtron as our teams have fostered a level of collaboration unmatched in the industry," he adds. "This teamwork has unlocked groundbreaking results that we initially thought impossible. Micro-LED technology demands a constant push of boundaries, and with Aixtron as a valued partner, we are confident in achieving our ambitious product goals."

www.hcsemitek.com

Vishay selects G10-SiC multi-wafer batch technology

Dual-wafer size 9x150mm/6x200mm CVD system to be delivered to automotive-certified Newport fab in South Wales

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that its G10-SiC chemical vapor deposition (CVD) epitaxy production platform has been chosen by discrete semiconductor and passive electronic component maker Vishay Intertechnology Inc of Malvern, PA, USA for its in-house silicon carbide (SiC) epitaxy needs for power device manufacturing. The system will be delivered to Vishay's automotive-certified Newport fab in South Wales. With its flexible dual-wafer size configuration of 9x150mm and 6x200mm, the G10-SiC supports the transition between wafer diameters.

Vishay's components are used in electronic devices and equipment in the industrial, computing, automotive, consumer, telecoms, aerospace, power supplies and medical markets.

"The new G10-SiC epi production tool delivers a leading cost structure for 200mm epitaxy, which meets Vishay's productivity goals. This, in combination with an excellent uniformity performance on 200mm wafers, has made us choose Aixtron technology," comments Danilo Crippa, senior director R&D for SiC development, at Vishay Intertechnology. "The Aixtron team has developed a unique solution for the tightest control of doping levels and uniformity on 200mm SiC wafers. This performance is maintained across the entire 6x200mm wafer batch with an impressive run-to-run stability," he adds.

"Our strong customer service team in the South Wales Compound Semiconductor Cluster is dedicated to fully support the production ramp of Vishay's SiC in-house epitaxy to the highest productivity within a short period of time," says Dr Frank Wischmeyer, vice president SiC, at Aixtron.

Aixtron says that its G10-SiC system, which was launched in September 2022, has become the tool of record for both 150mm and 200mm silicon carbide epitaxy. With the latest innovations, the system delivers what are claimed to be best-in-class uniformities combined with the highest wafer throughput per m^2 cleanroom space on the market, enabling the production of SiC power device epi at the lowest total cost of ownership. Uniformity performance and productivity are drivers for production yield and cost and are therefore drivers for electrification of the automotive and other industrial markets.

www.newportvishay.co.uk

www.aixtron.com

Wolfspeed orders multiple Aixtron G10-SiC systems to support ramp-up of 200mm epiwafer production

New tools to support expansion at the Durham campus and The John Palmour Manufacturing Center for Silicon Carbide

Aixtron says that in Q3 and Q4/2023 Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — placed multiple-tool orders to utilize its G10-SiC chemical vapor deposition (CVD) system to help further ramp up production for 200mm (8-inch) SiC epitaxial wafers.

"We're pleased with the Aixtron team's efforts to support the expansion of our 200mm silicon carbide epitaxy process," says Wolfspeed's chief technology officer Elif Balkas. "The company's G10-SiC has proven to be a suitable, reliable tool that will support our high-volume production needs currently on the Durham campus and ultimately at our new 200mm materials factory, The John Palmour Manufacturing Center for Silicon Carbide (The JP)."

Aixtron's G10-SiC system

Aixtron says that its G10-SiC system, launched in September 2022, has become the tool of record for both 150mm and 200mm silicon carbide epitaxy. With the latest innovations, the system delivers what are claimed to be best-in-class uniformities combined with the highest productivity, stability in manufacturing and the lowest cost of ownership.

"Wolfspeed has chosen our G10-SiC as part of their epitaxy solution plan for Durham and The JP, which will be the world's largest 200mm SiC materials factory," notes Aixtron's CEO & president Dr Felix Grawert.

www.wolfspeed.com

www.aixtron.com

EU Intellectual Property Office grants trademark registration for AlixLabs' APS process

Commercialization on 300mm silicon

Atomic layer etching (ALE) specialist AlixLabs AB of Stockholm, Sweden (which was spun off from Lund University in 2019) says that the European Union Intellectual Property Office has granted a certification of registration for its trademark APS (ALE Pitch Splitting). APS describes the company's process that aims to enable the production of chips at Ångström scale at lower cost and energy use.

"We are nearing commercialization of our technology on 300mm (12-inch) silicon wafers," notes CEO Jonas Sundqvist. "We have been etching transistor fins since 2019, and within the upcoming quarters we will have fully validated the APS process on 300mm wafers with new equipment developed by our fellow countrymen at Nanovac."

Having previously demonstrated APS on bulk silicon, AlixLabs aims to install the new Nanovac-developed equipment this summer. Once up and running, the goal is to finalize a commercial APS process that can be licensed to leading-edge semiconductor manufacturers to enable cheaper, more energy-efficient and sustainable production of advanced chips.

"This 300mm wafer tool combines our deep industry knowledge with practical design innovations, aiming to offer improved precision and efficiency in semiconductor manufacturing," says Nanovac's founder & CEO Thomas Engstedt. "It's a disruptive step forward for atomic layer etching and APS processing, setting a solid foundation for future advancements by employing modular design concepts."

APS is the first trademark of AlixLabs, joining the company's growing portfolio of patents related to the APS process that includes one EU, two US and two Taiwanese patents.

www.alixlabs.com

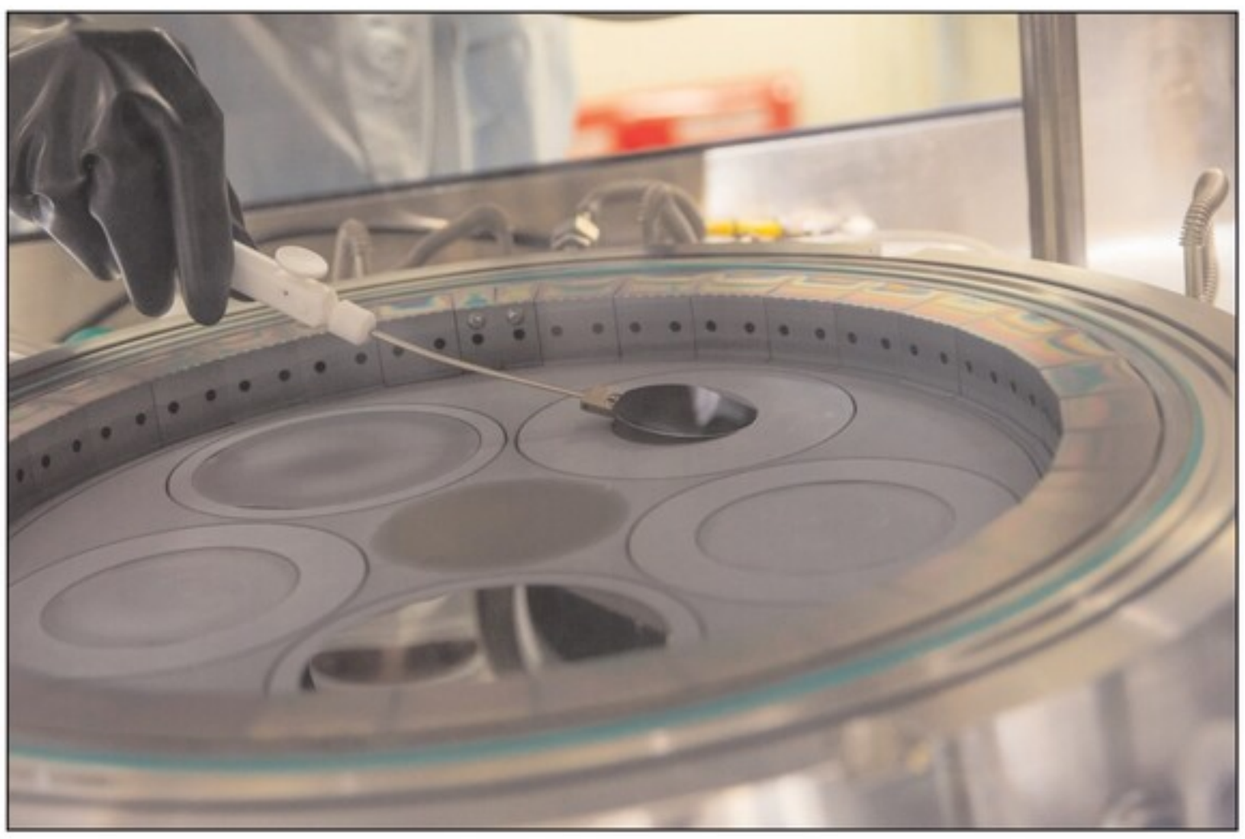
III-V Epi's 2023 growth driven by industrial projects comprising 70% of revenue

50% of industrial business goes to export

III–V Epi Ltd of Glasgow, Scotland, UK says that an exceptional 2023 saw unprecedented growth, strengthening its position in both global photonics manufacture and the quantum supply chain.

The company manufactures prototype and lower-volume III-V epitaxial structures by molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD). Of its revenue, 70% now comes from industrial projects with on-going production requirements for numerous markets including high-growth telecoms, datacoms, additive manufacturing, LiDAR, and multiple optical sensing industries.

"Industrial projects are key to our growth and long-term success," says director Calum McGregor. "Our devices now enable live product ranges in many industries, with on-going, increasing and sustained requirements. 50% of this business goes to export, with all industrial applications benefiting from the expertise gained from our fast-turnaround, academic projects which make up the remaining 30% of our portfolio. We continue to develop and improve our design, manufacture, test and characterization services, explicitly aimed at expediting device manufacture for customers and accelerating their NPI," he adds.



"Company highlights this year included CTO Richard Hogg's appointment as Professor of Photonics at Aston University, focusing entirely on research and photonic device commercialization. Furthermore, industry expert Dr Neil Gerrard became III-V Epi's director of epitaxy, supporting all aspects of III-V Epi's manufacturing and development process," McGregor continues. "Professor Hogg helped lead this year's European Semiconductor Laser Workshop (ESLW), hosted at the University of Glasgow during a successful ECOC exhibition in Glasgow. Company director professor Steven Beaumont OBE also supported the UK National Quantum Technologies Showcase, one of III-V Epi's prime markets."

www.iii-vepi.com

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Toyoda Gosei develops high-output UV-C LED

Light output quadrupled and disinfecting capability tripled

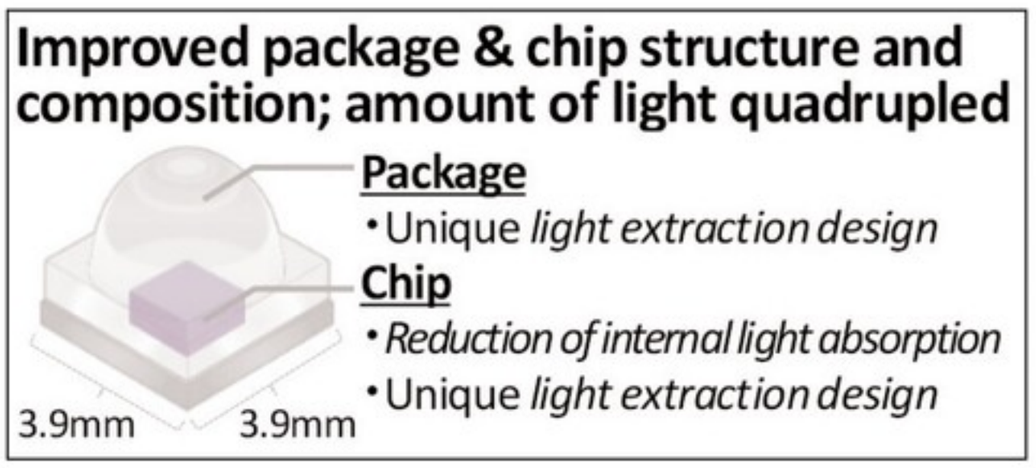
Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan has developed deep ultraviolet (UV-C) LEDs with light output that is among the highest in the world, it is claimed.

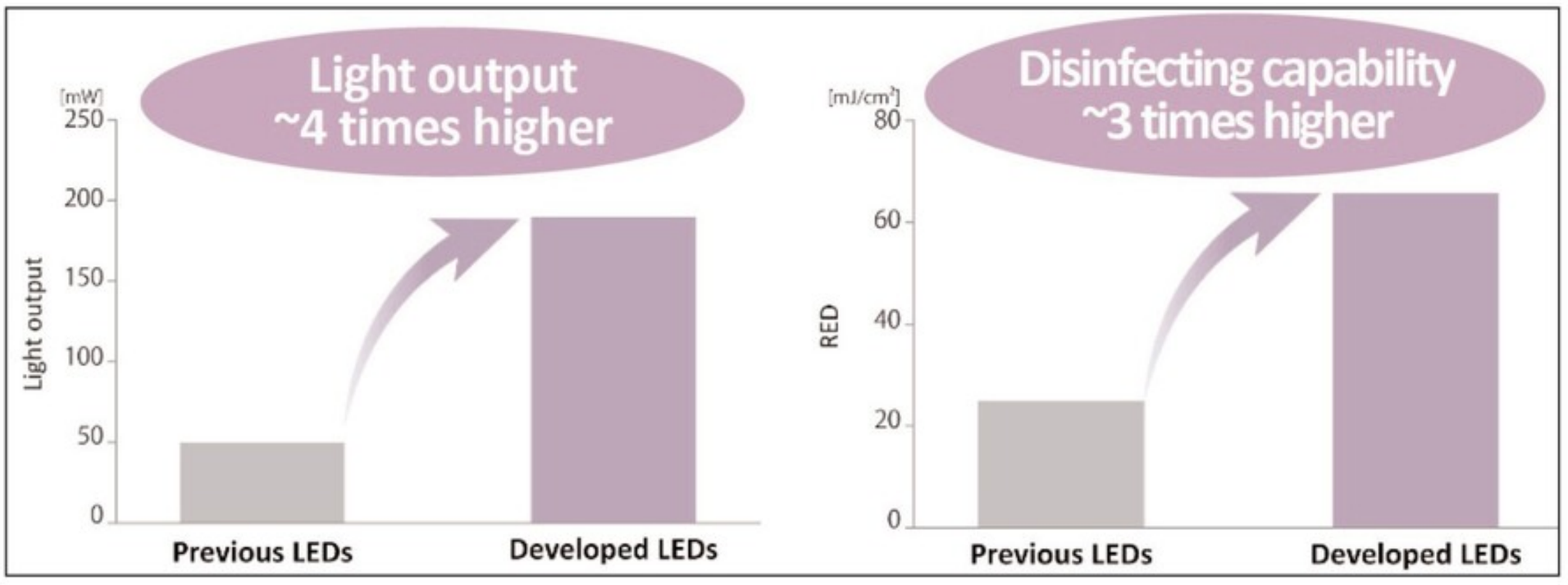
UV-C is used in disinfection as it destroys viral and bacterial DNA structures and inhibits their replication. As an alternative light source for mercury lamps used for disinfection, improved performance of UV-C LEDs has been expected. Sample sales of Toyoda Gosei's high-power LEDs will begin internationally from April (starting in Japan, China and South Korea, then successively for other regions) to promote their wider use for disinfecting water, air and surface.

Compared with mercury lamps, UV-C LEDs are environmentally friendly as they are mercury-free, more compact, and have a longer life, and these advantages drove their widespread use in devices for disinfecting air and surfaces during the Covid-19 pandemic. However, since they differ from lighting LEDs in composition, light output has been still limited. For water purification plants and other situations where high disinfection performance is needed, mercury lamps are still used.

Toyoda Gosei says that it has leveraged its expertise in crystallization and the design of blue LEDs for lighting to develop UV-C LEDs that achieve light output of 200mW with a single chip when driven by a 350mA current. Improvement of the LED structure and composition has quadrupled the amount of light that can be extracted. Enhanced LED performance — including about three-fold greater disinfecting capability — is expected to expand their range of applications, including to a future alternative to mercury lamps.

www.toyodagosei-led.jp
www.toyoda-gosei.com





Singulus develops TIMARIS STM coating system for micro-LED production

First system already sold and delivered

Singulus Technologies AG of Kahl am Main, Germany (which makes production equipment for the optical disc and solar sectors) has introduced the TIMARIS STM modular high-vacuum sputtering system, which is said to offer significant progress in micro-LED manufacturing. The first TIMARIS STM system has already been sold and delivered.

To meet the growing market needs for micro-LEDs (e.g, for the display industry), the focus is now on optimizing manufacturing processes. High-precision techniques are required to enable efficient placement and alignment of the micro-LEDs on a substrate. At the same time, controlling the crystal structure of the semiconductor material is crucial in order to maximize the overall performance of the LEDs.

Due to the wide range of applications, production must meet industrial standards in the future, with cost-efficient production methods playing a decisive role. Singulus says that, due to its experience and R&D, it has also demonstrated that it can meet the requirements individually and in a targeted manner.

"Our TIMARIS platform has a modular structure and can be equipped with various process and add-on modules for a wide range of requirements," notes CEO Dr Stefan Rinck. "Thanks to this flexibility, we are always addressing new areas of application with the system," he adds. "We are currently working on other interesting projects in semiconductor technology, which we expect to complete soon."

www.singulus.de

Vishay launches 440mcd blue & 2300mcd true green surface-mount LEDs in MiniLED package

Wavelengths of 525nm and 465nm suit heart rate monitoring and smoke detection

Vishay Intertechnology Inc of Malvern, PA, USA has introduced new blue and true green surface-mount LEDs in the ultra-compact MiniLED package. Measuring 2.2mm x 1.3mm x 1.4mm, the Vishay Semiconductors VLMB2332T1U2-08 blue and VLMTG2332ABCA-08 true green LEDs utilize the latest ultra-bright indium gallium nitride (InGaN)-on-sapphire chip technology to achieve typical luminous intensities at 20mA of 440mcd and 2300mcd, respectively, which is up to four times higher than previous-generation solutions in PLCC-2 packages.

With their high brightness and small size, the new LEDs are suitable for small-scale, high-power products that are expected to work reliably in arduous environments. Applications include medical light treatment; signal lights for agricultural equipment and energy generation systems; indicators and backlighting for office, entertainment and telecoms equipment; LCD switches; and symbols for general use.

In addition, with a typical wavelength of 525nm at 20mA, the VLMTG2332ABCA-08 is suitable for heart rate monitoring applications in fitness trackers and other devices that rely on variations in green light absorption. Offering a typical wavelength of 465nm at 20mA, the VLMB2332T1U2-08 is optimized for smoke detectors that utilize short-wavelength blue light for the detection of small particles.

The MiniLED package features a lead-frame embedded in a white thermoplast. The devices offer a ±60° angle of half-intensity, a wide viewing angle of 120° for homogenous illumination and backlighting, and forward voltage of 2.9V typical. The VLMB2332T1U2-08 and VLMTG2332ABCA-08 are categorized, per packaging unit, for luminous intensity and color.

RoHS-compliant, halogen-free and Vishay Green, the LEDs are available in 8mm tape, offer an ESD-withstand voltage up to 2kV in accordance with JESD22-A114-B, and are compatible with pre-conditioning according to JEDEC Level 2a, IR reflow soldering according to J-STD-020, and automatic placement equipment.

Samples and production quantities of the VLMB2332T1U2-08 and VLMTG2332ABCA-08 are available now, with lead times of 12 weeks

www.vishay.com

AquiSense's UV-C LED technology integrated into International Space Station's water dispenser

Potable Water Dispenser designed by Leidos

AquiSense Technologies LLC of Erlanger, KY, USA (which designs and manufactures UV-C LED water disinfection systems) says that its UV-C LED technology has been integrated into NASA's Potable Water Dispenser aboard the International Space Station (ISS) and has been operational since August 2023.

Designed by aerospace & defense firm Leidos of Reston, VA, USA and equipped with AquiSense's PearlAqua Micro point-of-use UV-C LED water disinfection system, the Potable Water Dispenser was launched aboard the SpaceX Falcon 9 rocket. Designed to provide safe and clean drinking water for astronauts on the ISS, the system is a collaboration between AquiSense and Leidos.

Using the PearlAqua Micro platform, AquiSense delivered the UV-C LED water disinfection system in the PWD, including the following features:

- *Advanced disinfection technology:*
AquiSense's UV-C LED technology rapidly deactivates harmful micro-organisms such as bacteria, viruses and protozoa, ensuring that water consumed by astronauts meets stringent safety standards, protecting their health in the demanding environment of space.
- *Compact and energy-efficient design:*
The compact footprint and energy-efficient operation of AquiSense's UV-C LED system make it suitable for outer-space applications, where resources are limited and space is at a premium.
- *Reliable performance in challenging conditions:*
AquiSense's UV-C LED water disinfection technology is engineered to withstand the rigors of space travel and operation in micro-gravity environments, with its robust construction and proven performance ensuring consistent and reliable operation.

The launch and deployment of NASA's Potable Water Dispenser underscores the importance of innovation and collaboration in advancing space exploration and supporting human life beyond Earth, says AquiSense. The firm is looking forward to continued partnership with Leidos and other aerospace industry leaders to further enhance water treatment for space missions.

www.aquisense.com

Q-Pixel debuts highest-resolution active-matrix color display

Micro-LED display startup Q-Pixel Inc of Los Angeles, CA, USA has achieved what it claims is the highest-resolution active-matrix color display: 3K x 1.5K resolution in a screen of ~1.1cm x 0.6cm.

The display has 6800 pixels per inch (PPI), far surpassing existing state-of-the-art displays such as the Apple Vision Pro (~3380PPI). Q-Pixel has fabricated its display entirely using micro-LED pixels.

Unlike most advanced VR displays, which use micro-organic LEDs (micro-OLEDs), Q-Pixel's displays consist entirely of III-V compound semiconductor micro-LED pixels. Synthesized from inorganic materials, III-V micro-LEDs offer advantages over OLEDs including faster response time, higher brightness, longer lifetime, and superior energy efficiency. From a physics perspective, inorganic III-V micro-LEDs have long been considered the ideal display technology but have lacked a clear path to commercial viability.

The main challenges to commercializing micro-LED displays arise from the traditional approach of assembling full-color pixels using individual monochromatic red, green and blue (RGB) LEDs. For high-resolution displays requiring small (<50_m) pixels, the assembly, testing, and repair of millions of RGB micro-LED subpixels is a complicated, labor-intensive and expensive process. Moreover, the physical space required for three RGB subpixels restricts the display's pixel density, posing an obstacle to realizing high-resolution displays. Q-Pixel's overcomes both hurdles by replacing three RGB subpixels with individual, fully color-tunable pixels.

According to chief technology officer Dr Michelle Chen, this enabling technology is based on a disruptive tunable polychromatic LED (TP-LED) pixel: a single pixel capable of emitting light across the full color spectrum, without any use of subpixels, quantum dots, color filters, polarizers, or mechanical stacking. In addition to possessing all the benefits inherent to III-V LED technology, Q-Pixel's single TP-LED is said to greatly simplify display assembly, reduce manufacturing costs, and enable record pixel densities.

Previously, in May 2023, Q-Pixel unveiled its record 5000PPI full-color micro-LED display, and in November it surpassed its record with the simultaneous announcement of a passive 10,000PPI micro-LED display made from the world's smallest full-color pixels (1μm diameter), all based on its TP-LED technology.

Now, by delivering the highest-resolution (6800PPI) active-matrix color display, Q-Pixel has accomplished two milestones. First, it has proved that it is possible to produce ultra-high-resolution, active displays based on micro-LED technology. Secondly, it has shown that its TP-LED pixel technology surpasses more mature display technologies such as OLEDs to attain record pixel densities. With these latest achievements, Q-Pixel is embarking on the commercialization of its displays.

Q-Pixel's technology and prototype is being demonstrated at the Society for Information Display's annual symposium and tradeshow SID Display Week 2024 on 14–16 May.

www.displayweek.org

SemiLEDs revenue halves quarter-to-quarter

Factory shut down during Chinese New Year holiday 3–18 February

For its fiscal second-quarter 2024 (to end-February), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of $886,000 (almost halving from $1.65m last quarter). However, this included the period 3–18 February, when SemiLEDs shut down its manufacturing production due to the Chinese New Year holiday.

Gross margin fell from 15% to 13%. Operating margin was –94%, compared with –50% last quarter.

Despite this, net loss has been cut further, from $598,000 ($0.12 per diluted share) last quarter to $559,000 ($0.11 per diluted share). During the quarter, cash and cash equivalents fell from $2.322m to $1.613m.

For fiscal third-quarter 2024 (to end-May), SemiLEDs expects revenue to rebound to $1m+/-10%.

On 11 July 2023, SemiLEDs received a notice from The NASDAQ Stock Market indicating that it did not meet the minimum of $2.5m in stockholders' equity required by Nasdaq Listing Rule 5550(b)(1) for continued listing, or the alternatives of market value of listed securities or net income from continuing operations. Pursuant to the Listing Rule, SemiLEDs submitted a plan to regain compliance. Nasdaq accepted the plan and granted the firm an extension through 8 January 2024. Based on the firm's Form 8-K dated 9 January 2024, Nasdaq determined that it complied with the Listing Rule 5550(b)(1). However, if SemiLEDs fails to evidence compliance upon filing its next periodic report, it may be subject to delisting. Based on fiscal second-quarter stockholders' equity, SemiLEDs believes that it in compliance with the minimum stockholders' equity requirement.

www.semileds.com

Mojo Vision appoints Achin Bhowmik to board

Society for Information Display president joins as independent member

Mojo Vision Inc of Saratoga, CA, USA — which is developing and commercializing micro-LED display technology for consumer, enterprise and government applications — has appointed Dr Achin Bhowmik to its board of directors. Bhowmik, chief technology officer at Starkey, a former executive at Intel, and currently the president of the Society for Information Display (SID), joins as an independent board member to provide guidance and oversight for Mojo Vision as it accelerates the development of next-generation micro-LED technology. With his appointment, Mojo Vision is tapping 23 years of industry experience in perceptual computing, display and semiconductor business.

"Through my work with the Society for Information Display, I have had a front-row seat to major innovations in the display industry and have worked with leading scientists and executives," says Bhowmik. "Mojo Vision is a pioneering display technology company, consistently breaking new ground in micro-LED advancements, including its recent achievement of single-panel RGB," he comments.

Bhowmik's background is rich in computational perception, displays and semiconductor business and, with his work at Starkey, he has led the development of emerging technologies into multi-functional computing and communication devices. As a long-time executive board member and currently president of the Society for Information Display, he has played a critical role in fostering collaboration and innovation within the industry. He was recently awarded Fellow of the Institute of Electrical and Electronics Engineers (IEEE) for his leadership in perceptual augmentation devices.

"Mojo Vision is applying significant discoveries by some of the world's leading scientists in the work we do with our own team in Saratoga, California," says Mojo Vision's CEO Nikhil Balram. "Our proprietary high-performance quantum dot technology significantly expands on the foundational technology that was awarded the Nobel Prize in Chemistry last year," he adds. "As we take this technology out of the lab and into the market, the guidance of Dr Bhowmik will be critical to our success."

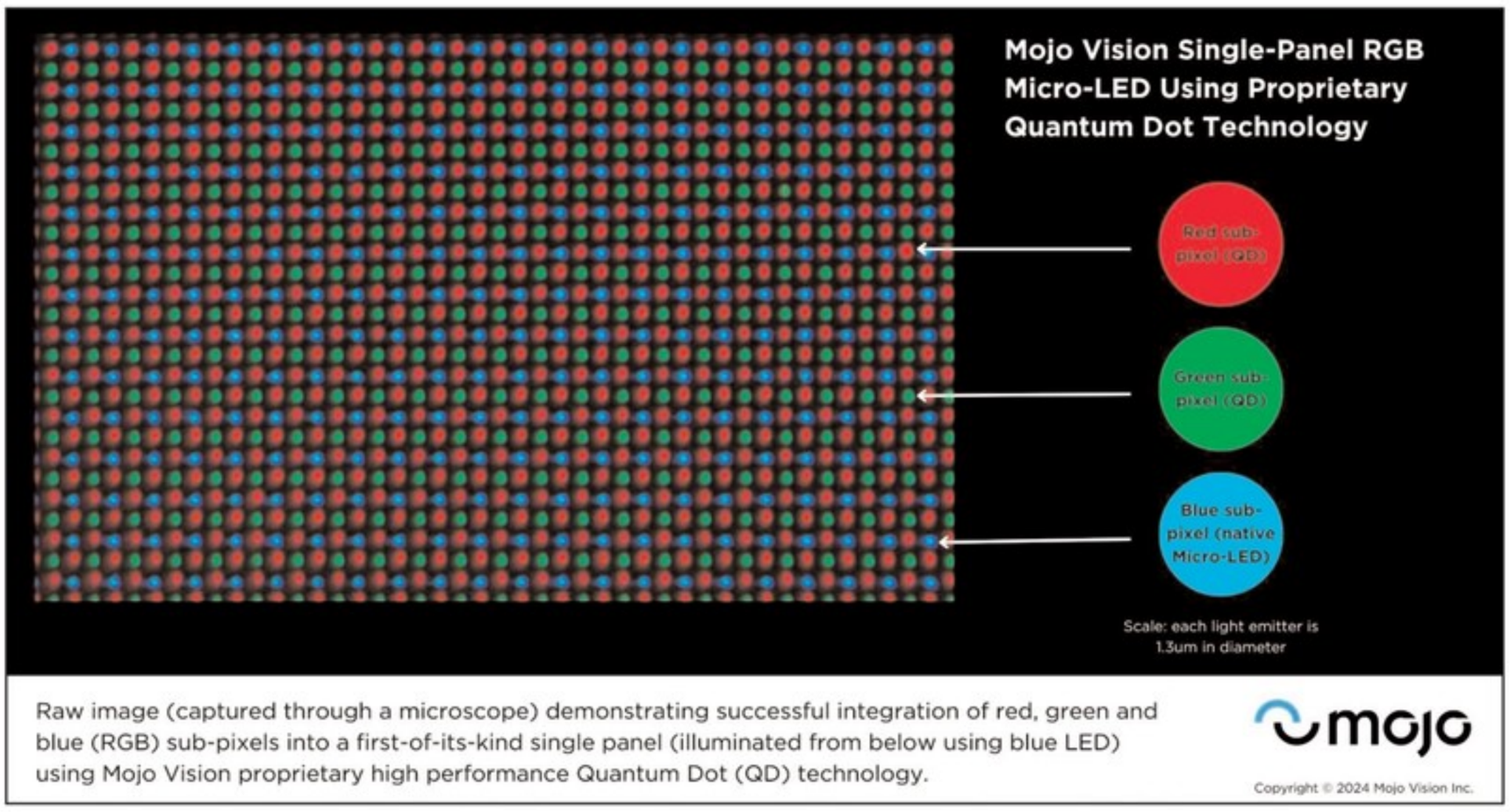
Bhowmik is the chief technology officer & executive VP of engineering at Starkey. Previously, he held positions at Intel as VP & general manager of perceptual computing. At Intel, he led research, development and business for various technologies including 3D sensing, interactive computing, artificial intelligence (AI), autonomous systems, and virtual/mixed-reality devices.

"Adding Dr Bhowmik to our board brings Mojo that much closer to the commercialization of our high-performance micro-LED technology," says Drew Perkins, chairman of the board of directors and co-founder. "Our display technology is semiconductor-based, so his experience in both of those industries, especially his 17 years at Intel, is critical perspective and expertise that we need as we design a high-volume manufacturing process based on 300mm wafers," he adds. "The addition of an independent director complements our experienced and accomplished board of directors."

Bhowmik's additional experience includes services as a board member and trustee for the National Captioning Institute, as well as a member of the board of advisors for the Fung Institute of Engineering Leadership at the University of California, Berkeley. He also holds positions as an adjunct professor at Stanford University School of Medicine, Stanford Human-Centered AI Institute and the Wu Tsai Neuroscience Institute.

"As the industry pushes for adoption beyond larger headsets like the Apple Vision Pro and Meta Quest Pro towards smart glasses and other form factors, micro-LED is primed to power these future displays," reckons Rajeeva Lahri, former VP at Global Foundries and current Mojo advisory board member. "While Mojo continues to build industry-leading micro-LED technology, it is assembling a world-class team, including experts like Dr Bhowmik, to bring this technology successfully to market."

www.mojo.vision



Raw image (captured through a microscope) demonstrating successful integration of red, green and blue (RGB) sub-pixels into a first-of-its-kind single panel (illuminated from below using blue LED) using Mojo Vision proprietary high performance Quantum Dot (QD) technology.

BluGlass closes share purchase plan, adding $5.87m to $4.3m placement

Total of $10.17m to be used to scale and speed delivery of visible lasers, extra fab equipment, and working capital

BluGlass Ltd of Silverwater, Australia — which develops and makes gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has closed its share purchase plan (SPP), raising $5.87m before costs.

The SPP enabled eligible shareholders to subscribe for up to $100,000 of new BluGlass shares at $0.037 per share, with (subject to shareholder approval) one free attaching option. Options are exercisable at $0.046 and expire on 28 February 2025. Every attaching option exercised will include an additional piggyback option, exercisable at $0.06 and expiring 28 February 2027. The SPP followed a strongly supported $4.3m placement to institutional and sophisticated investors on the same terms, raising a total of $10.17m.

Funds will accelerate production and delivery of the company's GaN lasers, fulfilling new and existing contracts, as well as support additional fab capabilities and working capital.

"This capital supports our continued growth, enabling us to step-up production and delivery of our visible GaN lasers in rapidly growing markets, driven by adoption across advanced manufacturing, quantum sensing and computing, defence, space and biotech applications," says CEO Jim Haden. "We're also investing in future capabilities, such as our distributed feedback (DFB) lasers, which have been key to winning revenue-generating projects and partnerships with the US Commercial Leap Ahead for Wide Bandgap Semiconductors (CLAWS) Hub and laser pioneer Applied Energetics. These projects provide substantial revenue growth while allowing us to bring to market higher-value products that further differentiate us from larger competitors," he adds. "We're executing against clear technical and commercial roadmaps to deliver higher-value products, and are focused on delivering business growth and maximising shareholder value."

Allotment of new shares is on 3 April with the issue of 157,842,057 fully paid ordinary shares. An additional 756,489 new shares are proposed to be issued under the SPP to directors of the company in the amount for which they have paid for those shares, on or around 5 April. The issue of attaching options and director SPP shares are subject to shareholder approval, which is being sought at an Extraordinary General Meeting on 4 April.

www.bluglass.com.au

NUBURU raises $3m from strategic investors

Funds to speed fulfillment of orders from customers in new markets

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — has announced a $3m investment in its common stock by strategic investors focused on strengthening and growing the company. The firm has also announced initial purchase orders from new customers in new markets.

"The customer qualification process for our products can be lengthy and complex, but we are finally seeing the fruits of our efforts," says CEO Brian Knaley. "We have orders to fill in critical new markets and with new customers, and we believe this investment will accelerate our fulfillment process and path towards consistent revenue generation."

Investment by strategic partner

NUBURU reckons that the investment marks a step forward in its evolution towards a more diversified and innovative future. The strategic investment was led by experienced fintech industry leader Alessandro Zamboni, who has extensive experience as chairman of AvantGarde Group S.p.A., including successful ventures in risk management and working capital solutions.

Key initial orders

Among the new orders, NUBURU has been awarded an initial purchase order to supply BL-300s to a best-in-class manufacturer of battery systems in the sustainable energy market, with manufacturing capabilities primarily in Asia. NUBURU's blue laser technology will be used in the production of fully automated, high-quality welding of components within electric vehicle (EV) battery modules, which will be used primarily in the automotive and e-mobility markets.

Special meeting to approve stock acquisition of further assets and diversification

In connection with the strategic investment, NUBURU intends to call a special meeting of stockholders to, among other things, approve the issuance of additional common stock for the purpose of acquiring controlling and non-controlling interests in one or more entities. These changes would allow for the acquisition of additional assets and the strategic diversification of the company's business. Additional details will be provided in the notice of the special meeting and the related proxy statement. NUBURU will also continue to explore capital-raising opportunities, as permitted by the authorization obtained at its most recent special meeting of stockholders on 22 February.

www.nuburu.net

PhotonVentures' second fundraising round of €15m raises total to €75m

Target of over €100m for initial fund by end 2024

Independent deep-tech venture capital fund PhotonVentures says that its second fundraising round of over €15m has been completed, bringing the fund's total to the targeted €75m, following the first €60m round led by PhotonDelta and private investors.

PhotonVentures was spun off from PhotonDelta, which was founded in 2014 as a growth accelerator for the integrated photonic chip industry in the Netherlands and Europe. PhotonDelta has since invested in photonics companies and R&D, establishing a cross-border ecosystem of organizations that research, design, develop and manufacture solutions with integrated photonic chip technology. In 2022, PhotonDelta secured €1.1bn in public and private investment to scale up production, build 200 start-ups, create new applications for photonic chips and develop infrastructure and talent.

The PhotonVentures fund targets essential applications in data transmission, health diagnostics, and smart sensor systems, while also aligning with major global trends such as artificial intelligence (AI), augmented reality (AR), and virtual reality (VR).

PhotonVentures says that the latest fundraising strengthens its position in the Dutch and European ambitions in this strategically important emerging market.

The latest funding round has been enabled by private and strategic investors, together with the support of the Brabant Development Agency (BOM), Oost NL (the East Netherlands Development Agency, which focuses on the provinces of Gelderland and Overijssel), research institute TNO (the Netherlands Organization for Applied Scientific Research in Delft) and the University of Twente.

PhotonVentures' objective is to raise over €100m for the closure of its initial fund by the end of 2024. The fund focuses on seed to Series A investments, with participation ranging from €1m to €2.5m. With strategic support from the Dutch National Growth Fund and the European Chips Act for the Dutch and European ecosystem, PhotonVentures says that it is creating conditions for the growth of 20 deep-tech frontrunners to position themselves as international leaders within the European ecosystem.

PhotonVentures reckons that its commitment to integrated photonic technology and sustainable AI-driven trends uniquely positions the fund to promote significant economic growth and social progress.

"We are proud that BOM, Oost NL, TNO and University Twente came on board. It proves their belief that PhotonVentures is creating value for investors and sustainable economic impact for the Netherlands and the rest of Europe," says PhotonVentures general partner Ewit Roos. "We also thank our new private and strategic investors for their trust and commitment to make this happen," he adds.

"The further development of photonics is crucial for the future of the Dutch semiconductor ecosystem. It's no coincidence that photonics is one of the key technologies for BOM," says Marc Jansen, managing director investments at BOM. "To scale innovative companies in this sector, funds like PhotonVentures are indispensable. We anticipate collaborating intensively with all partners," he adds.

"Many Dutch photonics companies are located around the universities in Eindhoven and Enschede. But also, the Noviotech Campus in Nijmegen is an important driver for innovations in photonics," notes Freek Welling, director Capital at Oost NL. "PhotonVentures has previously invested in companies from our region such as Surfix and PHIX. We are pleased to have joined with other parties because we see the importance of the growth of photonics in our region, The Netherlands and Europe."

www.photonventures.vc

Integrated Photonics System Roadmap unveiled, led by PhotonDelta and MIT Microphotonics Center

IPSR-I identifies key technologies needed for industries including RF photonics, 3D imaging, datacoms and sensing

More than 400 technology, academic and industrial organizations worldwide (including Airbus, Meta, NASA, Dupont Electronics, General Motors, The European Space Agency and VodafoneZiggo) have contributed to a new integrated photonics system roadmap led by integrated photonic chips industry accelerator PhotonDelta of Eindhoven, The Netherlands (which connects and collaborates with an ecosystem of photonic chip technology organizations worldwide) and the Microphotonics Center (MphC) at the USA's Massachusetts Institute of Technology (MIT).

Aiming to provide a platform for a unified, global trust-based network of industrial and R&D partners to drive innovation and adoption of photonics, the purpose of the Integrated Photonics System Roadmap — International (IPSR-I) is to provide a technology roadmap and a way forward for building a global, aligned integrated photonics industry with the ability to help solve major societal challenges. This is underpinned by a call to establish and sustain a trust-based global network of industrial and R&D partners, who work together to create photonic integrated circuit (PIC) technology and systems requirements. By aligning the entire supply chain from research to end users, the integrated photonics industry should be able to drive volume manufacturing of PICs.

The integration of photonics with electronics is the key enabler for the creation of smaller, faster and more energy-efficient devices. The integration has the potential to expand functionality and create many new applications and is helping to unlock major advances in many areas including autonomous vehicles, data telecom and healthcare. Integrated photonics is also the technology that generates, processes and detects light for sensing and communication applications.

IPSR-I summarizes the consensus from over 400 experts from over 100 workshops and 13 conferences. It includes a comprehensive overview of major technology gaps for volume manufacturing of PICs and a detailed analysis of the challenges that the integrated photonics industry needs to overcome in order to achieve its potential.

The roadmap, which was produced over the past three years, also includes insights into wireless communication and 3D imaging.

"Getting all research and development resources of the integrated photonics industry and academia behind solving the technological gaps identified by the IPSR-I will contribute to solving the large societal challenges in a spectacular manner," believes PhotonDelta's chief technology officer Peter van Arkel. "At the heart of the roadmap is a global approach for the integrated photonics industry to rally behind to meet core challenges. Reaching a consensus on these technological gaps has been very challenging with such a diverse group of contributors," he adds.

"Electronic-photonic integration has the capacity to radically transform a whole host of industries and unlock a range of new technologies that will change our lives," believes Lionel Kimerling, the Thomas Lord Professor of Materials Science and Engineering at MIT. "Transitioning this vision to high-volume manufacturing requires a well thought-out plan built on the knowledge of a huge range of experts across different fields, organizations and nations," he adds. "This is what IPSR-I has achieved — it outlines a clear way forward and specifies an innovative learning curve for scaling performance and applications for the next 15 years."

www.photondelta.com/ipsri-2024

EU's photonixFAB consortium open for first prototyping

Consortium partners in the European Union (EU)-funded photonixFAB initiative have taken the first step on the path to industrialize the European silicon photonics value chain by providing early access to R&D and small-scale manufacturing through technology partners.

Unveiled in mid-2023, photonixFAB aims to lift Europe's global standing in silicon photonics by championing its value chain. It draws together the continent's most innovative enterprises within the photonics sector (each supplying their own specific proficiencies), along with respected research establishments.

The customer engagement portal will facilitate early engagement with clients as photonixFAB progresses — enabling initial technology evaluations and consultations It will provide users with a consolidated access point, so they can explore the possibilities available. Consequently, early product development may begin while the various technologies/services encompassed by photonixFAB are being transferred to an industrial environment over the course of 2024–2026.

Those using the intuitive web-based platform can learn about the various capabilities offered by members of the photonixFAB consortium. After deciding on which technologies/services are needed, they can then be directed to the relevant partners, so that dialog with them can be initiated. Work can hence commence sooner on developing the concept and creating prototypes, as well as moving to small-volume fabrication.

Examples of the capabilities that customers can initiate will include prototyping in relation to silicon nitride (SiN) via LIGENTEC and silicon-on-insulator (SOI) through imec, as well as for indium phosphide (InP) chiplets by working with SMART Photonics. There will also be the packaging expertise that PHIX Photonics Assembly offers for both SiN and SOI processes, plus early technology access for InP micro-transfer printing on SiN/SOI supplied directly by X-FAB and supported by SMART. Process design kits (PDKs) based on Luceda's electronic design automation (EDA) tool are available through the technology partners.

"Substantial progress is already being witnessed on photonixFAB, with valuable contributions being made by all of the consortium members," says X-FAB France's Youssouf Guerfi, project coordinator for photonixFAB. "The customer engagement portal is an important milestone in our ongoing journey with this initiative. Using the portal, customers will be able to find the correct partners and start carrying out the preliminary stages of their photonic projects, to be ready to benefit from full-scale production in the future," he adds.

"We are seeing a great deal of interest in the European-based silicon photonics value chain that photonixFAB represents," says Joni Mellin, business line manager for Photonics at X-FAB. "This launch signifies that we are now open for business and projects can get underway, so no time is wasted. It means that we can accelerate engagement activity and customers can get ahead of the game."

www.photonixfab.eu/technologies-services

Celestial AI closes $175m Series C funding round

Investment to scale commercialization of Photonic Fabric technology

After raising $100m in a Series B funding round at the end of June 2023, Celestial AI of Santa Clara, CA, USA has raised $175m in a Series C funding round led by Thomas Tull's US Innovative Technology Fund (USIT), joined by new and existing investors including AMD Ventures, Koch Disruptive Technologies (KDT), Temasek, Temasek's subsidiary Xora Innovation, IAG Capital Partners, Samsung Catalyst, Smart Global Holdings (SGH), Porsche Automobil Holding SE, Engine Ventures, M-Ventures and Tyche Partners.

Celestial AI's Photonic Fabric optical interconnect technology platform aims to provide foundational technology for optically scalable, disaggregated data-center compute and memory to unleash advances in AI with sustainable and profitable business models.

"This highly oversubscribed financing round is another testament to Celestial AI's position to disrupt the market, and reflects the magnitude of business opportunity before us," reckons founder & CEO Dave Lazovsky. "Today's advanced AI models require exponentially more I/O bandwidth and memory capacity but are currently constrained by low bandwidth and high latency," he adds. "Our Photonic Fabric technology is rapidly becoming the de facto standard for accelerated computing optical interconnectivity, driven by unparalleled performance and efficiency."

Amid the explosive growth in demand for generative AI applications and next-generation data centers, hyperscalers are increasingly constrained by utility power availability, memory capacity and high cost of operation. Celestial AI says that its Photonic Fabric optical interconnect technology addresses these critical challenges by revolutionizing memory and compute fabrics, providing the foundational technology for users to continue making advances in AI while maintaining scalable, sustainable and profitable business models.

This latest round of funding will enable Celestial AI to execute multiple large-scale customer collaborations focused on commercializing its Photonic Fabric technology platform.

"As AI continues to rapidly evolve, it's imperative that the US remains a global leader in AI innovation," says USIT's chairman Thomas Tull. "The sophisticated work Celestial AI is doing on interconnectivity is critical to addressing key concerns across performance and energy efficiency to ensure the industry has the necessary infrastructure to continue to innovate and scale," he believes.

Celestial AI's Photonic Fabric is claimed to be the industry's only optical connectivity solution that enables the disaggregation of compute and memory, which allows each component to be leveraged and scaled most effectively. The technology delivers over 25x greater bandwidth and memory capacity while reducing latency and power consumption by up to 10x compared with existing optical interconnect alternatives and copper.

"The exponential growth of AI models coupled with successful validation of Celestial AI's Photonic Fabric technology in silicon has led to tremendous demand for this technology by hyperscalers," says Chase Koch, founder of KDT & executive VP at Koch Industries. "The potential of this technology to dramatically reduce the power consumption for processing extensive AI workloads enables a new era of sustainable and scalable compute capacity."

Photonic Fabric adopted by lead hyperscaler customers

After successful validation of the Photonic Fabric silicon that implements a complete link (electrical–optical–electrical) during summer 2023, hyperscaler customers and semiconductor customers are now designing in the Photonic Fabric optical chiplets as an initial phase of technology adoption. This integration requires no software change and is directly compatible with customer logical protocols and existing multi-chip packaging flows. The roadmap to deeper integration of Photonic Fabric technology in customers' system architectures offers as much as a 25x increase in off-package bandwidth compared with other available state-of-the-art technologies, it is reckoned.

"The surge in demand for our Photonic Fabric is the product of having the right technology, the right team and the right customer engagement model," says co-founder & CEO Dave Lazovsky. "We are experiencing broad customer adoption resulting from our full-stack technology offerings, providing electrical-optical-electrical links that deliver data at the bandwidth, latency, bit-error rate (BER) and power required, compatible with the logical protocols of our customer's AI accelerators and GPUs," he adds. "Deep strategic collaborations with hyperscale data-center customers focused on optimizing system-level accelerated computing architectures are a prerequisite for these solutions."

To accelerate customer adoption of the memory and compute fabric, Celestial AI is cultivating a Photonic Fabric ecosystem. These tier-1 partnerships consist of custom silicon/ASIC design services including Broadcom, system integrators, HBM and packaging suppliers including Samsung.

"Silicon photonics technologies are set to significantly improve chip-to-chip and chip-to-memory interconnect," comments Jim Elliott, executive VP & head of US Memory Business at Samsung Electronics. "Celestial AI's Photonic Fabric has the potential to eliminate the 'Memory Wall' by connecting large amounts of shared memory at the full speed of HBM, achieving nanosecond-level latencies for AI training and inferencing."

www.celestial.ai
www.usitfund.com

Fraunhofer IAF's 2.4W single-mode GaSb VECSELs provide low-noise pump source for quantum frequency conversion

1.9–2.5µm wavelengths with stability <2fm target quantum Internet

Fraunhofer Institute for Applied Solid State Physics (IAF) of Freiburg, Germany has developed single-mode gallium antimonide (GaSb) VECSELs with what are reckoned to be best-in-class output powers of up to 2.4W, enabling quantum frequency conversion as a low-noise pump source.

The expansion of fiber optics is progressing worldwide, which not only increases the bandwidth of conventional Internet connections, but also brings closer the realization of a global quantum Internet. The quantum Internet can help to fully exploit the potential of certain technologies. These include much more powerful quantum computing through the linking of quantum processors and registers, more secure communication through quantum key distribution or more precise time measurements through the synchronization of atomic clocks.

However, the differences between the glass fiber standard of 1550nm and the system wavelengths of the various quantum bits (qubits) realized to date represent a hurdle, because those qubits are mostly in the visible or near-infrared spectral range. Researchers want to overcome this obstacle with the help of quantum frequency conversion, which can specifically change the frequencies of photons while retaining all other quantum properties. This enables conversion to the 1550nm telecom range for low-loss, long-range transmission of quantum states.

Single-mode disk laser module with up to 2.4W output power for the frequency range 1.9–2.5µm.

Project HiFi: enabling technologies for quantum frequency conversion

In the joint project 'HiFi — Highly integrated quantum frequency converter of highest fidelity based on innovative laser, fiber and production technology' funded by the German Federal Ministry of Education and Research (BMBF), researchers are working on the realization of all necessary technologies to provide quantum frequency converters (QFK) with high efficiency and low noise for initial test tracks. The Fraunhofer Institute for Applied Solid State Physics IAF has contributed to the project with the development of disk lasers (vertical-external-cavity surface-emitting lasers, VECSELs) based on gallium antimonide (GaSb). These are optically pumped, surface-emitting semiconductor lasers with an external resonator and intracavity filter for wavelength selection.

2.4W output power with absolute frequency stability below 100kHz

"The VECSELs we developed as part of HiFi are spectrally narrowband pump sources which, depending on the output wavelength of the qubits used, specifically cover a wavelength range of 1.9–2.5µm and achieve an output power of up to 2.4W with an absolute wavelength stability of less than 2fm. This corresponds to a frequency stability of less than 100kHz and clearly falls below the frequency stability class 1E-9. The result represents an international record for this type of laser," says Dr Marcel Rattunde, HiFi subproject coordinator and head of Fraunhofer IAF's optoelectronics department.

"The result was made possible by the close cooperation with project partner MENLO Systems GmbH. Together, we locked the disk laser to a frequency comb, which in turn was coupled to a 10MHz reference," says Rattunde.

In their experiments, the researchers set the emission wavelength exactly to the target wavelength for demonstration experiments at the fiber link of Saarland University (2062.40nm), to which Fraunhofer IAF has handed over the laser module. In addition to power scaling, the most important research tasks of Fraunhofer IAF in the HiFi project are the precise understanding of the mode behavior of the lasers and the identification and elimination of noise sources.

Quantum frequency conversion using pump lasers

In quantum frequency conversion, the energy of the pump photon is subtracted from the signal photon by a difference frequency process in a non-linear optical crystal. To ensure a low-noise process, the energy of the pump photons must be below the target wavelength (usually 1550nm), otherwise the pump laser can generate photons in the output signal due to parasitic effects.

In combination with the MENLO frequency comb, the VECSELs developed at Fraunhofer IAF meet the high requirements of quantum frequency conversion, as their narrow bandwidth and wavelength stability prevent fluctuations in the pump wavelength and consequently changes in the target wavelength of the qubits. If there is a deviation above the natural linewidth, the qubits would no longer be indistinguishable, which would eliminate a basic requirement for subsequent quantum mechanical processing.

www.iaf.fraunhofer.de/en/researchers/optoelectronic-devices/Hifi.html

TriEye and Vertilas demo CMOS-based SWIR sensor using 1.3µm indium phosphide VCSEL array

A collaboration between TriEye Ltd of Tel Aviv, Israel and Vertilas GmbH of Garching bei München, Germany has led to the development of a joint technology demonstrator that integrates TriEye's Raven shortwave infrared (SWIR) image sensor with Vertilas' indium phosphide (InP) vertical-cavity surface-emitting laser (VCSEL) technology. Adopting high-volume, scalable manufacturing strategies, the technologies aim to provide cost-effective solutions for both consumer and industrial markets.

The system highlights the capabilities of TriEye's industry-first CMOS-based SWIR sensor, which is said to be noted for its high sensitivity and 1.3MP resolution. Designed to enhance imaging in industries including automotive, consumer, biometrics and mobile robots, the solution is claimed to represent a significant step forward in sensing technology.

In parallel, Vertilas has introduced SWIR InP VCSEL technology that provides high output power with high power efficiency. The new VCSEL technology is a complementary innovation that is said to enhance the SWIR camera's functionality. Deploying 1.3µm VCSEL arrays enables greatly improved eye safety and signal quality while minimizing sunlight distortion. Vertilas' InP VCSEL array technology also offers wavelengths at 1.55µm and up to 2µm. The new technology is expected to broaden the scope of applications in imaging and illumination across multiple industries.

"Our InP VCSEL technology, combined with TriEye's exceptional SWIR sensor, marks a significant advancement in the realm of imaging and illumination solutions," says Vertilas' CEO Christian Neumeyr. "Collaboration is more than just a technological achievement; it represents our shared vision of innovating for a better, more efficient future in both consumer and industrial applications," he adds.

"We are proud to unveil a solution that not only enhances imaging capabilities across various industries but also does so in a cost-effective and scalable manner, making advanced sensing technology more accessible," says TriEye's CEO Avi Bakal.

www.vertilas.com
www.TriEye.tech

Quintessent raises $11.5m in seed funding round

Funding to grow team and accelerate development of optical interconnects based on multi-wavelength comb laser

Quintessent Inc of Santa Barbara, CA, USA, which specializes in heterogeneous integration of quantum dot lasers and silicon photonic integrated circuits (PICs), has closed on just over $11.5m in an oversubscribed seed funding round led by Osage University Partners (OUP), joined by new investors including M Ventures, and existing investors Sierra Ventures, Foothill Ventures, and Entrada Ventures.

The proliferation of artificial intelligence (AI) is catalyzing a rapid transition and growth of the world's computing infrastructure from general purpose architectures to ones specifically designed for accelerated computing. This new paradigm of computing requires the orchestration of massively parallel units of distributed but interconnected compute resources at the cluster or data-center scale. As a result, data movement efficiency of the interconnecting fabric is a critical bottleneck to accelerating system performance at scale.

Achieving sustainable growth of computing and data movement will require new technologies and architectures that can match the rapid progression of bandwidth (density) scaling from computing and switching interfaces while simultaneously minimizing power, latency, fiber count, chip size and total cost of ownership, says Quintessent. In addition, to enable practical deployment at scale and ensure quality of service, significant improvements in reliability relative to today's solutions are required, the firm adds.

"This new funding allows us to grow our team and accelerate the development of highly scalable and highly reliable optical interconnects that transcend the scaling limitations of incumbent solutions, built on top of a unique technology stack including our multi-wavelength comb laser," says CEO & co-founder Alan Liu.

"Novel chip-scale laser architectures have rarely been the focus of today's photonics companies because the industry is still so nascent and focused in on engineered solutions. But at OUP, as we observed various AI and computing hardware companies push the limits of bandwidth and packaging with optical systems, we found they were all challenged by the scaling and cost of their optical laser source," says OUP partner Manny Stockman, who will be joining Quintessent's board of directors. "Quintessent's plans to productize interconnect solutions powered by multi-wavelength quantum dot comb lasers may become one of the most critical product developments in photonics at just the right time to intercept the surging demand for optical connectivity at the largest computing corporations in the world," he adds.

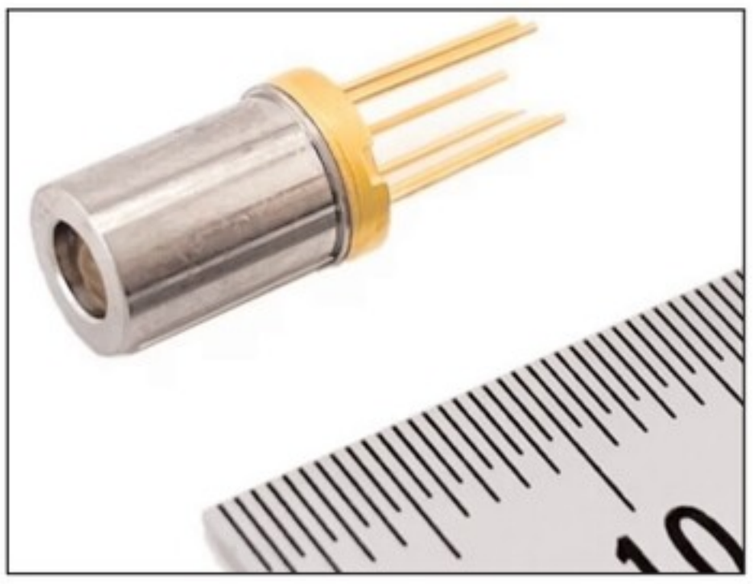
www.quintessent.com

Mitsubishi Electric sampling DFB-CAN laser with built-in wavelength monitor for digital coherent communications

Small-package TO-56CAN to contribute to miniaturized, low-power-consumption optical transceiver modules

Tokyo-based Mitsubishi Electric Corp has begun shipping samples of a DFB-CAN distributed feedback laser diode with built-in wavelength monitor. The new light source — reckoned to be the industry's first to use the inexpensive TO-56CAN package (often used for low-speed optical signals, such as passive optical networks) for digital coherent communication capable of high-speed, long-distance transmission — is expected to contribute to the realization of ultra-small, low-power consumption of optical transceiver modules.

Communication traffic is growing rapidly due to advances in IoT technology, high-resolution video streaming, and generative AI technology, requiring networks to deliver ever-higher speeds and capacities. However, faster optical communication signal speeds can cause waveform distortion due to chromatic dispersion, which limits signal transmission distances. Digital coherent communication corrects such distortions using digital signal processing technology, allowing optical signals to be transmitted at higher speeds and over longer distances compared with conventional intensity modulation methods. In parallel, the use of optical transceiver modules is increasing as optical communication traffic grows. Both trends are driving demand for optical transceiver modules and related components that combine small footprints and low power consumption.



The ML973A71 DFB-CAN with built-in wavelength monitor.

Mitsubishi Electric's new DFB-CAN's compact package combines a DFB laser chip with a wavelength monitor chip in a volume of just 0.2ml (80% smaller than the firm's discontinued FU-679PDF butterfly-type wavelength-tunable light source).

Its unprecedented low power consumption of just 1W (66% less than existing devices) was achieved by improving the thermal exchange element for temperature control in the DFB laser chip and optimizing the design for increased heat dissipation.

In addition, the newly designed wavelength monitor chip enables high-accuracy wavelength control of the laser output at a fixed wavelength of 1547.72nm, suitable for next-generation digital coherent communications.

Integrating he DFB laser chip and wavelength monitor chip in the same package enables accurate measurement of the output laser wavelength and can be used in combination with a wavelength-error correction circuit to achieve highly stable laser output.

The device is expected to contribute to miniaturization and low power consumption in both existing widely deployed 400Gbps digital coherent optical transceiver modules and next-generation 800Gbps modules currently under consideration by the Optical Internetworking Forum (OIF).

Future developments

The signal wavelength for digital coherent communication systems is expected to expand to two wavelength bands, i.e. 1550nm and 1310nm in the future, as the latter exhibits less waveform distortion due to chromatic dispersion, reducing the amount of power required for correction. Going forward, Mitsubishi Electric hence expects to develop a 1310nm-band light source and eventually begin supplying samples.

www.mitsubishielectric.com/semiconductors/products/opt

Adtran and Vertilas unveil first ultra-low-power 100G PAM4 single-mode VCSEL technology

VCSEL arrays achieve 800Gb/s and 1.6Tb/s speeds with transmit optics power savings of up to 80%

At the Optical Fiber Communication conference (OFC 2024) in San Diego, CA, USA (26–28 March), Adtran Inc of Huntsville, AL, USA (which provides open, disaggregated networking and communications solutions for voice, data, video and internet communications) and vertical-cavity surface-emitting laser (VCSEL) maker Vertilas GmbH of Garching bei München, Germany announced what is claimed to be the industry's first 100Gb/s PAM4 single-mode VCSEL technology with capabilities up to 1.6Tb/s.

It is said to set new standards for low power consumption in optical engines and modules, with up to 80% reduction in power on the transmit optics compared with conventional solutions.

Tailored specifically for the rigorous demands of intra-data-center operations and AI/ML workloads, Adtran's latest offering consumes less than 2pJ/bit, including the laser driver. This significantly undercuts existing industry standards, including those cited by co-packaged optics. The advance is set to extend the capabilities of Adtran's MicroMux family of small-form-factor pluggable transceivers.

A step towards meeting the needs of the rapidly expanding generative AI application market, Adtran's latest innovation addresses the growing demand for robust, high-capacity and environmentally friendly data processing solutions.

"As the importance of data volume and speed escalates, the demand for increased bandwidth and enhanced energy efficiency a ccelerates. Our introduction of the market's first 100Gb/s PAM4 single-mode VCSEL technology, scalable to 1.6Tb/s, epitomizes our proactive approach to tackling these emerging requirements. By pushing the limits of speed and significantly reducing power consumption, we're creating tomorrow's benchmarks," says Ross Saunders, general manager of optical engines at Adtran. "Our new technology promises to significantly improve intra-data-center connectivity and AI application efficiencies, merging high performance with long-term sustainability," he adds. "As we prepare for the leap towards 800Gb/s and 1.6Tb/s applications, we're enhancing the foundations of efficient, high-capacity data ecosystems worldwide."

Building on Adtran's MicroMux family, the new VCSEL technology leverages a short-cavity single-mode design and is based on indium phosphide. This enables it to operate across both O-band and C-band wavelengths, delivering 100Gb/s per channel. By stacking multiple single-mode lasers into arrays, this approach achieves throughput of 800Gb/s and 1.6Tb/s, ensuring superior performance with a significant reduction in power consumption and costs.

This enhanced energy efficiency presents an advantage for IP router and Ethernet switch faceplate density, says Adtran. Also, its versatility extends to supporting a wide array of applications from DR4/8/16 to various FR4 links within optical engines, all while maintaining power consumption below 200mW per lane.

"As applications such as generative AI proliferate and enterprises expand their AI clusters, the need for advanced optical interconnects capable of supporting Terabit connectivity has reached a critical juncture," notes Adtran's chief technology officer Christoph Glingener. "Our 100Gb/s PAM4 single-mode VCSEL technology meets this challenge head-on. It enables energy efficiency and the capacity for higher-density deployments while at the same time addressing manufacturing, testing and assembly costs," he adds. "This technology supports throughput of up to 800Gb/s and 1.6Tb/s, significantly reducing operational expenses while enhancing network capabilities. Our approach underscores a commitment to delivering sustainable, high-capacity networking solutions that break through existing barriers, readying networks for the next wave of AI infrastructure development."

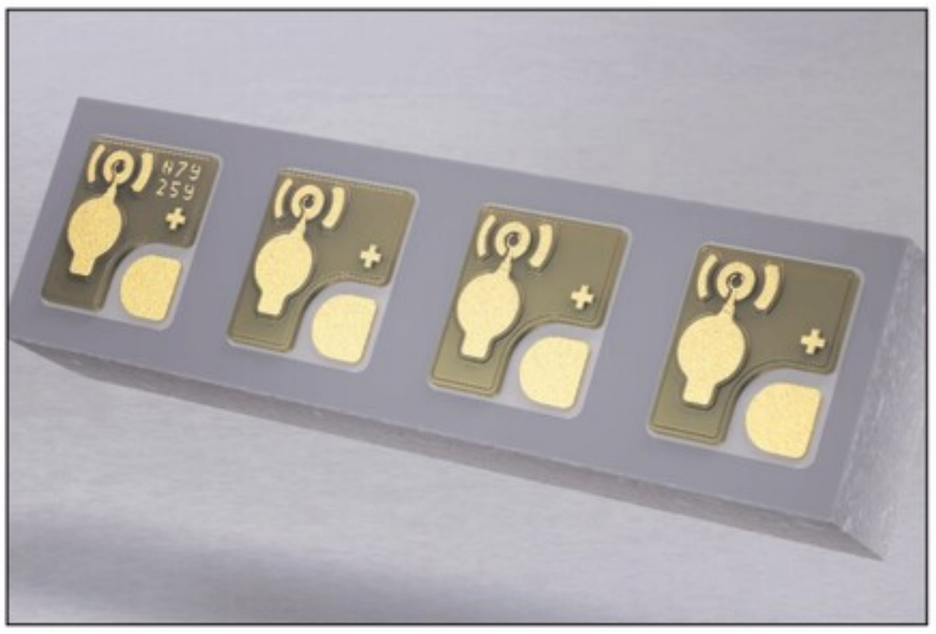
www.vertilas.com
www.adtran.com/en/products-and-services/open-

TRUMPF's 980nm VCSEL extends transmission reach to 500m using optimized multimode fiber

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 & heat treatment and automotive markets — has announced a transmission reach extended to 500m with its 980nm VCSEL and a multi-mode fiber optimized for this wavelength.

The results was presented in more detail by Jochen Hellmig, head of Technology & Application Development at TRUMPF Photonic Components, during his presentation at the Optical Fiber Communication conference (OFC 2024) in San Diego, CA, USA (26–28 March). TRUMPF continues to make progress towards its long-wavelength VCSELs and photodiodes for applications requiring expanded specs for wider temperature range and enhanced reliability.

"As a pure-play supplier of VCSEL and photodiodes, we are partnering with customers to develop long-wavelength solutions that address applications such as automotive in addition to traditional data center," says Ralph Gudde, VP of marketing & sales. TRUMPF says that it continues to invest heavily in its technology for 100Gbps and beyond. With fabs in Germany and Taiwan, the firm adds that it offers a more dependable supply chain to serve global demands.



TRUMPF's 1x4 VCSEL array for 56G.

The VCSELs are specifically designed to meet the demands of data centers, including for AI/ML, high-performance computing, and other bandwidth-intensive applications

Advanced optical data communication systems benefit from the high-speed data transmission that VCSEL-based technology offers. TRUMPF is offering both VCSELs and photodiodes as a matching-pair solution, in singlets, 1x4 and 1x12 arrays for 14G and 25G for the NRZ applications. The same is offered for 56G PAM4 applications. The VCSELs are specifically designed to meet the demands of data centers, including for AI/ML, high-performance computing, and other bandwidth-intensive applications, as they deliver stable and reliable data transmission at high speeds.

www.ofcconference.org

TRUMPF applies proprietary subwavelength surface-grating technology to datacom VCSELs

Grating key to improving polarization stability and signal performance in datacom VCSELs, paving way to 200G

TRUMPF Photonic Components has announced a "breakthrough" by transferring its proprietary, patented subwavelength surface-grating technology (developed since 2006 and implemented on tens of millions of VCSELs for sensing applications) from its sensing products to datacom VCSELs, where it is said to bring a competitive edge for the firm's 100Gbps VCSEL with lower relative intensity noise (RIN) and robust polarization stability.

"In addition, the ground–signal–ground (GSG) pad's layout further enhances the performance due to less cross-talk," says Ralph Gudde, VP of marketing & sales at TRUMPF Photonic Components. "With the addition of these new technology tools, we are well equipped to take the lead in VCSELs with data rates of 100G and beyond," he reckons.

The demonstration of the subwavelength grating on the datacom VCSEL showed a stabilized polarization mode, a key benefit among many others.

TRUMPF has also announced the future release of the 100G VCSEL which has a ground–signal–ground (GSG) pad layout to further enhance the performance. The firm says that the technology has proven itself, being the result of a long development process and having been demonstrated on many devices and in various applications.

TRUMPF Photonic Components exhibited at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March).

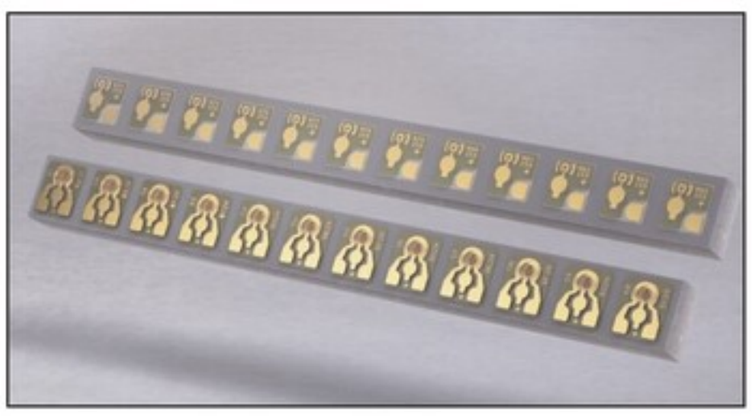
www.trumpf.com/s/VCSEL-solutions

TRUMPF and Optomind demo 100Gbps VCSEL in 800Gbps transceiver at OFC

Full-featured version of 100G VCSEL planned for production release in summer

At the Optical Fiber Communication conference (OFC 2024) in San Diego, CA, USA (24–28 March), 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 & heat treatment and automotive markets — demonstrated 100Gbps VCSEL performance together with customer Optomind Inc of Suwon, South Korea, which provides optical interconnect solutions for data centers including artificial intelligence (AI) and high-performance computing (HPC) networks. With increasing demand for multi-channel high-speed data transmission in artificial intelligence/machine learning (AI/ML)-based hyperscale cloud computing space, 800Gbps data rate at 100Gbps per lane and beyond is essential.

"We look forward to solidifying our partnership with TRUMPF as the strategic best-in-class VCSEL supplier for distinguished transceiver and active optical cable (AOC) to our customers," says Optomind's chief marketing officer Yung Son.



VCSEL and photodiodes as 1x1, 1x4 or 1x12 arrays. TRUMPF offers VCSEL and photodiode solutions as pairs. © TRUMPF.

"We are pleased to have collaborated with Optomind to demonstrate the performance of our VCSEL at PAM4 112Gbps/ch in their transceiver, which validates the use of it in a real-world application," says Ralph Gudde, VP of marketing & sales at TRUMPF Photonic Components. "A full-featured version of our 100G VCSEL is planned for production release this summer," he adds. "TRUMPF is diversified, has a strong technology background and brings solid long-term commitment as a technology partner and a key supplier into the datacom business."

Advanced optical data communication systems benefit from the high-speed data transmission that VCSEL-based technology offers, says TRUMPF. For interconnect distances of up to 100m, VCSELs are the best solution in terms of power, cost and the productivity of short-reach (SR) modules, it adds. TRUMPF is offering both VCSELs and photodiodes as a matching-pair solution, in singlets, 1x4 arrays and 1x12 arrays for 14G and 25G for NRZ applications. The same is offered for 56G PAM4 applications. The VCSELs are specifically designed and implemented to meet the requirements of hyperscale data centers including for AI/ML applications, high-performance computing systems, and other bandwidth-intensive applications, as they deliver high performance and reliable data transmission at high speeds.

www.ofcconference.org
www.optomindinc.com
www.trumpf.com/s/VCSEL-solutions

Lumentum unveils innovations & demonstrations at OFC

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has introduced the latest additions to its suite of photonic products at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March). Lumentum says that its innovations are designed to accelerate the speed, efficiency and scalability of cloud, artificial intelligence (AI), and networking applications. At OFC, the firm showcased its products and hosted demonstrations of its photonic technologies in its booth as well as partner booths.

"We are excited to share with the industry our latest innovations, including our highly differentiated and broad portfolio of photonics products and technology that enable cloud operators and cloud infrastructure providers to further scale AI data centers," says president & CEO Alan Lowe. "Our showcase at OFC 2024 highlights Lumentum's commitment to meeting the ever-increasing demands of AI, machine learning (ML), and next-generation communications networks."

Featured innovations and product demonstrations

- 200G per Lane InP Components: Lumentum is extending its indium phosphide (InP) transceiver component range with its new 200G Lens Integrated Photodiode (LIPD) that supports operation up to 200Gbps per lane, enabling next-generation 800G and 1.6T optical transceivers for large-scale AI and ML applications. Featuring high responsivity and bandwidth, the 200G LIPD is designed for seamless integration with flip-chip bonding techniques and is now available for sampling. The 200G LIPD complements Lumentum's high-volume, production-ready 200G externally modulated lasers (EMLs), giving optical transceiver manufacturers what are claimed to be best-in-class transmit and receive components for their next-generation 800G and 1.6T solutions.
- Ultra-High Power 400mW 1310nm DFB Laser: Lumentum is introducing an ultra-high-output-power 1310nm DFB laser capable of delivering 400mW of optical power at 50°C. This beta release is designed for co-packaged optics and silicon photonic 800G and 1.6T transceiver applications, offering a solution to reduce the required number of lasers, boosting power efficiency and reliability in large-scale AI and ML infrastructure. Lumentum is demonstrating its ultra-high-power 1310nm DFB laser at its booth.
- Data Center Connectivity Demo including Linear Receiver AOC: Lumentum is demonstrating data-center connectivity scenarios with a 51T switch, a server with a 4x100G NIC, and several of its Cloud Light 800G optical modules operating in a loopback configuration. The performance of a linear receive-only AOC connecting an 800G switch port and the server NIC are being shown in the demonstration.
- 400G QSFP112 DR1.2: Lumentum is also demonstrating its Cloud Light 400G QSFP112 DR1.2 module, which features a 4x100G electrical interface and produces two wavelengths (1290nm and 1310nm), each operating at 200G.
- 400/800ZR+ Modules: Lumentum demonstrated its 800ZR+ OSFP module operating at 118GBaud 16QAM. Designed to be used in direct router interface applications, performance was demonstrated over a more than 400km amplified optical link, highlighting the suitability for extended DCI and metro applications. In addition, a high-power 400ZR+ QSFP-DD was operated over the same link, showing the high performance possible in existing long-haul networks using pluggable modules.
- OIF 400ZR/800ZR Interoperability and CMIS: At OIF's booth, Lumentum highlighted the interoperability of its 800ZR and 400ZR transceivers with QSFP-DD- and OSFP-equipped switches and routers for IP over DWDM, supporting up to 800Gbps and complying with OIF standards. Additionally, demonstrations of Lumentum's OpenZR+ and 400ZR QSFP-DD transceivers emphasized the benefits of the CMIS standard for efficient module management and interoperability, enabling precise control over status, optical channels and power across various applications.
- D22 Series Pump Module: This dual-chip 980nm pump laser module offers individual control over each emitter. It integrates Lumentum's 980nm diode lasers into a compact, hermetically sealed design, delivering exceptional optical power density. The D22 series provides a noise-free, narrowband spectrum and maintains peak performance across various temperatures and current levels. It is suitable for applications demanding superior spectrum control and high-power output, offering up to 2x1100mW.
- 49M Series Multimode Pump Module: Available with 4 or 6 emitters at 980nm, the 49M series delivers powerful output of 40W or 60W while maintaining a compact footprint. Its innovative design simplifies thermal management, supporting both air- and water-cooling systems. This versatility makes the 49M Series suitable for a range of applications, including vacuum, space and terrestrial EDFA pumping.
- Tunable SFP28 ER Module: Designed for industrial temperatures, this high-performance optical transceiver supports 25Gbps DWDM links over distances up to 40km. It offers an upgrade for cable MSOs facing increasing bandwidth demands driven by DOCSIS 4.0 and FTTH deployments. Additionally, it enhances 5G transport network connectivity, leveraging existing C-band fiber infrastructure. Lumentum is demonstrating the capabilities of this new tunable SFP28 ER module at its booth.

www.ofcconference.org
www.lumentum.com/en/ofc-2024

Lumentum enhances performance of 800ZR+ transceivers for broader applications

Transceivers transforming metro and regional networks and unlocking new possibilities in long-haul applications

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has announced performance enhancements to its 800ZR+ transceivers that enable the modules to serve a wider range of applications, including expanded use in metro and regional networks through the ability to interface directly into routers. Additionally, the enhanced performance modes now make 400ZR+ and 600ZR+ operation suitable for true long-haul applications, with optical signal-to-noise ratio (OSNR) and dispersion tolerance enabling reaches exceeding 2000km at 400Gbps. Lumentum's 800ZR+ transceivers were recently recognized in the 2024 Lightwave Innovation Review Awards and were demonstrated in a 400km+ amplified link at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March).

Lumentum has optimized its latest generation of 800ZR+ modules to maximize performance, while maintaining a compact QSFP-DD and OSFP form factor. Currently available for sampling, the modules employ Lumentum's latest hybrid photonic integrated circuit (PIC) technology, which incorporates both the company's indium phosphide PICs and silicon photonics. The performance and use-case flexibility provided by the modules mark a significant step in the evolution of high-speed communications networks, reckons the firm.

"Lumentum's unique photonic component capabilities and innovative module designs, together with our partners' latest-generation coherent DSPs, enable us to provide solutions that dramatically increase scalability for both cloud and telecom network operators," says Wupen Yuen, president of Cloud and Networking at Lumentum. "Our advancements also help address the challenges of scaling data-center interconnects for the bandwidth needs related to artificial intelligence and machine learning," he adds.

"Our new 800ZR+ and 400ZR+ modules enhance cost efficiency in applications spanning DCI [data-center interconnect] to metro and long-haul applications, with significant improvements in optical power and optical signal-to-noise ratio," says Marc Stiller, VP of product line management. "They represent a major advance in reducing cost and power per bit versus existing technologies."

Demand for 400ZR and 400ZR+ modules has surged, particularly for data-center interconnect applications, with the ecosystem of transceiver modules, routers and system software having reached maturity and critical mass for widespread adoption. Escalating demands for bandwidth to support advanced artificial intelligence and machine learning applications are accelerating the need to transition to higher-speed 800Gbps modules. With enhanced performance, including higher output power and reach, these latest coherent pluggable modules are also increasingly able to meet the stringent requirements of traditional telecom metro and long-haul applications, while offering increased deployment flexibility and cost, size and power savings versus traditional solutions.

www.ofcconference.org
www.lumentum.com

Coherent showcases new products & technology at OFC

At the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March), materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA showcased its new products and technologies for next-generation optical communications networks, as well as presenting at panels, technical sessions, and other OFC events.

Recent product announcements

● *Significant Advancements in VCSEL Performance*

Bandwidth improvement in Coherent's vertical-cavity surface-emitting laser (VCSEL), paving the way for use in next-generation optical interconnects that will operate at 200Gbps per lane. 200Gbps VCSELs are expected to power future 1.6Tbps transceivers.

● *6-inch Indium Phosphide Semiconductor Wafer Fabs*

6-inch InP wafer fabrication introduced in both Coherent's US and European fabs to significantly reduce die cost for InP optoelectronic devices including lasers, detectors and electronics.

● *I-Temp 100G ZR QSFP28-DCO Module*

Industry-first 100G ZR QSFP28 digital coherent optics (DCO) transceiver supporting an industrial operating temperature range; designed for deployment in outdoor environments, this module utilizes Coherent's Steelerton digital signal processor (DSP), a purpose-built DSP component family launched in 2022, in conjunction with an efficient silicon photonics optical front-end and a power-optimized tunable laser.

● *High-Power Uncooled Pump Laser Module*

New uncooled pump laser modules able to deliver, in a compact 10-pin form factor, up to 1000mW of output power for submarine applications and up to 2x700mW of output power for terrestrial applications.

● *Bi-Directional Circulator Adaptor*

Bi-di circulator adaptor based on Coherent's vertically integrated circulator technology that enables bi-directional transmission over a single fiber between two transceivers in a compact footprint compatible with all transceiver LC connector ports.

● *Extended C+L-Band Grism*

A family of advanced, aberration-correcting, high-efficiency grisms and transmission gratings capable of encompassing the entire extended C+L band in a single optic.

● *Microlens Array (MLA) Solution*

Comprehensive and versatile platform for advanced collimation, focusing and beam-shaping capabilities in a highly compact package: suitable for high-speed communication transceivers and modules, optical circuit switches, and LiDAR systems.

Technology & product demos

● *Optical Circuit Switch for Datacenters*

300x300-port Datacenter Lightwave Cross-Connect (DLX), an optical circuit switch based on the firm's field-proven and ultrareliable digital liquid-crystal technology to enable new AI network architectures that replace traditional packet switches with optical circuit switches.

● *200G per lane Linear Pluggable Optics for 800G*

Demonstration of linear pluggable optics performance with 200Gbps PAM4 electrical and optical lanes in an 800G-DR4 transceiver platform.

● *800G ZR/OpenZR+ QSFP-DD-DCO*

Demonstration of 800G QSFP-DD-DCO in various setups: over an optical link of 450km fiber, in data-center router, and at the OIF booth with 400G and 800G interoperability demo.

● *100G ZR QSFP28-DCO I-Temp Module*

Demonstration of the industry's first 100G QSFP28 ZR supporting an industrial operating temperature range (–40°C to 85°C). The coherent transceiver is integrated with in-house purpose-built DSP, silicon photonics optical engine, and tunable laser.

● *C+L-Band Transport Product Modules*

Demonstration of ultrawide-band OCM, C+L-band EDFA, and 3x33 Flexgrid C+L-band twin wavelength-selective switch (WSS) to meet the increasing demand for the expanded transmission bandwidth in DCI, metro and long-haul applications.

Test and measurement

● *WaveMaker 4000A/X Programmable Optical Spectrum Synthesizer for C+L-Band Operation*

A compact, integrated source offering an out-of-the-box solution to provide suitable test signals for C+L-band systems.

● *WaveShaper 1000B/O Programmable Optical Filter/WaveShaper 4000B/O Programmable Optical Processor*

A Lightwave Innovation Reviews award recipient, this instrument concept is an enabler for testing WDM systems in the O-band, with a spectral range that covers all channels of LR4, LR8 and CWDM transmissions schemes.

Panels

● Show Floor Panel: Mobile Optics (MOPA) for the 6G Era: panelist Gert Sarlet.

● Data Center Summit — DCS Panel I: ML/AI and Future Networks to Support It: organizer Sanjai Parthasarathi; panelist Vipul Bhatt.

● Show Floor Programs — CableLabs: Empowering Access Networks with Coherent Optics: speaker Shawn Esser.

● Show Floor Programs — Coherent Optics Unleashed: From 400ZR Success to 800ZR/LR Advancements and 1600ZR Kick-off: speaker Gert Sarlet.

Conference sessions and paper

● Session M2D: VCSELs and Modulator Technologies: presenter Stefano Tirelli.

● Session W3A: Transmitters and Receivers: presenter Efthymios Rouvalis.

● Session Th1B: Datacom: VCSELs, Multi-Lambda Sources, Spatial Multiplexing: invited speaker Vipul Bhatt.

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ZSW and First Solar partner on thin-film PV research

Focus on performance and developing and optimizing all-thin-film tandem technologies on gigawatt scale

Germany's ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung — or Center for Solar Energy and Hydrogen Research — Baden-Württemberg) and cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA have announced a strategic research partnership focused on advancing thin-film photovoltaics (PV). The partnership will focus not only on performance but also on the potential to develop and optimize all-thin-film tandem technologies on a gigawatt scale.

As a research institute with over 30 years of experience and knowledge in thin-film photovoltaics, ZSW's main objective has been materials development and processes for technology transfer to production. This has been pursued for decades for the copper indium gallium diselenide (CIGS) thin-film technology developed by ZSW researchers. For more than 10 years their process development has also been advancing in the rapidly evolving field of perovskite photovoltaics, with a focus on scaling robust processes on both rigid and flexible substrates.

In 2023, First Solar acquired perovskite technology firm Evolar AB of Uppsala, Sweden. Evolar's laboratory has since become First Solar's European Technology Center, with about 30 of its R&D staff transitioning to First Solar, working in close collaboration with the company's team of about 60 scientists at its advanced research technology center in Santa Clara, California, and the development teams in Perrysburg, Ohio.

Tandem solar cells can better use the solar spectrum by splitting the absorption of sunlight in a top and a bottom cell. Furthermore, as every tandem contains at least one layer of thin-film solar cell, the development of thin films is of key importance to the next generation of solar technologies.

Additionally, thin-film PV production allows for reduced supply chain challenges in parallel to optimized CO_2 footprints, both of which have gained increased attention in recent years. From the material perspective, compound semiconductors are particularly suited to tandem cells as the bandgap can be tuned by composition engineering to match the spectral needs of the top and bottom cells.

Other potential areas of research include the optical adaption of the stacked cells and the specialized characterization techniques. The overall goal of the research partnership is to explore opportunities to make thin-film modules more efficient through better use of the solar spectrum.

www.zsw-bw.de

First true ternary near-IR III–V nanowire-lasers

Silicon-transparent wavelengths have been achieved at near to room temperature.

Researchers based in Germany have demonstrated lasing from single, ternary gallium arsenide antimonide (GaAsSb) nanowire (NW) lasers, accessing wavelengths at which silicon (Si) is transparent and at temperatures close to room temperature [P. Schmiedeke et al, Appl. Phys. Lett., v124, p071112, 2024].

The team from Technical University of Munich, and Ludwig-Maximilians-University Munich, comments: "These advanced and, in fact, first true ternary near-infrared III–V NW lasers were enabled by two key factors, i.e. GaAsSb NWs with suitable cavity lengths and the

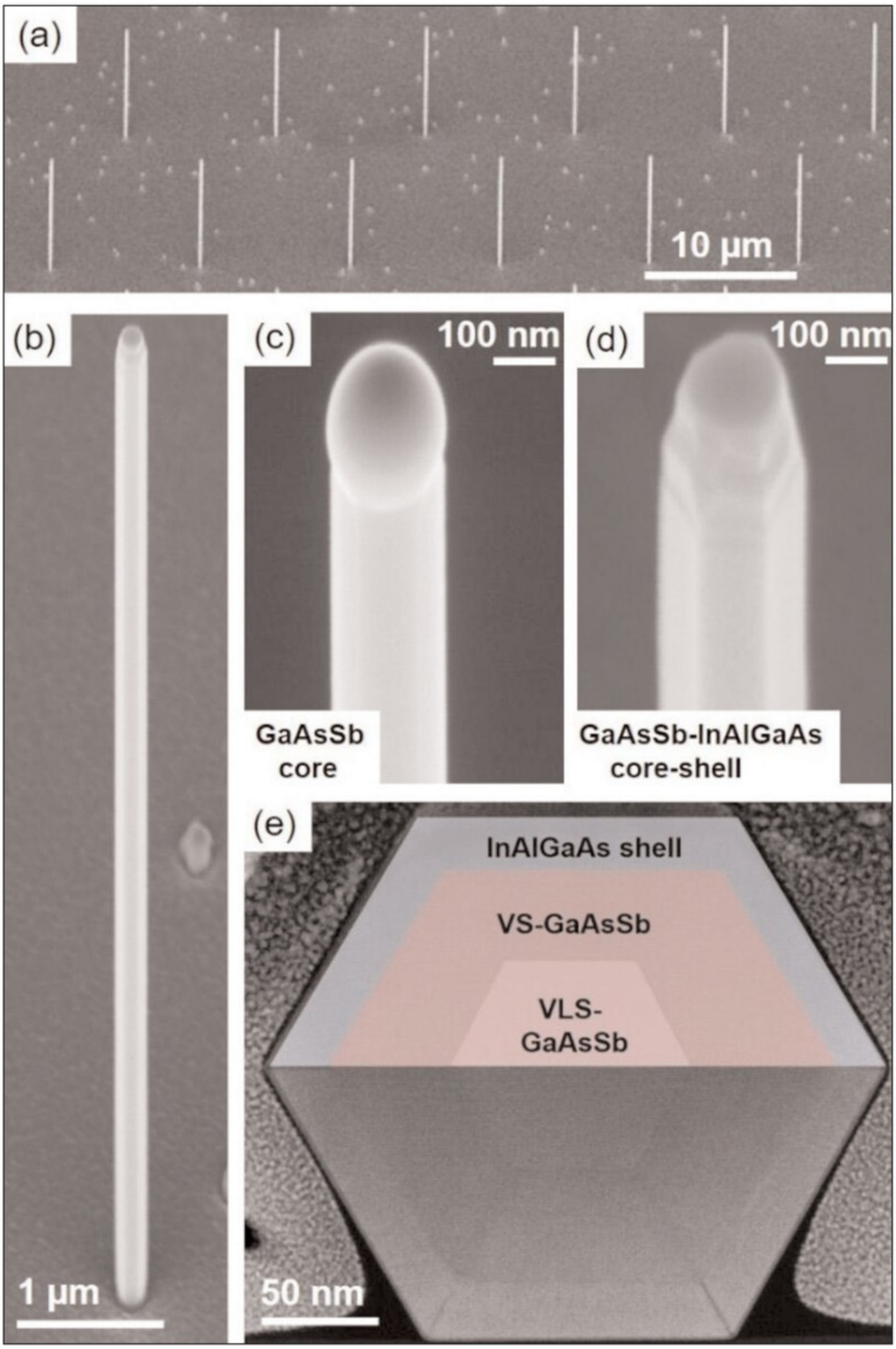

Figure 1. Scanning electron microscope (SEM) images of InAlGaAs-passivated GaAsSb NWs (~20% Sb-content): (a) overview image of array at 10µm pitch; (b) higher magnification of a single NW; (c) core-only GaAsSb reference showing Ga droplet at tip; and (d) corresponding image of core–shell GaAsSb–InAlGaAs NW. (e) Cross-sectional scanning transmission electron microscopy high-angle annular dark-field (STEM-HAADF) image and overlaid, color-coded schematic of the GaAsSb–InAlGaAs core–shell structure.

Figure 2. (a) SEM image of InAlGaAs-passivated GaAsSb NW laser; (b) photoluminescence (PL) spectra under low pump fluences; and semi-logarithmic plots of PL spectra under higher pump fluences at 10 (c) and 250K (d).

exploitation of lattice-matched indium aluminium gallium arsenide (InAlGaAs) surface passivation with >200-fold emission efficiency enhancement. The high-quality NW lasers were reflected by very low lasing thresholds (~3μJ/cm^2 at 10K and ~45μJ/cm^2 at 250K) that are competitive with the best ever reported III–V NW lasers in the literature."

Binary III–V NW lasers require complex heterostructures to massage the wavelength into the silicon-transparent region longer than 1.1μm. Such wavelength are needed for silicon photonics, and other high-speed optical communication systems. Ternary material lasers would use the bulk material as the lasing medium. Up to now, ternary NW lasers have been size limited and needed external-cavity structures to operate in the silicon-transparent region. The Munich NWs use their own intrinsic resonator cavities as the lasing medium.

The NWs (Figure 1) were produced on pre-patterned silicon dioxide/silicon (SiO_2/Si(111)) substrate via selective-area molecular beam epitaxy (MBE). The researchers used a recently developed self-catalyzed vapor–liquid–solid (VLS) growth scheme.

The GaAsSb NW lasers were grown on a 0.3μm GaAs NW nucleation stem. The laser cavity length of the NWs was around 5.2μm. The GaAsSb growth temperature was 660°C, aiming at an antimony content of 25%. The core diameter was about 260–270nm, while ~30nm quaternary $In_{0.5}Al_{0.17}Ga_{0.33}As$ was added as shell passivation. The shell growth temperature was 420°C.

A study using energy-dispersive x-ray spectroscopy (EDXS) on NWs with slightly different compositions (~20% Sb-content) suggested that the GaAsSb core consisted of two regions: an inner part with a higher Sb content of 20% and an outer region with a lower content of 15%. These compositions were found to be uniform along the growth axis.

The team comments: "The center (Sb-rich) region is attributed to the VLS-GaAsSb growth along the NW axis, whereas the surrounding region stems from a spontaneous vapor–solid (VS) sidewall growth that stabilizes the non-tapered NW morphology via step-flow growth."

For the lasers, the inner and outer Sb contents increased to 25% and 20%, respectively, with a view to shifting the spectral response to wavelengths longer than 1.2μm.

A single NW lying on sapphire was subjected to optical pumping at 10K and 250K (Figure 2). Lasing occurred at higher pump power with distinct peaks at energies between ~1.06eV and 1.15eV. Below threshold, the spectrum peaked around 1.28μm wavelength. At 10K, the transition from amplified spontaneous emission to lasing began around 11μJ/cm^2. The 250K peaks were shifted about 50meV in energy, reflecting thermal bandgap narrowing. The lasing thresholds for 10K and 250K were 12.1μJ/cm^2 and 45.2μJ/cm^2, respectively. One NW had a 10K laser threshold as low as 3.2μJ/cm^2.

The researchers attribute the laser emissions to the HE11 modes of the laser cavity. Lower laser thresholds could be accessed from TE01 modes, but this would require NWs of diameter larger than 400nm for this wavelength range. ■

https://doi.org/10.1063/5.0191070

Author: Mike Cooke

Triple-lattice photonic crystal laser

Surface-emitting device achieves low threshold and high output power.

China's Changchun Institute of Optics, Fine Mechanics and Physics, and University of Chinese Academy of Sciences have reported continuous-wave operation of a 1550nm low-threshold triple-lattice photonic-crystal surface-emitting laser (PCSEL) on indium phosphide (InP) substrate [Ziye Wang et al, Light: Science & Applications, v13, p44, 2024].

The team comments: "Our results present an opportunity for InP-based high-speed 1.557μm PCSELs, which are expected to play an essential role in high-speed optical communication and LiDAR applications."

The 1.55μm range transmits though optical fiber with minimum loss, and features eye-safety up to higher power. However, traditional lasers suffer from poor performance due to high interband absorption in this range. The PCSEL structure can deliver strong optical feedback to overcome this, reducing thresholds and improving output power.

Photonic crystals consist of two-dimensional structures of different refractive index that create in-plane resonance from interference of the reflected light waves.

The researchers explain: "Light amplification and lasing are realized at the band edge by forming a broad-area standing wave in the lateral direction, with the light extracted from the normal direction by first-order diffraction. A narrow-divergence far-field pattern can be achieved due to the broad-area coherent resonance."

The researchers used a photonic crystal of holes filled with low-refractive-index InP in a triple-lattice formation (three holes per unit cell). A higher index contrast could be achieved with air-voids, but such structures suffer from manufacturability and reliability problems.

The team comments: "We believe that PCSELs with smaller cavity and lower threshold current can be obtained by combining the advantages of strong feedback of triple-lattice photonic crystal and high dielectric contrast of void-containing resonator, if the manufacturability and reliability are solved in future."

The material for the device (Figure 1) was grown by metal-organic chemical vapor deposition (MOCVD) on n-InP substrate. The multiple quantum well (MQW) active region consisted of indium aluminium gallium arsenide (InAlGaAs) grown on an n-InP cladding layer. The first growth sequence was completed with a p-InAlAs electron-blocking layer and p-InAlGaAs.

The photonic crystal consisted of a square lattice of three offset holes, created by electron-beam lithography

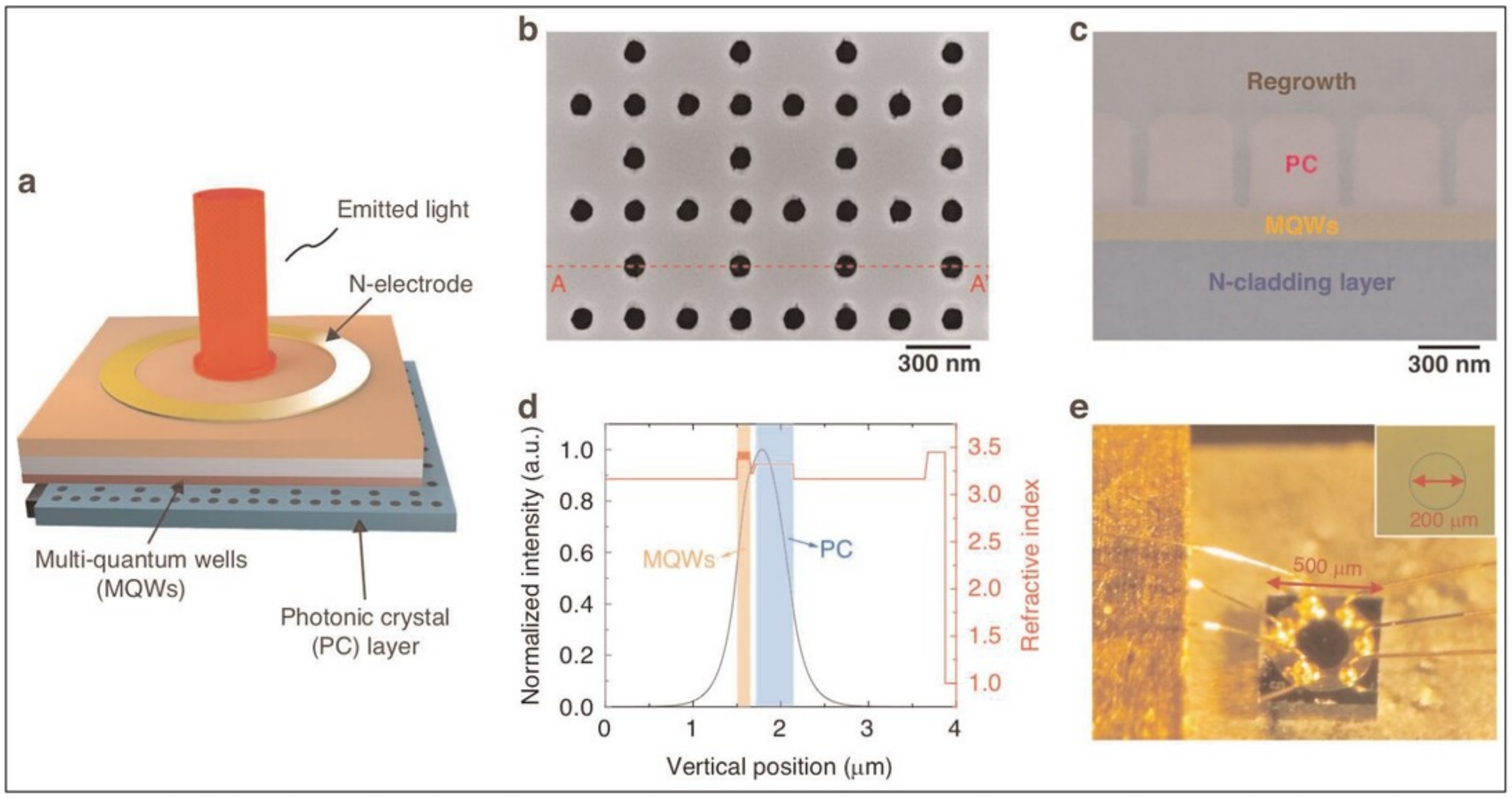

Figure 1. a PCSEL schematic. b Top-view scanning electron microscope image of triple-lattice photonic-crystal resonator. c Cross-sectional SEM image of resonator after epitaxial regrowth. d Refractive index profile and corresponding optical field distribution along crystal growth direction. e Images of laser chip bounded to thermally conductive submount with p-side down. Inset: p-side of chip.

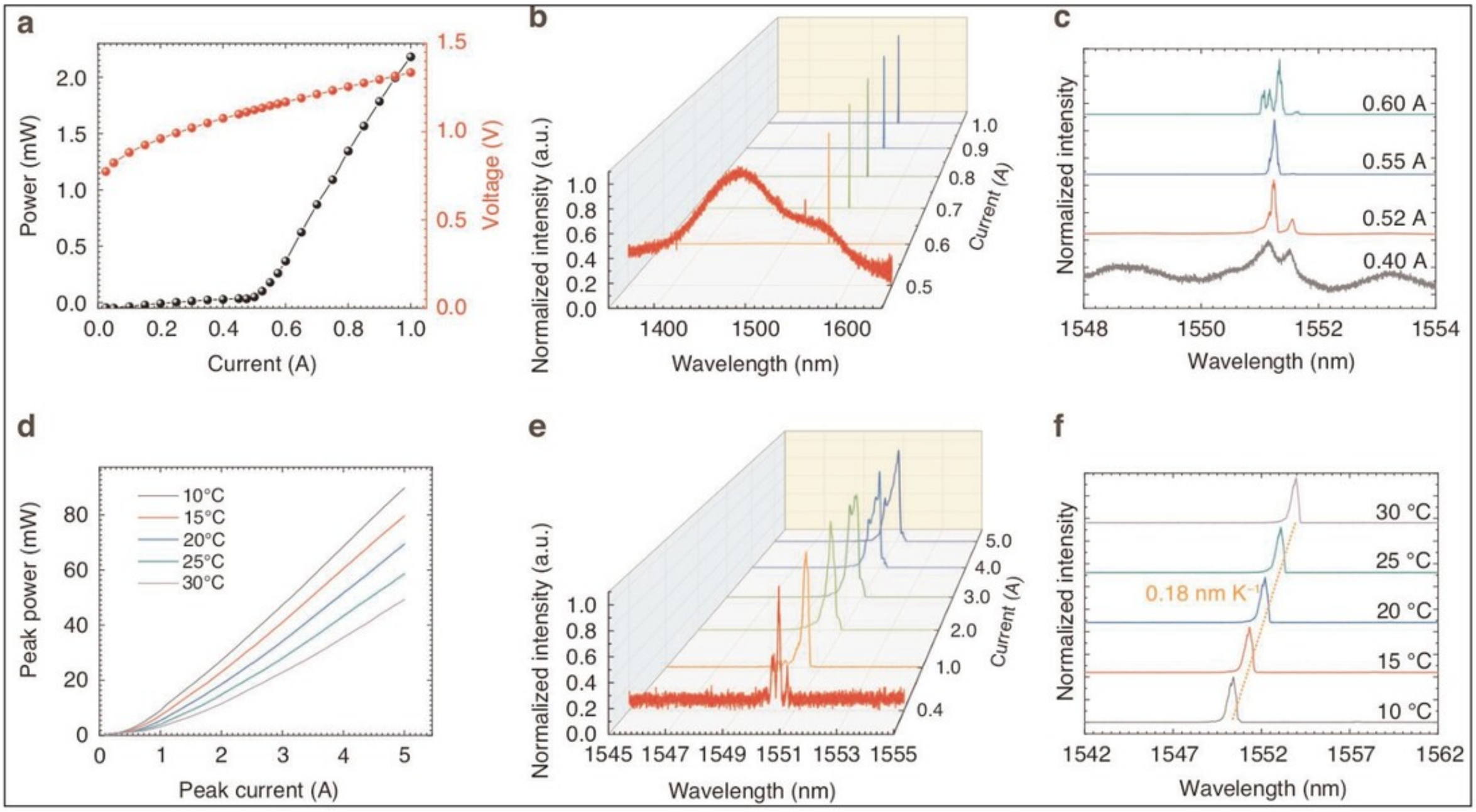

Figure 2. a Light–current–voltage characteristics under continuous-wave (CW) conditions at 10°C. b Emission spectra at various CW injection currents. c Magnified spectra near peak wavelength around threshold. d Light–current characteristics at various temperatures under pulsed conditions. e Emission spectra of pulsed lasers at various injection currents at 10°C. f Temperature dependence of emission spectra at 1A.

and inductively coupled plasma etch to a 375nm depth in a square 300μm region. The holes were filled by MOCVD regrowth of low-dielectric-constant InP.

This was followed by 50nm p-InAlGaAs and then 30nm grading to the p-InP cladding layer. The material structure was completed with p-InGaAs for the contact layer.

The photonic crystal holes were 90nm diameter. The photonic lattice constant was 474nm. The holes were arranged with a view to maximizing the 180° coupling to the optical field of the PCSEL. The mutual interaction of the nested lattices increased the 180° coupling threefold with respect to that of a single-lattice case, according to the team.

The researchers add: "The data show that the enhancement of the in-plane optical feedback significantly reduces the lasing threshold compared with the double-lattice PCSELs."

The PCSELs were fabricated with substrate thinning to 180μm, circular mesa etching, 300nm silicon dioxide electrical insulation, and a 200μm-diameter reactive-ion etched circular contact window. The p-electrode and n-electrode metals were, respectively, titanium–platinum–gold and nickel–gold/germanium–nickel–gold.

The device was mounted p-side down on copper.

The output power of the device reached 2.1mW at 1A CW current injection (Figure 2). The threshold current was 0.52A (1.66kA/cm^2 density). Spectra over the range 1350–1650nm showed emissions only around the 1551nm target wavelength. Above 0.6A injection the emissions were multi-mode. The maximum output power was 89mW with 5A pulsed current injection.

The researchers also present a comparison with recent achievements in PCSEL research in this wavelength range (Table c). ■

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Author: Mike Cooke

Table 1. Recent ~1.5μm PCSEL achievements. Top line is PCSEL in this report.

Year	Wavelength (μm)	Threshold	Maximum output power (mW)	Slope efficiency (W/A)	Structure
2023	1.55	1.66kA/cm^2	89	0.02	all-semiconductor
2023	1.55	2.0kA/cm^2	120	0.056	void-containing
2022	1.56	180 mA	12.58	0.016	Fabry–Pérot coupled
2020	1.52	1.6kA/cm^2	0.5	0.002	void-containing

Cascading VCSELs to boost power efficiency

Room-temperature performance comparable with edge-emitting devices.

Sichuan University and Suzhou Everbright Photonics Co Ltd in China have reported cascaded vertical-cavity surface emitting lasers (VCSELs) with up to 74% power conversion efficiency (PCE) at room temperature [Xiao et al, Light: Science & Applications, v13, p60, 2024].

By stacking VCSELs, the design increases optical gain multiplicatively, overcoming resistance and other internal losses that impact efficiency.

Single VCSELs have lower power efficiency compared with edge-emitting lasers (EELs) in general. For one device, the researchers report a differential quantum efficiency exceeding 1100% which, along with the 74% PCE, represents "the largest electro-optical conversion efficiency and differential quantum efficiency reported until now for VCSELs". The researchers also believe that the differential efficiency is a present world record for all types of semiconductor laser.

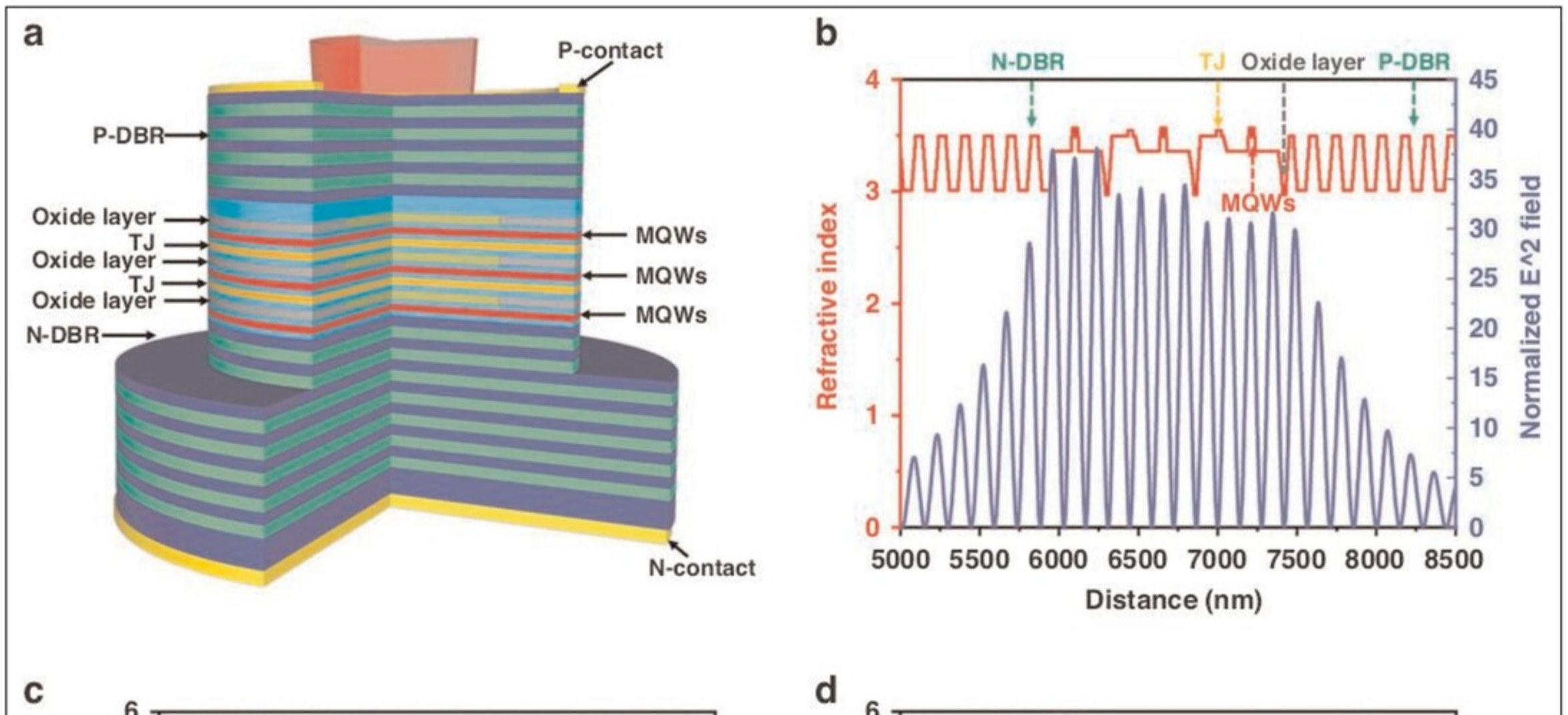

Figure 1. a Structural schematic diagram; b refractive index distribution, standing-wave light-field distribution; c active-region band structure of three-junction VCSEL under bias. d Tunnel-junction band structure under bias.

The researchers comment: "This performance improvement offers a potent solution to the energy consumption issues of VCSELs in their widespread future applications. Considering this, we plan to further explore the potential applications of multi-junction VCSELs in the field of communication in the future."

For communications the series connection of multiple VCSELs reduces the capacitance of the resonant cavity. The researcher comment: "The increased gain volume allows us to maintain a low threshold while reducing the top reflectivity, thereby decreasing the photon lifetime and enhancing the modulation bandwidth".

High power is also particularly useful for time-of-flight 'laser radar' (LiDAR) for longer-range mapping.

Founded in 2012, Suzhou Everbright Photonics Co Ltd is a company specializing in high-power diode laser chips, and high-efficiency LiDAR, 3D sensing, high-speed optical communication and related optoelectronic systems.

The design for the cascaded VCSEL (Figure 1) included an N-type distributed Bragg reflector (N-DBR), P-DBR, multiple quantum wells (MQWs), oxidation layers, and tunnel junctions (TJs) connecting the stages. The aim was to place the wells at anti-nodes, and the oxide apertures and TJs at nodes, of the optical field. Having the wells at points of maximum oscillation, one would enhance the coupling efficiency between carriers and photons, increasing optical gain. Loss from free-carrier absorption in the TJ was reduced by positioning at a node.

The material was grown using metal-organic chemical vapor deposition (MOCVD). The DBRs used aluminium gallium arsenide (AlGaAs) alloy layers of different compositions. The quantum wells were 7nm indium gallium arsenide (InGaAs) with 6nm gallium arsenide phosphide (GaAsP) barriers. The MQW structures consisted of three wells. The

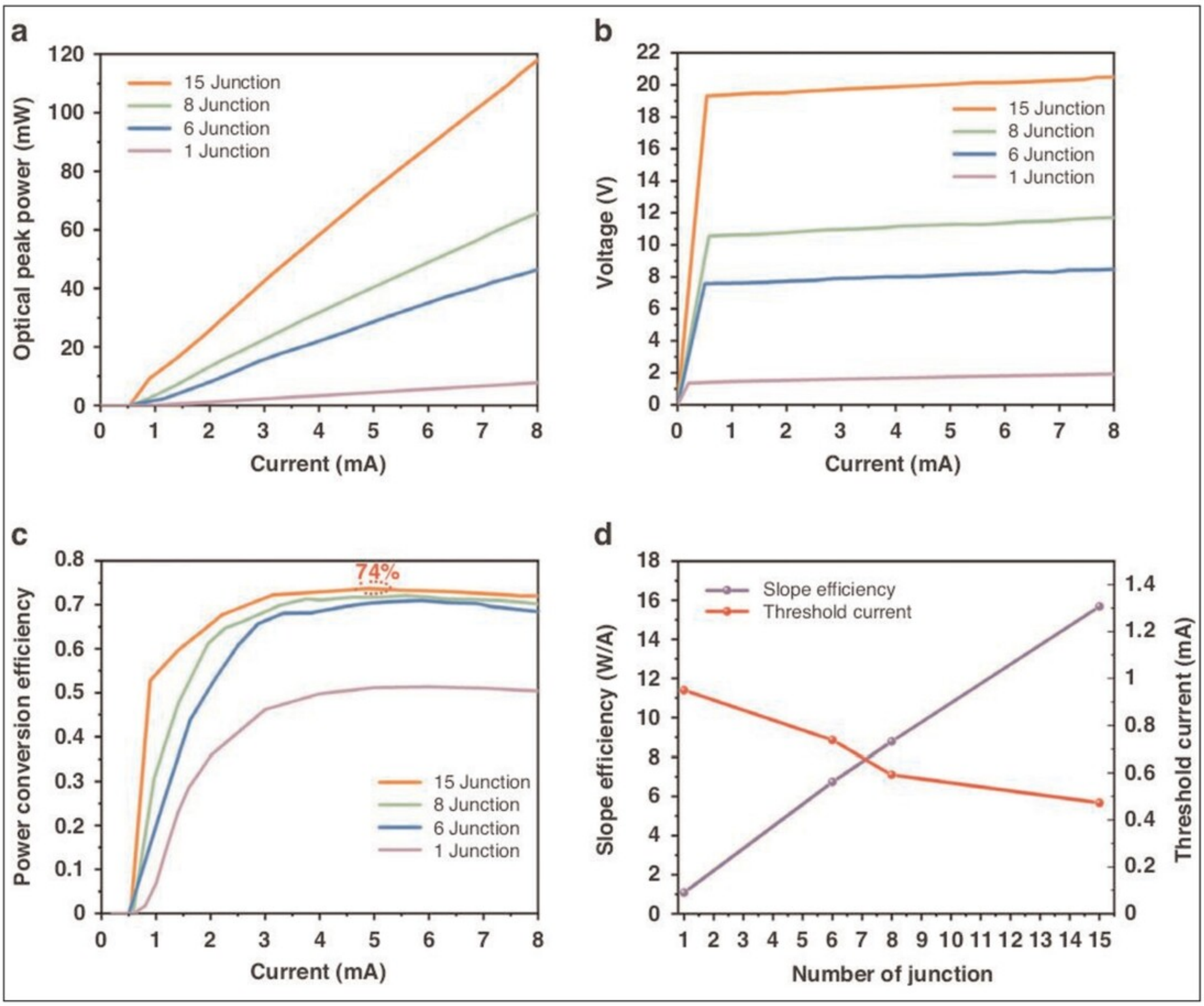

Figure 2. VCSEL cascade performance with different numbers of junctions: a, b Light output power, current, and voltage (L–I–V); c PCE of different numbers of junctions; d slope efficiency and threshold current.

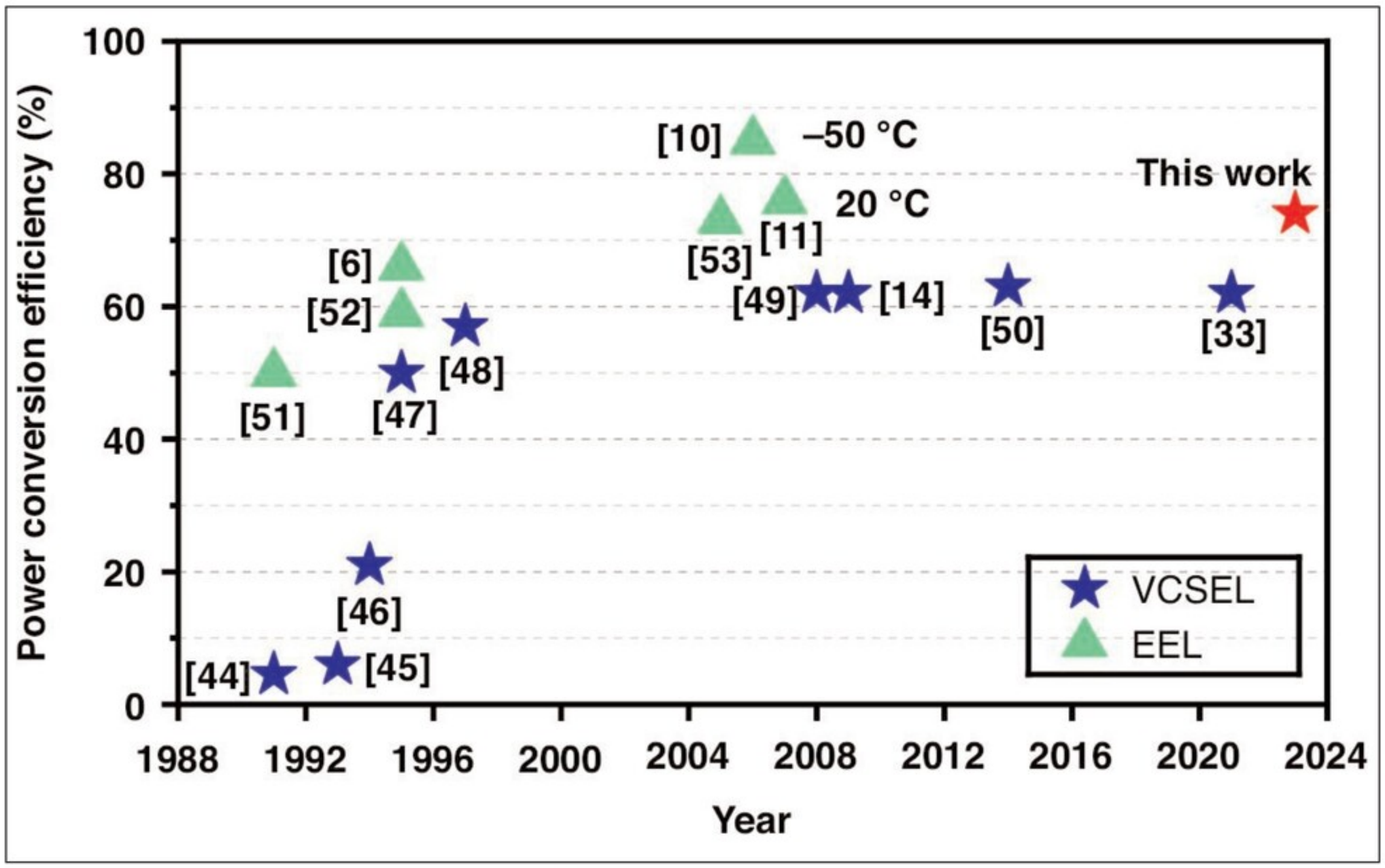

Figure 3. Summary of reported semiconductor laser PCEs for VCSELs and edge-emitting lasers.

oxidation layers were 20nm AlGaAs. The TJs were 15nm GaAs, suitably doped.

The oxidation apertures were formed during fabrication after mesa etching by exposure to high temperature and humidity conditions, oxidizing the high-aluminium-content AlGaAs material, leaving a 10μm-diameter aperture in the non-oxidized core. Passivation was provided by plasma-enhanced CVD silicon nitride (Si_3N_4). The substrate was reduced to 80μm for testing.

Fabricated devices were operated under 20ns pulses at 0.1% duty cycle (50kHz). A 15-junction VCSEL achieved 100mW peak power at 7mA injection (Figure 2). The maximum electro-optical conversion, slope, and differential quantum efficiencies were 74%, 15.6W/A, and more than 1100%, respectively.

The turn-on voltage of 19V for the 15-junction device is seen as being advantageous for short-pulse, high-modulation-rate applications. "Electrical signals with high voltage are more conducive to generating extremely short pulse widths and higher-modulation-rate signals compared to high-current signals," the researchers explain.

The threshold current showed a declining trend with number of junctions, despite a reduced top DBR reflectivity in the VCSELs with larger numbers of junctions. The researchers believe that optimizing the top DBR reflectivity could reduce the threshold further.

Simulations suggest that a 20-junction device could reach 88% PCE. Apart from the top DBR reflectivity, the researchers believe that inconsistent quality between the top and bottom MQWs impacted the performance of the actual 15-junction VCSEL cascade.

Study of the far-field emission showed the divergence angle increased with the number of junctions. A six-junction VCSEL cascade had a divergence of 28.8°.

The team comments: "A large divergence angle is disadvantageous for many application scenarios, hence existing multi-junction VCSELs used in LiDAR typically reduce the number of oxide layers to decrease the divergence angle. In 2022, we reported that, through the design of the oxide layers, the divergence angle in an eight-junction VCSEL was reduced to 18° for short-pulse driving current."

The emission wavelengths of the devices was in the 940–950nm range. As the number of junctions increased, the number of excited modes increased.

Based on a power consumption analysis, the team believes the improvement in PCE with the number of junctions is mainly attributable to reductions in Joule heating and in internal losses from free-carrier absorption.

The researchers compare their 15-junction device with other reported semiconductor lasers (Figure 3), commenting that it "marks not only a significant improvement in VCSEL efficiency over the past two decades but also essentially reaches a level comparable to the highest power conversion efficiency of EELs under room-temperature conditions." While EELs have achieved 86% at low temperature, the room-temperature PCE of 76% is comparable with the 74% performance of the 15-junction VCSEL. ■

https://en.everbrightphotonics.com/

https://doi.org/10.1038/s41377-024-01403-7

Author: Mike Cooke

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Recycling GaN for vertical power device performance

Researchers see potential cost savings for key electric vehicle markets.

MIRISE Technologies Corp, Nagoya University and Hamamatsu Photonics K.K. in Japan have reported on the potential for recycling gallium nitride (GaN) substrates with a view to reducing costs for high-performance power devices [Takashi Ishida et al, Appl. Phys. Express, v17, p026501, 2024]. The team comments: "The proposed recycling process is an effective method for reducing the cost of GaN substrates and has the potential to encourage the popularization of GaN vertical power devices."

Vertical devices presented up to now tend to be produced on expensive freestanding or bulk GaN substrates. Lateral devices can be produced on lower-cost substrates, like silicon, particularly for the lower voltage ratings.

Previous work has investigated the electrical performance of lateral GaN high-electron-mobility transistors (HEMTs) on GaN substrate before and after the laser slicing process that is used to reclaim the expensive GaN substrate. A thick epitaxial layer was added to the reclaimed wafer after slicing, but the electrical properties of devices fabricated on such recycled wafers has not been reported previously.

The potential of GaN as a premium material for power electronics is based on a high critical field (~10x that of silicon) and high channel mobilities (~2x those achieved in devices on silicon carbide, SiC). Another advantage of GaN over SiC is a lower epitaxial growth temperature, which reduces production cost.

MIRISE was founded in 2020 to carry out "research and development of in-vehicle semiconductors and development of electrical components that use semiconductors". The company is jointly owned by DENSO Corp (51%) and Toyota Motor Corp (49%). Hamamatsu Photonics produces optical sensors, light sources, and systems that use these components.

The researchers see high potential for vertical power devices in "high-power applications such as in-vehicle inverters that control main motors".

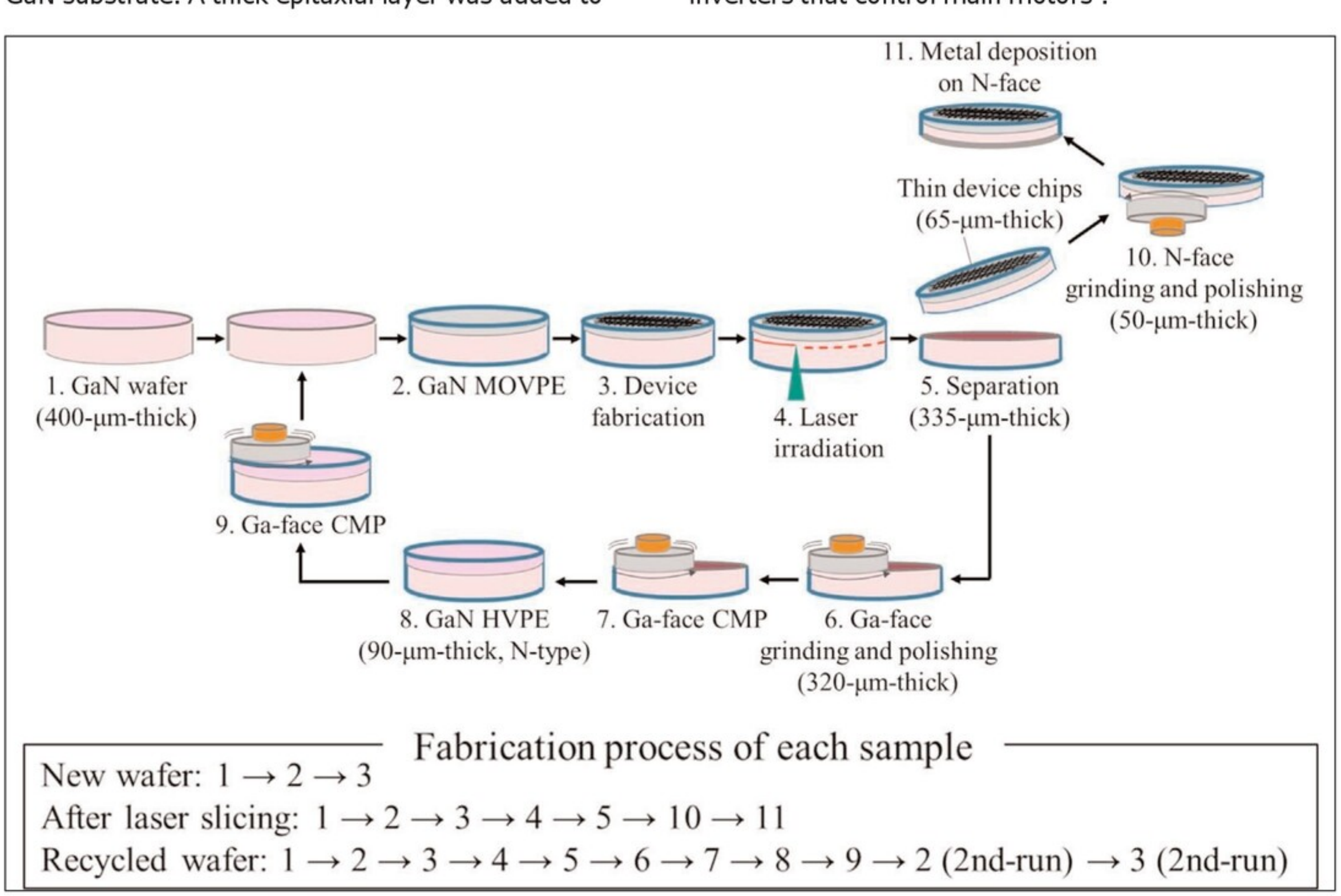

Figure 1. Overview of GaN substrate recycling through laser slicing.

The recycling consisted of separating a relatively thin layer with fabricated devices from the bulk of the GaN substrate (Figure 1).

The separation was accomplished using a 532nm focused laser beam from the N-side (bottom) of the wafer. The GaN decomposed into Ga metal and N gas at the focal plane in a two-photon absorption process. The focal plane could be adjusted to give different thicknesses for the separated wafer.

After the separation the rough separation surfaces were smoothed by grinding and polishing before further processing.

For the device wafer, processing was completed with deposition of the N-side metal and assembly into packages. The recycled wafer was subjected to chemical mechanical polishing (CMP) and hydride vapor phase epitaxy (HVPE) to return it to a state ready for further metal-organic vapor phase epitaxy (MOVPE) and fabrication.

The researchers comment: "It is indispensable to avoid wafer cracks for the success of the recycling process. To avoid wafer cracks, the suppression of the wafer warp caused by thinning wafer thickness is necessary. In particular, the amount of Ga-face grinding and polishing after separation should be minimized."

The researchers fabricated lateral metal-oxide-semiconductor field-effect transistors (MOSFETs) and vertical PN diodes.

The MOVPE device layers consisted of 4μm n^--GaN drift layer and 2μm p-GaN on n^+-GaN substrate. The n^-- and p-doping concentrations were 1x and $5x10^{17}/cm^3$, respectively.

The n-type MOSFET source and drain regions were fabricated using Si ion implantation through windows in the 100nm silicon dioxide (SiO_2) capping layer. The n-implant and p-body dopants were activated by 1050°C annealing in nitrogen for 5 minutes.

PN diodes were fabricated by removing the SiO_2 layer and creating beveled mesa structures for edge termination. The bevel angle and depth were 6° and 30μm, respectively.

The MOSFET gate insulation was provided by 100nm SiO_2 from plasma chemical vapor deposition (CVD). The MOSFET gate, source, drain and body electrodes were 160nm sputtered nickel (Ni).

This nickel deposition also provided the anode terminal on the p-side of the vertical PN diodes fabricated on the same wafer as the MOSFETs. The n-side cathode consisted of 500nm sputtered aluminium (Al) on the backside of the wafer.

Key characteristics for the MOSFETs for devices fabricated on fresh wafers showed somewhat better average performance after separation (Figure 2). However, the vertical PN diode structure did suffer some slight degradation in leakage under reverse bias after separation.

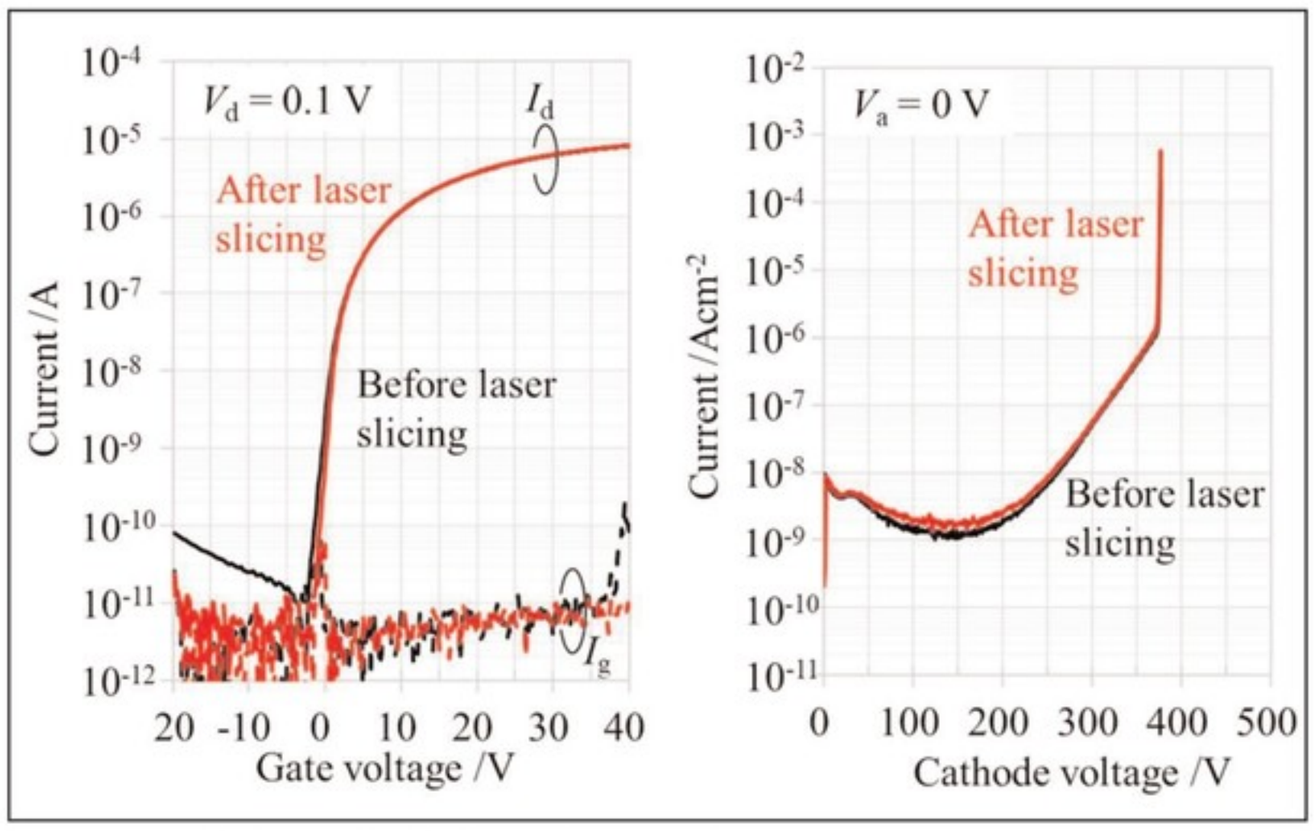

Figure 2. (a) Drain (I_d) and gate (I_g) current versus gate potential (V_g) for lateral MOSFET and (b) reverse curves of vertical PN diode before and after laser slicing.

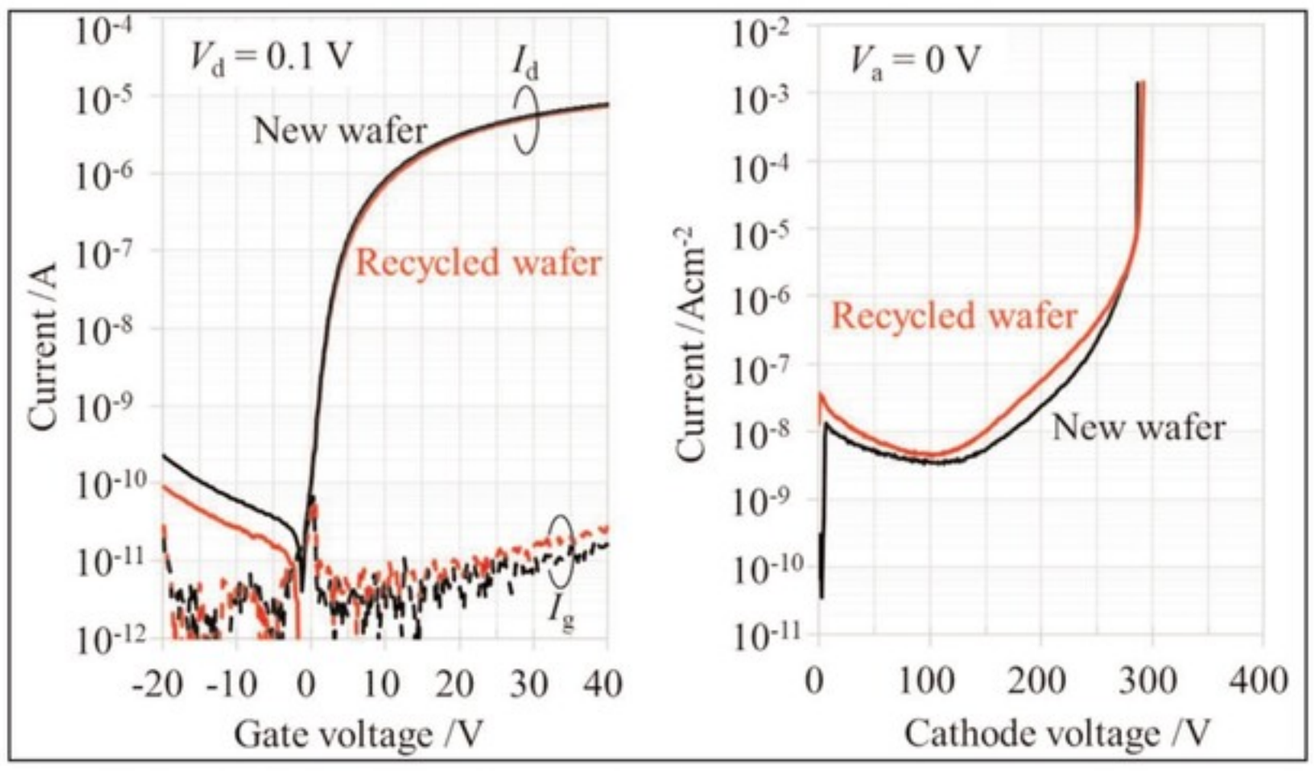

Figure 3. (a) Drain and gate leakage versus MOSFET gate potential for devices fabricated on new and recycled wafers. (b) Reverse leakage versus cathode voltage (V_c) of vertical PN diode.

The recycling process was verified by processing a recycled wafer along with a fresh wafer from the same supplier, simultaneously, both in terms of MOVPE and device fabrication (Figure 3). The recycled lateral MOSFET seems to have lower drain leakage in the OFF state (negative gate potential) but higher gate leakage at 40V. The recycled PN diode has a somewhat larger leakage under reverse bias.

The threshold voltages of the lateral MOSFETs were between −0.1V and +0.8V. The MOSFET channel mobilities were in the range 70–80cm^2/V-s. This is lower than reported vertical transistor mobilities in the range 173–266cm^2/V-s. ■

www.mirise-techs.com/en/
www.hamamatsu.com/jp/en.html
https://doi.org/10.35848/1882-0786/ad269d
Author: Mike Cooke

Layer transfer of III–N MEMS via 2D hexagonal boron nitride

Researchers fabricate free-standing structures on silicon micro-cavities.

Researchers based in France and the USA report on the extension of two-dimensional (2D) material-based layer transfer to simple fabrication of free-standing III–nitride micro-electro-mechanical systems (MEMS) on silicon [Rajat Gujrati et al, Appl. Phys. Lett., v124, p104102, 2024]

The team from the GT-CNRS International Research Lab collaboration between Georgia Institute of Technology in the USA and France's CNRS government research organization, along with the Université de Bordeaux and the LAAS-CNRS systems research laboratory, comments: "The realization of flexible III–N MEMS, which are difficult to manufacture through conventional micro-machining processes, would open the door to a wide range of applications, from wearable devices for health monitoring to the Internet of Things, even if further technical developments are needed to reach the level of yield and device performance offered by conventional fabrication methods."

The researchers suggest that the methods could be extended to flexible substrates, such as polyethylene terephthalate (PET) or Kapton.

Apart from the wide bandgaps exhibited by III–nitride materials such as aluminium gallium nitride (AlGaN), they also feature important piezoelectric and piezo-resistive characteristics, high temperature stability, chemical robustness, and potential for GaN electronics integration. AlGaN/GaN structures also generate a thin 'two-dimensional electron gas' (2DEG) near the interface of the two materials. The 2DEG is a key component of

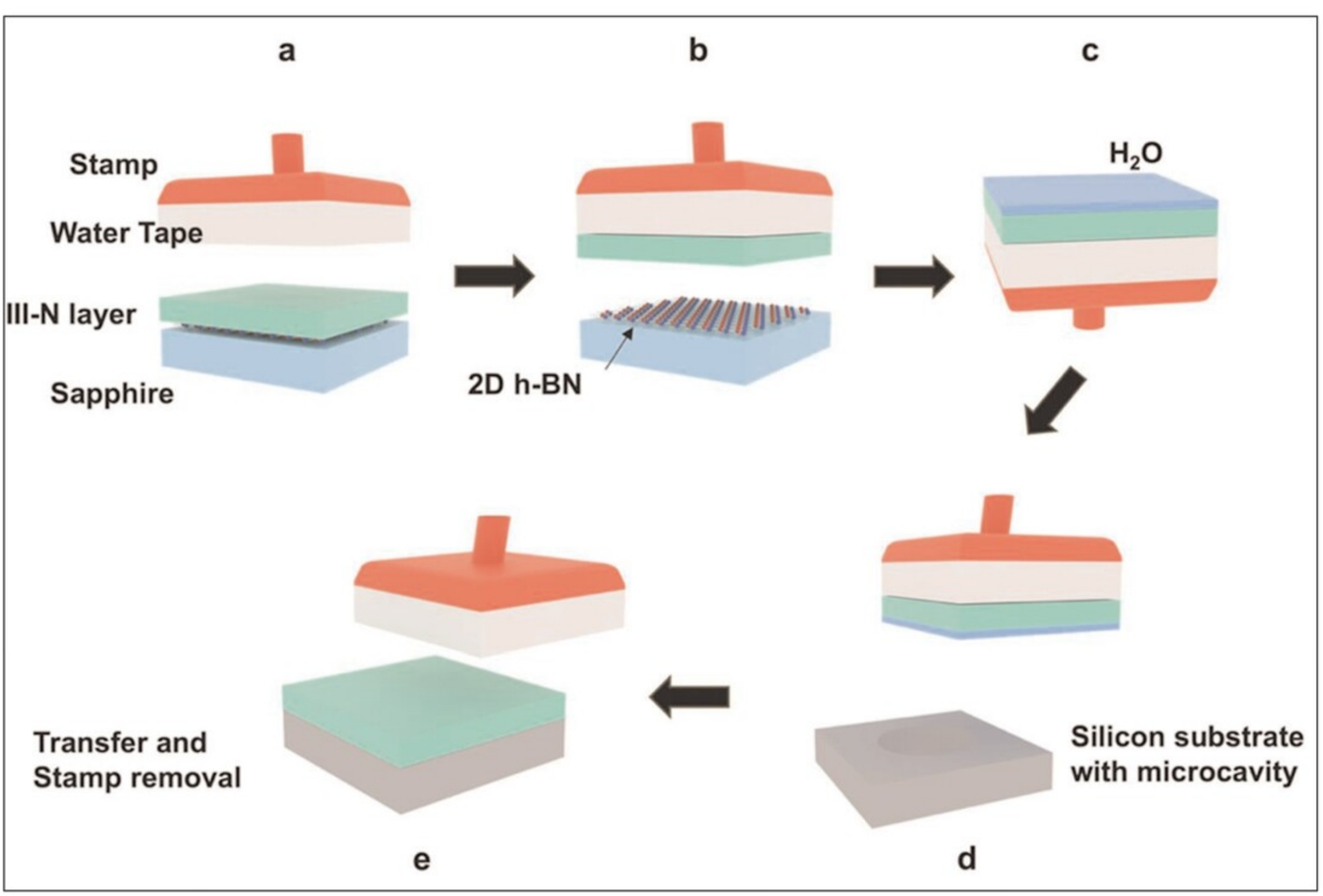

Figure 1. (a, b) Water-soluble adhesive tape used to pick up epilayer grown on h-BN/sapphire template. (c, d) Epilayer transferred using pressure and capillary forces onto silicon substrate with etched cavities and (e) tape dissolved to obtain III-N structure held to silicon substrate by van der Waals forces.

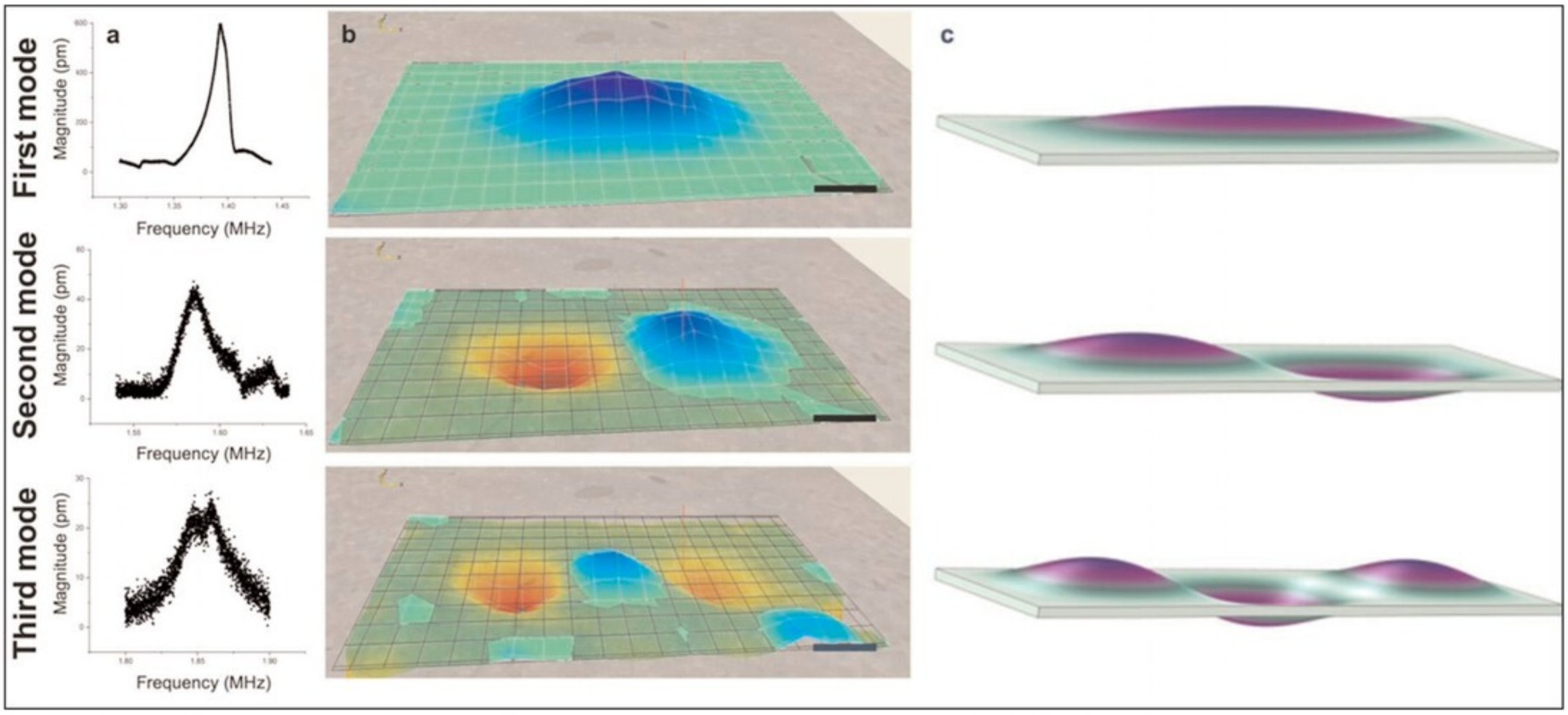

Figure 2. (a) Resonance spectra of first three modes of rectangular AlGaN/GaN plate on silicon at largest displacement location; (b) corresponding measured 3D displacement maps showing maximum deflection amplitude (scale bars: 20µm); and (c) COMSOL simulations.

high-electron-mobility transistors (HEMTs), operating as channel between source and drain. The 2DEG formation is also attractive in a MEMS sensor context, where it can function as a strain transducer.

Reports of GaN MEMS structures include Lamb wave resonators, infrared detection, and electronic filters. Layer-transfer techniques enable high-quality growth on reusable substrates, lowering production costs.

The researchers used a pick-and-place method to fabricate free-standing III–N MEMS structures on silicon (Figure 1). The III-nitride material was grown on a hexagonal boron nitride (hBN) layer on sapphire and transferred to a micro-cavity in a silicon substrate. The growth method was metal-organic chemical vapor deposition (MOCVD). Two samples were produced: one with 300nm GaN and 300nm AlGaN layers on 3nm hBN, and the other with 2.5µm hBN.

The hBN consists of 2D layers of atoms held together by covalent forces. The weaker van der Waals forces between the layers enables relatively easy separation of the material grown on the hBN.

A 15mmx15mm stamp with double-sided water-soluble adhesive tape on its surface picked the III–N from the growth substrate. The underside of the III–N structure was wetted with a water-soaked lens wipe before placing in 22µm-deep micro-cavities deep reactive-ion etched (DRIE) into a silicon substrate. The wetting enabled 'capillary assembly', where "the drying of a water film at the interface of the III–N film and the substrate is used to create a large surface area to promote adhesion via van der Waals forces," the team explains.

The stamp was removed by dissolving the tape by immersion in a water-filled beaker for 30 minutes.

The researchers studied the material structures' mechanical properties by placing the assemblies on lead zirconate titanate (PZT) piezoelectric actuators (Figure 2). Excitations were detected using laser Doppler vibrometry. The lowest mode frequencies for a GaN/AlGaN structure in a 180µmx60µm cavity were 1.39MHz, 1.58MHz and 1.85MHz, respectively. Finite-element method simulations with typical Young's modulus values for the component materials (261GPa EGaN, 285GPa EAlGaN) gave corresponding values of 1.25MHz, 1.39MHz and 1.65MHz. The 2nd/3rd mode ratios relative to the 1st mode were 1.14/1.33 experimentally, and 1.11/1.32 in simulation.

The mechanical behavior of hBN in a 450µmx150µm format was more difficult to interpret. Single-layer hBN has a Young's modulus of about 0.8TPa. Thicker layers, beyond 8 mono-layers, show a much reduced value. The modulus value extracted from the behavior of the hBN plate was 18GPa. The researchers also varied some other parameters in an attempt to fit the experimental data with a higher Young's modulus of 120GPa, "the lowest value found in the literature". In particular, the researchers studied the possibilities of residual stress in the plate, and a smaller effective size of the plate. Neither hypothesis gave a fully satisfactory explanation of the observations. ■

https://doi.org/10.1063/5.0191772

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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

5–10 May 2024
2024 Conference on Lasers & Electro-Optics (CLEO)
Charlotte Convention Center,
Charlotte, NC, USA
E-mail: info@cleoconference.org
www.cleoconference.org

12–17 May 2024
21st International Conference on Metal Organic Vapor Phase Epitaxy (ICMOVPE XXI)
Las Vegas, NV, USA
www.mrs.org/icmovpe-xxi

20–23 May 2024
2024 CS MANTECH: International Conference on Compound Semiconductor Manufacturing Technology
JW Marriott Starr Pass Resort, Tucson, AZ, USA
E-mail: registration@csmantech.org
www.vlsisymposium.org

28–30 May 2024
SEMICON Southeast Asia (SEMICON SEA 2024)
MITEC, Kuala Lumpur, Malaysia
E-mail: semiconsea@semi.org
www.semiconsea.org

7–10 June 2024
LOPS 2024: 4th Edition of Annual Conference on Lasers, Optics, Photonics, Sensors, Bio Photonics, Ultrafast Nonlinear Optics & Structured Light
DoubleTree Resort by Hilton Hollywood Beach,
Fort Lauderdale, FL, USA
E-mail: lopsannual@gmail.com
https://exceleve.com/photonoptics

9–14 June 2024
IEEE PVSC 2024: 52nd IEEE Photovoltaic Specialists Conference
Seattle, WA, USA
E-mail: Registration@ieee-pvsc.org
www.ieee-pvsc.org/PVSC52

Microwave Week

16–18 June 2024
RFIC 2024: IEEE Radio Frequency Integrated Circuits Symposium
Washington DC, USA
E-mail: support@mtt.org
www.rfic-ieee.org

16–20 June 2024
2024 IEEE Symposium on VLSI Technology and Circuits
Hilton Hawaiian Village Waikiki Beach Resort,
Honolulu, HI, USA
E-mail: vlsi@vlsisymposium.org
www.vlsisymposium.org

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16–21 June 2024
IMS 2024: 2024 IEEE/MTT-S International Microwave Symposium
Washington DC, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/about-ims/past-and-future-ims

9–11 July 2024
SEMICON West 2024
Moscone Center,
San Francisco, CA, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

17–21 July 2024
4th European School on Crystal Growth (ESCG4)
Jachranka near Warsaw, Poland
E-mail: escg4@unipress.waw.pl
https://eccg8.syskonf.pl/escg-4-about

21–25 July 2024
8th European Conference on Crystal Growth (ECCG-8)
Warsaw, Poland
E-mail: info@eccg8.pl
https://eccg8.syskonf.pl

22–24 July 2024
38th North American Conference on Molecular Beam Epitaxy (NAMBE 2024)
Tufts University, Boston, MA, USA
E-mail: della@avs.org
www.nambe2024.avs.org

23–26 July 2024
5th International Congress on Advanced Materials Sciences and Engineering (AMSE-2024)
University of Rijeka, Opatija, Croatia
E-mail: eve@istci.org
www.istci.org/amse2024

4–6 September 2024
SEMICON Taiwan 2024
TaiNEX 1&2, Taipei, Taiwan
E-mail: semicontaiwan@semi.org
www.semicontaiwan.org

22–26 September 2024
ECOC 2024: European Conference on Optical Communication
Frankfurt am Main, Germany
E-mail: michelle.dampier@nexusmediaevents.com
www.ecocexhibition.com/future-dates

22–27 September 2024
27th European Microwave Week (EuMW 2024)
Paris Expo, Porte de Versailles, Paris, France
E-mail: eumwreg@itnint.com
www.eumweek.com

14–18 October 2024
2024 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Fort Lauderdale, FL, USA
E-mail: cs@cshawevent.com
www.bcicts.org

3–8 November 2024
12th International Workshop on Nitride Semiconductors (IWN 2024)
Hilton Hawaiian Village Waikiki Beach Report,
Honolulu, O'ahu, Hawaii, USA
E-mail: info@iwn2024.org
www.iwn2024.org

12–15 November 2024
SEMICON Europa 2024
Messe München, Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

1–6 December 2024
2024 Materials Research Society (MRS) Fall Meeting & Exhibit
Hynes Convention Center, Boston, MA, USA
www.mrs.org/meetings-events/fall-meetings-exhibits/2024-mrs-fall-meeting

16–20 February 2025
ISSCC 2025: IEEE International Solid- State Circuits Conference
San Francisco, CA, USA
E-mail: issccinfo@yesevents.com
www.isscc.org

4–8 May 2025
LightFair 2025
Las Vegas Convention Center,
Las Vegas, NV, USA
E-mail: info@lightfair.com
www.lightfair.com

4–9 May 2025
2025 Conference on Lasers & Electro-Optics (CLEO)
Long Beach, CA, USA
E-mail: info@cleoconference.org
www.cleoconference.org

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