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Investment in photonic integrated circuits

US CHIPS funding for Infinera, Wolfspeed • NUBURU raises $65m
Episil and Vanguard building 8” SiC fab • Lynred buys NIT

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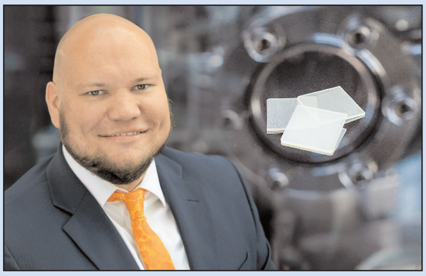
p11 ZF is withdrawing from the delayed SiC fab in Germany planned by Wolfspeed, which has gained US CHIPS Act funding for its expansions in New York and North Carolina.



p20 The All-GO-HEMT project has gained €2m in German funding to develop high-mobility gallium oxide .

p27 Finland-based III-V quantum surface engineering firm Comptek has completed installation of its pilot line, funded by the European Innovation Council.

Cover image: Netherlands-based PhotonVentures has received funding, including €5m from national financing and development institution Invest-NL
In the USA, Infinera has been allocated $93m in CHIPS and Science Act funding to expand and upgrade InP-based photonic integrated circuit manufacturing. **p34**

CHIPS funding for compound semis

Enacted in August 2022 authorizing $39bn in subsidies to regenerate onshore semiconductor manufacturing, the US CHIPS and Science Act announced its first funding award last December, of $35m to BAE Systems to modernize its Microelectronics Center in Nashua, NH, where capabilities include 6-inch gallium arsenide (GaAs) and gallium nitride (GaN) HEMT wafer foundry. This was followed in February by $1.5bn to New York-based GlobalFoundries (including creating the first US high-volume GaN manufacturing facility) and in June by $24m for Rocket Lab to expand its III-V solar cell production. Most large awards have been to high-volume silicon IC makers including Microchip, TI, Intel, Micron, Samsung, SK Hynix and TSMC, plus many firms in the equipment & materials supply chain such as polysilicon manufacturer Hemlock.

October has seen two further compound semiconductor-related awards. Silicon Valley-based Infinera has been allocated $93m which, combined with investment tax credits, amounts to over $200m in government incentives. This will fund building (1) a new wafer fab to expand its indium phosphide (InP) photonic integrated circuits (PICs) manufacturing capacity ten-fold and (2) a new chip test & packaging facility for InP PICs (see page 38).

Also, $750m of funding has been allocated to Wolfspeed, supplemented by $750m from a consortium of investors and $1bn of expected tax credits under the CHIPS and Science Act (see page 10). Funds will "support Wolfspeed's long-term growth plans — specifically expansion of its 200mm SiC wafer and device production in North Carolina and upstate New York — and bolster domestic production of silicon carbide to power clean energy systems underpinning EVs, AI data centers, and battery storage". The US government has denoted silicon carbide as one of 17 'critical materials' with a high risk of supply disruption that are integral to clean energy technologies, and key to national security.

Driven by the shift from silicon to SiC power electronics in industrial and automotive applications, there are a further 13 200mm-wafer SiC fabs planned worldwide by a dozen companies, according to market research firm TrendForce. This includes most recently (in September) Taiwan-based epi foundry Episil and specialty IC foundry Vanguard agreeing to jointly research, develop and produce 8-inch SiC wafers, including building a new SiC wafer fab (see page 14).

In February 2023, US-based Wolfspeed announced plans to spend $3bn building the world's largest 200mm-wafer SiC device fab in Saarland, Germany. However, this June the firm postponed the start of construction to mid-2025 at the earliest, while funding was still being sought, as it is "focused on ramping up production of its Mohawk Valley Fab in New York State after spending cuts in response to weakness in the European and US EV markets". Now, Germany-based automotive supplier ZF is reported to be withdrawing its $185m investment in the Saarland project, citing the delays in construction and the delays in approval of German government and EU subsidies (see page 11).

A factor for investments in the USA is the outcome of 5 November's US presidential election, since Donald Trump has criticized the Biden-Harris administration's CHIPS and Science Act. It remains to be seen if this impacts subsidies to domestic US-headquartered firms or just non-US-based inward investors such as Taiwan's TSMC and South Korea's Samsung and SK Hynix, on whose imports tariffs would be applied instead.

Mark Telford, Editor

semiconductor TODAY
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Editor
Mark Telford
Tel: +44 (0)1869 811 577
Cell: +44 (0)7944 455 602
Fax:+44 (0)1242 291 482
E-mail: mark@semiconductor-today.com

Commercial Director/Assistant Editor
Darren Cummings
Tel: +44 (0)121 288 0779
Cell:+44 (0)7990 623 395
Fax:+44 (0)1242 291 482
E-mail: darren@semiconductor-today.com

Advertisement Sales
Darren Cummings
Tel: +44 (0)121 288 0779
Cell:+44 (0)7990 623 395
Fax:+44 (0)1242 291 482
E-mail: darren@semiconductor-today.com

Original design Paul Johnson
www.higgs-boson.com

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

Regular issues contain:
- news (funding, personnel, facilities, technology, applications & markets);
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- conference reports;
- event calendar and event previews;
- suppliers' directory.

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UKRI grants £5.5m for new Responsible Electronics and Circular Technologies Centre

REACT coordinated by University of Glasgow in collaboration with University of Edinburgh, Heriot-Watt University and CSA Catapult

As part of its 'Building a Green Future' strategic theme (which aims to accelerate the green economy by supporting research and innovation that unlocks solutions essential to achieving net zero in the UK by 2050), UK Research and Innovation (UKRI) is granting £25m under its 'Accelerating the Green Economy' program to five new green industry centers across the UK.

One of these is the £5.5m Responsible Electronics and Circular Technologies Centre (REACT), based in Scotland's central belt, as the UK's first center for sustainable electronics manufacturing and design.

REACT aims to drive the transition to net-zero electronics, addressing both the environmental and economic challenges faced by the industry, while promoting the adoption of green technologies through collaboration between academia, industry, and policymakers.

The four-year project is being led and coordinated by the University of Glasgow in collaboration with the University of Edinburgh, Heriot-Watt University, and Compound Semiconductor Applications (CSA) Catapult in Scotland.

The electronics industry is primarily driven by technical and economic considerations, often neglecting sustainability principles. This has led to significant challenges, including large amounts of waste electrical and electronic equipment (WEEE), high emissions across the supply chain, and widespread use of critical raw materials (CRMs) such as gold, palladium and indium, which have with limited reserves.

In Scotland, however, the electronics industry is vital to the regional economy, driving economic growth, environmental commitments, and national security. With over 130 companies and 10,300 staff contributing to an annual turnover of more than £2.8bn, the sector plays a crucial role in fostering productivity and growth.

However, as more prominent manufacturers and buyers increasingly demand that suppliers commit to decarbonizing their products, alongside growing legislative pressure, it is clear that the industry must adapt.

"The Centre will unite leading researchers to drive the industry's transition toward a net-zero economy," says University of Glasgow professor Jeff Kettle, who will lead and coordinate the REACT Hub. "Its primary focus will be developing solutions to reduce electronic waste, minimize reliance on critical raw materials, and reduce carbon footprints."

The REACT team brings extensive expertise across areas including electronic materials, design, manufacturing and assembly, environmental impact, supply chain management, and business modelling.

REACT will collaborate with SMEs in the region to develop demonstrators and market-led solutions and provide skills training. CSA Catapult in Scotland will provide access to equipment and expertise to support start-ups, SMEs, large organizations, and academia

"REACT will leverage its partnerships to translate research into practical applications, boosting both the region's and the UK's global competitiveness in the sector," says professor Bing Xu of Heriot-Watt University.

Specifically, REACT will collaborate with SMEs in the region to develop demonstrators and market-led solutions and provide skills training. The Compound Semiconductor Catapult in Scotland will provide access to equipment and expertise to support start-ups, SMEs, large organizations, and academia in advancing compound semiconductor technology integration.

"REACT will bring together industrial partners as well as the supply chain of companies and proactively communicate to the wider public, driving change at a governmental level," says professor Jason Love of the University of Edinburgh.

It is expected that REACT's work will offer key benefits, including reductions in e-waste, improved energy efficiency and cost savings by adopting greener manufacturing processes. Additionally, REACT will play a role in fostering public–private partnerships to drive these innovations, focusing on co-creation, outreach, and advocacy.

Through conferences, workshops and applied research projects, the center aims to reshape the electronics industry in Scotland's Central Belt, transforming it into a sustainability model for the global market.

www.ukri.org
www.gla.ac.uk
www.csa.catapult.org.uk

Northeast Microelectronics Coalition Hub awards $1m to 13 companies

Awardees include Finwave and Princeton Innotech

The Northeast Microelectronics Coalition (NEMC) Hub has announced $1,038,133 in grants to 13 companies through its Powering Regional Opportunities for Prototyping Microelectronics (PROPEL) manufacturing program, which was launched in June. Funded through the federal US CHIPS and Science Act, the program supports NEMC Hub members (particularly startups and small companies) and helps them to move microelectronics projects from early-stage concepts through to production of validated devices by offsetting costs associated with hardware lab-to-fab development.

Established in 2023 with funding from the US federal CHIPS and Science Act as one of eight regional Microelectronics Commons Hubs working to accelerate domestic semiconductor prototyping, the NEMC Hub is a network of 200+ organizations including commercial and defense companies, academic institutions, federally funded R&D centers (FFRDCs), and startups concentrated in eight Northeast US states. The NEMC Hub is a division of the Massachusetts Technology Collaborative and is executed through the Naval Surface Warfare Center Crane Division (NSWC Crane) and the National Security Technology Accelerator (NSTXL).

The PROPEL Manufacturing Program awards aim to reduce the burdens on time and capital investment of commercializing promising semiconductor technologies by reducing development costs and helping to fund the manufacturing, packaging and testing of advanced microelectronics.

"The NEMC Hub plays a critical role in accelerating the development of microelectronics and supporting advanced manufacturing companies in our region," says Massachusetts Economic Development Secretary Yvonne Hao. "The PROPEL program will empower startups and small businesses to build a stronger semiconductor economy in the Northeast."

Spanning a broad range of microelectronics applications including power electronics, AI hardware, quantum technology and wearable computing, the 13 awardees include:

- $100,000 for Finwave Semiconductor of Waltham, MA, which is developing innovative transistor designs and process technology based on gallium nitride on silicon (GaN-on-Si).
- $100,000 for Princeton Innotech Inc of Princeton, NJ, which is developing high-performance vertical-cavity surface-emitting lasers (VCSELs) for quantum computing.

"The 13 awardees represent important innovation for the future of microelectronics," comments NEMC Hub director Mark Halfman.

www.finwavesemi.com
www.princetoninnotech.com
https://nemicroelectronics.org/

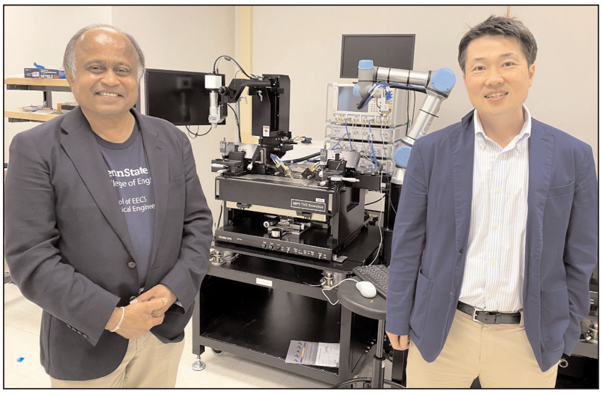
Penn State and UCSB team gain three-year, $2m NSF Future of Semiconductors grant

Heterogeneous integration of high-speed silicon IC, glass packaging and InP amplifier targets 6G wireless communications and sensing

The US National Science Foundation (NSF) has awarded a three-year, $2m Future of Semiconductors (FuSe2) grant to researchers at Penn State University and the University of California, Santa Barbara (UCSB) to develop wireless communications and sensing platforms through advanced chips and packaging.

The team includes Penn State associate professor of electrical engineering Wooram Lee; Penn State professor Madhavan Swaminathan, head of the Department of Electrical Engineering and director of the Center for Heterogeneous Integration of Micro Electronic Systems (CHIMES); and UCSB professor of electrical and computer engineering Mark Rodwell.

The Penn State-UCSB team aims to focus on 6G technology — the ultra-high-frequency, high-speed successor to 5G networks, which is still in the early stages of R&D. "The key to achieving this is through a process that resembles an assembly line, with individual parts, each with their own functions, combined into a single advanced



Professor Madhavan Swaminathan (left), head of the Department of Electrical Engineering and director of the Center for Heterogeneous Integration of Micro Electronic Systems, and Wooram Lee (right), associate professor of electrical engineering. Photo courtesy of: Lyndsey Biddle/Penn State. Creative Commons.

package," Swaminathan says. Such heterogeneous integration enables the production of enhanced, high-functioning compact electronic devices that overcome limitations to performance, functionality, size and thermal management, he adds.

For this project, Lee will focus on high-speed silicon-based integrated circuit design, Swaminathan on advanced glass packaging and Rodwell on indium phosphide amplifier design, which is needed to generate sufficient power at such high frequencies. Together, the researchers will work to integrate the three technologies into a single device.

The team also plans to educate doctoral-level scientists and engineers in various areas of semiconductor design and packaging as well as provide short courses on specialized training in semiconductor manufacturing to students and industry professionals. The overarching goal is to infuse the US semiconductor industry with experts, educators and skilled technicians.

The NSF's FuSe2 program is a national initiative granting about 20 awards up to $2m each in 2024. This program is aligned with the 2022 CHIPS and Science Act, a federal statute investing $52.7bn in funding to the development of the US semiconductor industry.

www.psu.edu

Wolfspeed announces $750m in proposed funding from US CHIPS Act plus $750m from investment group

Funding to support North Carolina and New York expansions; extra $1bn expected in cash tax refunds over several years

The US Department of Commerce and Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — have signed a non-binding preliminary memorandum of terms (PMT) for up to $750m in proposed direct funding under the US CHIPS and Science Act. In addition, a consortium of investment funds led by Apollo, The Baupost Group, Fidelity Management & Research Company and Capital Group have agreed to provide an additional $750m of new financing. Together these investments support Wolfspeed's long-term growth plans and bolster domestic production of silicon carbide to power clean energy systems underpinning electric vehicles (EVs), artificial intelligence (AI) data centers, and battery storage. In addition, Wolfspeed expects to receive $1bn of cash tax refunds from the advanced manufacturing tax credit under the CHIPS and Science Act (section 48D), giving the company, in total, access to up to $2.5bn of expected capital to support the expansion of silicon carbide manufacturing in the USA.

Wolfspeed notes that the importance of bolstering the domestic production of silicon carbide has been recognized across multiple US federal agencies; the Department of Energy denoted it as one of 17 'critical materials' with a high risk of supply disruption that are integral to clean energy technologies, while the Department of Commerce recognizes it as key to national security.

"This support galvanizes our ability to expand domestic manufacturing, accelerate innovation in next-generation semiconductor technology, and meet the increasing global demand for silicon carbide," says CEO Gregg Lowe. "This proposed investment will enable us to solidify our leadership position with a first-of-its-kind 200mm silicon carbide manufacturing footprint in upstate New York and central North Carolina, while contributing to the resilience and competitiveness of the US supply chain," he adds.

"Silicon carbide is already enabling superior energy efficiency across mission-critical industries of the future like electric vehicles, e-mobility, solar and wind energy, industrial power applications, and AI data centers. While EVs have been the driver of silicon carbide adoption thus far, we believe the use cases for our technology are expansive and will only continue to grow as more and more industries find themselves needing to solve for the same power loss, system size and system cost challenges as automakers," Lowe concludes.

"Artificial intelligence, electric vehicles, and clean energy are all technologies that will define the 21st century, and thanks to proposed investments in companies like Wolfspeed, the Biden–Harris Administration is taking a meaningful step towards reigniting US manufacturing of the chips that underpin these important technologies," says US Secretary of Commerce Gina Raimondo. "Because of the Biden–Harris Administration's CHIPS and Science Act, the United States is building and fortifying our semiconductor manufacturing capabilities to serve our economic and national security interests while creating jobs and economic opportunities for communities across the country," she adds.

Funds, to be received upon milestone achievements in the coming years, would enable Wolfspeed to complete its multi-billion-dollar greenfield US capacity expansion plan

"This major multi-billion dollar investment powered by my CHIPS & Science Law will accelerate the ongoing expansion in the Mohawk Valley, helping speed up hiring of hundreds of new good-paying jobs that Wolfspeed is creating in the Mohawk Valley and providing long-term work for the Marcy fab to succeed well into the future, further establishing Upstate NY as a global hub for chip manufacturing," reckons Senator Chuck Schumer.

"Wolfspeed is a homegrown semiconductor innovator and manufacturer creating great jobs in North Carolina, and it's important they received this major grant under the CHIPS and Science Act," says North Carolina Governor Roy Cooper. "Thanks to this landmark legislation from the Biden-Harris Administration and our great workforce, we will continue to see good paying jobs coming to North Carolina," he adds.

"North Carolina continues to be a leader in cutting-edge manufacturing that is vital to our country's national and economic security," says Senator Ted Budd. "This new Wolfspeed site in Siler City will bring good-paying jobs to the area and is an important first step in making sure America has secure supply chains for critical semiconductors," he adds.

"Wolfspeed is at the forefront of a critical transformation in sustainable transportation, and ensuring that the company has durable capital access to complete its expansion plans will help solidify its leadership in this space," comments Apollo partner Joseph Jackson. "Along with our lending consortium, which includes multiple funds that also own substantial equity stakes in the company, we believe this strategic investment will drive significant long-term value while advancing key tenets of the CHIPS and Science Act."

The proposed funds, which are expected to be received upon milestone achievements in the coming years, would enable Wolfspeed to complete its multi-billion-dollar greenfield US capacity expansion plan, which consists of the world's largest 200mm silicon carbide footprint. In addition to the proposed direct funding, Wolfspeed intends to benefit from the US Treasury Department Investment Tax Credit of up to 25% of the qualified capital expenditures primarily related to its construction and installation of equipment at The John Palmour Manufacturing Center for Silicon Carbide in Siler City, NC and completion of the Mohawk Valley Fab M-Line West Expansion in Utica, NY.

The multi-billion-dollar investment will bolster Wolfspeed's balance sheet and is expected to help to fuel significant growth through cash generation and accelerate its long-term profitability goals.

www.wolfspeed.com

Thomas Seifert and Woody Young nominated to board

Clyde R. Hosein and John B. Replogle retiring from board

Wolfspeed says that Thomas Seifert and Woody Young have been nominated to its board of directors. Their nominations will be considered at the 2024 Annual Meeting of Shareholders, scheduled for 5 December.

Seifert has served as chief financial officer of internet security company Cloudflare Inc since June 2017. Previously, he held executive leadership positions at technology and semiconductor companies, including CFO of Symantec Corp, Brightstar Corp and Advanced Micro Devices Inc. Seifert is currently a member of the board of directors of ultra-high-performance analytics software company First Derivatives plc.

Young most recently served as president and a member of the board of directors of flash memory semiconductor company Solidigm from October 2022 until August 2023. He has over 30 years of experience as an investment banker and is the former chairman of mergers & acquisitions at Perella Weinberg Partners LP. He previously served as co-head of global telecommunications, media & technology at Lazard and in similar roles at Merrill Lynch and Lehman Brothers. Young is currently a member of the board of directors of fiber internet provider Frontier Communications Parent Inc.

"With yesterday's CHIPS Act capital structure update, I believe the company successfully took a key step towards funding the execution of its business plan," says Thomas Werner, chair of Wolfspeed's board. "Thomas and Woody will be valuable additions to the Board as we focus on executing that plan, driving operational execution improvement, and continuing our previously disclosed efforts to explore ways to enhance shareholder value and unlock Wolfspeed's strategic value."

Clyde R. Hosein and John B. Replogle, who have served on the board since 2005 and 2014 respectively, are not standing for re-election and will retire from the board after expiration of their terms at the 2024 Annual Meeting.

www.wolfspeed.com

ZF said to be withdrawing from Wolfspeed's German silicon carbide device fab project

Rethink follows Wolfspeed delaying project, says Reuters

Germany-based ZF Friedrichshafen AG (one of the world's largest suppliers to the automotive industry) intends to withdraw from the projected $3bn silicon carbide (SiC) device fabrication plant and R&D center in Ensdorf, Saarland, Germany that Wolfspeed Inc of Durham, NC, USA plans to build (as announced in February 2023), reports Reuters. ZF had been set to contribute $185m for a stake in the plant, which was to make SiC devices for electric vehicles (EVs).

The rethink follows Wolfspeed's decision to put the project on hold because of weaker-than-expected semiconductor demand and doubts about whether its entry into the European market would be worthwhile, the Reuters report added.

ZF refutes media reports that it was responsible for delaying the project, adding: "Wolfspeed is responsible for the project. ZF has always provided intensive and active support".

Reuters reported last June that Wolfspeed had delayed its plans, with funding still being sought and construction not set to start until mid-2025 at the earliest. The plant was not scrapped entirely, a Wolfspeed spokesperson said at the time, adding that the company was focused on ramping up production of its Mohawk Valley Fab in New York State after spending cuts in response to weakness in the European and US EV markets.

www.zf.com

Infineon launches first 2000V SiC Schottky diode

Complement for CoolSiC MOSFETs 2000V offers high efficiency and design simplification in DC link systems up to $1500V_{DC}$

Many industrial applications are transitioning to higher power levels with minimized power losses, which can be achieved through increased DC link voltage. Infineon Technologies AG of Munich, Germany has hence addressed this challenge by introducing the CoolSiC Schottky diode 2000V G5, which is claimed to be the first discrete silicon carbide diode on the market with a breakdown voltage of 2000V. The product family is suitable for applications with DC link voltages up to $1500V_{DC}$ and offers current ratings from 10A to 80A, making it suitable for higher DC link voltage applications such as in solar and electric vehicle (EV) charging applications.

Products come in a TO-247PLUS-4-HCC package, with 14mm creepage and 5.4mm clearance distance. This, together with a current rating of up to 80A, enables a significantly higher power density. It allows developers to achieve higher power levels in their applications with only half the component count of 1200V solutions, simplifying the overall design and enabling a smooth transition from multi-level topologies to 2-level topologies.

Also, the CoolSiC Schottky diode 2000V G5 utilizes .XT interconnection technology, which leads to significantly lower thermal resistance and impedance, enabling better heat management. Furthermore, the robustness against humidity has been demonstrated in HV-H3TRB reliability tests. The diodes exhibit neither reverse recovery current nor forward recovery and feature a low forward voltage, ensuring enhanced system performance.

The 2000V diode family is a match for the CoolSiC MOSFETs 2000V in the TO-247Plus-4 HCC package that Infineon introduced in spring 2024. The CoolSiC diodes 2000V portfolio will be extended by offering them in the TO-247-2 package, which will be available in December. A matching gate driver portfolio is also available for the CoolSiC MOSFETs 2000V.

The CoolSiC Schottky diode 2000V G5 family in TO-247PLUS-4 HCC is available now. An evaluation board for product family is also available.

www.infineon.com/coolsic

Infineon launches HybridPACK Drive G2 Fusion

Silicon and SiC balance performance and cost efficiency in e-mobility

To make electric mobility accessible to a broader market by combining affordability with high performance and efficiency, Infineon is launching the HybridPACK Drive G2 Fusion, establishing a new power module standard for traction inverters in e-mobility. The HybridPACK Drive G2 Fusion is the first plug'n'play power module that implements a combination of Infineon's silicon and SiC technologies. This provides a balance between performance and cost efficiency, giving more choice in the optimization of inverters.

A main difference between silicon and SiC in power modules is that SiC has a higher thermal conductivity, breakdown voltage and switching speed, making it more efficient but also more expensive than silicon-based power modules. With the new module, the SiC content per vehicle can be reduced, while maintaining vehicle performance and efficiency at a lower system cost. For example, system suppliers can realize nearly the system efficiency of a full-SiC solution with only 30% SiC and 70% silicon area.

"Addressing the demand for greater e-mobility range, this technological breakthrough smartly combines silicon carbide and silicon," says Negar Soufi-Amlashi, senior VP & general manager High Voltage at Infineon's Automotive division. "Integrated in a well-introduced module package footprint, it offers compelling cost-performance ratio over pure silicon carbide modules without adding system complexity for automotive system suppliers and vehicle manufacturers."

HybridPACK Drive G2 Fusion expands Infineon's HybridPACK Drive power module portfolio and can be quickly and easily integrated in vehicle components or modules without requiring complex adjustments or configurations. The HybridPACK Drive G2 Fusion module features up to 220kW in the 750V class. It ensures high reliability over the entire temperature range from −40°C to +175°C and improved thermal conductivity. The unique properties of Infineon's CoolSiC technology and its silicon IGBT EDT3 technology with very fast turn-on enable the use of a single gate driver or dual gate drivers. This allows easy re-design from full-silicon- or full-SiC-based inverters to a fusion inverter. Infineon says that, generally, its holistic expertise in SiC MOSFET and silicon IGBT technology, power module packaging, gate drivers as well as sensors enables premium products with cost savings at the system level. One example is the integration of Swoboda or XENSIV Hall sensors in the HybridPACK Drive package for more precise and efficient motor control.

Infineon is showcasing the new HybridPACK Drive G2 Fusion in booth 502 (hall C3) at electronica 2024 in Munich (12–15 November).

Infineon and AWL-Electricity partner on wireless power

GaN transistors being used in MHz resonant capacitive coupling power transfer system

Infineon Technologies AG of Munich, Germany has partnered with Canada-based AWL-Electricity Inc to provides it with CoolGaN GS61008P, allowing the development of advanced wireless power solutions for various industries.

The partnership combines Infineon's gallium nitride (GaN) technology with AWL-E's MHz resonant capacitive coupling power transfer system, achieving what is claimed to be industry-benchmark wireless power efficiencies. Infineon's GaN transistor technology offers high efficiency and high power density while operating at high switching frequencies. This enables AWL-E to increase its system lifetime, reduces downtime and operating costs, and improves ease-of-use for consumers, it is reckoned. In the automotive sector, the technology enables what is claimed to be a new level of interior experiences and seat dynamics. In industrial systems, it provides design freedom, such as for automated guided vehicles or robotic applications. Additionally, the technology allows for a fully sealed system design, eliminating the need for charging ports, which contributes to reducing global consumption of batteries.

"With our partner approach we prove once more the ability to unlocking the full system-level benefits of Infineon's CoolGaN technology, enabling compactness and efficiency," says Falk Herm, global partnership & ecosystem management at Infineon's Power & Sensor Systems (PSS) Division at Infineon. "The combination of AWL-E and Infineon's complementary capabilities demonstrates how the features of GaN, namely operating at MHz frequencies, change the paradigm of what can be done with power transistors, driving greener and better-performing products."

"Infineon uniquely brings you into their family with a recognition that a strong ecosystem ultimately solves today's power needs," comments Francis Beauchamp-Verdon, co-founder, VP & business development director at AWL-E. "Infineon's GaN transistors, eval boards, and partner opportunities have boosted acceptance of our GaN-based MHz power coupling systems."

www.infineon.com/gan

TI adds 200mm GaN power semiconductor production in Japan, quadrupling internal capacity

Development of GaN manufacturing on 300mm wafers piloted

Dallas-based Texas Instruments Inc (TI) has begun production of gallium nitride (GaN)-based power semiconductors at its factory in Aizu, Japan. Coupled with its existing GaN manufacturing in Dallas, Texas, TI will internally manufacture four times more GaN-based power semiconductors as Aizu ramps to production.

"Building on more than a decade of expertise in GaN chip design and manufacturing, we have successfully qualified our 200mm GaN technology – the most scalable and cost-competitive way to manufacture GaN today – to start mass production in Aizu," says Mohammad Yunus, TI's senior VP of technology & manufacturing. "This milestone enables us to manufacture more of our GaN chips internally as we grow our internal manufacturing to more than 95% by 2030, while also sourcing from multiple TI locations, ensuring a reliable supply of our entire GaN portfolio of high-power, energy-efficient semiconductors."

TI claims that it currently offers the widest portfolio of integrated GaN-based power semiconductors, ranging from low to high voltage, to enable the most energy-efficient, reliable and power-dense electronics.

"With GaN, TI can deliver more power, more efficiently in a compact space, which is the primary market need driving innovation for many of our customers," says Kannan Soundarapandian, VP of high-voltage power. "As designers of systems such as server power, solar energy generation and AC/DC adapters face challenges to reduce power consumption and enhance energy efficiency, they are increasingly demanding a reliable supply of TI's high-performance GaN-based chips." He adds. "TI's product portfolio of integrated GaN power stages enables customers to achieve higher power density, improved ease of use and lower system cost."

Further, with the company's proprietary GaN-on-silicon process, more than 80 million hours of reliability testing, and integrated protection features, TI says that its GaN chips are designed to keep high-voltage systems safe.

GaN manufacturing technology

TI says that its new capacity enables increased product performance and manufacturing process efficiency, as well as a cost advantage.

Also, the more advanced, efficient manufacturing tools can produce smaller chips, packing more power. Such designs can be manufactured using less water, energy and raw materials, and end products that use GaN chips enjoy these same environmental benefits.

Scaled for future advances

TI says that the performance benefits of its added GaN manufacturing also enable it to scale its GaN chips to higher voltages, starting with 900V and increasing to higher voltages over time, furthering power-efficiency and size innovations for applications like robotics, renewable energy and server power supplies.

TI's expanded investment also includes a pilot earlier in 2024 for the development of GaN manufacturing processes on 300mm wafers. Further, the firm's expanded GaN manufacturing processes are fully transferable to 300mm technology, positioning it to readily scale to customer needs and move to 300mm in the future.

www.ti.com/power-management

Taiwan's Episil and Vanguard to jointly build 8-inch silicon carbide device fab

Episil Technologies of Hsinchu Science Park, Taiwan — which produces silicon, silicon carbide (SiC) and gallium nitride on silicon (GaN-on-Si) epitaxial wafers — has signed a strategic cooperation agreement with Hsinchu-based Vanguard International Semiconductor Corp (which provides specialty IC foundry services including GaN on 8-inch QST engineered substrates) to jointly research, develop and produce 8-inch silicon carbide wafers.

Vanguard also aims to establish a long-term strategic collaboration by investing NTD2.48bn to acquire 50 million shares in Episil (a 13% equity stake) in a private placement. Following regulatory approval of the capital raise, the two companies will begin their collaboration.

Episil plans to use the proceeds to fund construction of a new 8-inch SiC fab. The initial technology transfer will be carried out by Episil, with mass production expected to start in second-half 2026. Leveraging both parties' technological strengths and market resources, Episil and Vanguard intend to jointly engage in SiC technology development and marketing.

Additionally, the two parties will evaluate SiC technology development and production progress for further collaboration in the future.

www.epi.episil.com/en
www.vis.com.tw

Navitas launches GaNSlim power ICs for ease-of-use, system cost and energy savings in mobile, consumer and home appliances

New GaN power ICs integrate autonomous EMI control and loss-less sensing in optimized DPAK-4L package

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA has announced GaNSlim, a new generation of highly integrated GaN power ICs that will further simplify and speed the development of small-form-factor, high-power-density applications by offering the highest level of integration and thermal performance.

GaNSlim is said to enable the simplest, fastest and smallest system design by integrating drive, control and protection, with integrated EMI control and loss-less current sensing, all within a high-thermal-performance proprietary DPAK-4L package. Additionally, with an ultra-low startup current below 10μA, GaNSlim devices are compatible with industry-standard SOT23-6 controllers and eliminate HV startup.

Integrated features such as loss-less current sensing eliminate external current sensing resistors and optimize system efficiency and reliability. Over-temperature protection ensures system robustness and auto sleep-mode increases light and no-load efficiency. Autonomous turn-on/off slew rate control maximizes efficiency and power density while reducing external component count, system cost and EMI.

GaNSlim features a patented 4-pin, high-thermal-performance, low-profile, low-inductance, DPAK package. This package enables 7°C lower temperature operation versus conventional alternatives, supporting high-power-density designs with ratings up to 500W. Target applications include chargers for mobile devices and laptops, TV power supplies, lighting, etc.

"Our GaN focus is on integrated devices that enable high-efficiency, high-performance power conversion with the simplest designs and the shortest possible time-to-market," says Reyn Zhan, senior manager of technical marketing. "Our new GaNSlim portfolio - built on integration, ease-of-use and low-cost manufacturing methods — continues to grow the customer pipeline, with over 50 new projects already identified," he adds. "GaNSlim increases our GaN addressable market by enabling lower system costs compared to silicon designs for many applications, targeting applications under 500W across mobile, consumer and home appliance."

Devices in the NV614x GaNSlim family are rated at 700V with $R_{DS(ON)}$ ratings from 120mΩ to 330mΩ and are available in versions optimized for both isolated and non-isolated topologies.

As with other Navitas GaN ICs, GaNSlim devices are supplied with an industry-leading 20-year warranty, while demo boards for QR flyback, single-stage PFC, boost PFC plus QR flyback and TV power supply designs allow for rapid evaluation and selection of the optimum device for a given application.

www.navitassemi.com

Navitas adds TOLT package to GaNSafe family

Rugged, cool, extended-power performance in thermally enhanced package

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA says that its high-power GaNSafe family is now available in a TOLT (Transistor Outline Leaded Top-side cooling) package.

The GaNSafe family has been created specifically to serve demanding, high-power applications, such as AI data centers, solar/energy storage, and industrial markets. Navitas' 4th generation integrates control, drive, sensing and critical protection features that enable what is reckoned to be unprecedented reliability and robustness. GaNSafe is claimed to be the world's safest GaN with short-circuit protection (350ns max latency), 2kV ESD protection on all pins, elimination of negative gate drive, and programmable slew rate control. All these features are controlled with 4-pins, allowing the package to be treated like a discrete GaN FET, requiring no V_{CC} pin.

The TOLT packaging enhances thermal dissipation through the top side of the package, allowing heat to be dissipated directly to the heatsink (not through the PCBA). This enables the reduction of operating temperature and increases current capability, resulting in the highest level of system power density, efficiency and reliability.

"With over 200 million units shipped and supplied with a 20-year warranty, Navitas' highly integrated high-power GaNSafe ICs are proven to deliver performance and reliability while simplifying design-in for systems up to 22kW," says Charles Bailley, senior director of business development. "As the most protected, reliable and safe GaN devices in the industry, GaNSafe took our technology into mainstream applications above 1kW. Now, with the enhanced thermal dissipation of the TOLT package, we are enabling customers to deliver even better performance, efficiency, power density and reliability in even the most demanding applications."

Suitable for applications from 1kW to 22kW, 650V GaNSafe in TOLT packaging is available with a range of $R_{DS(ON)MAX}$ from 25mΩ to 98mΩ. Integrated features and functions include:

- high-speed short-circuit protection, with autonomous 'detect and protect' with ultra-fast 350ns/50ns latency;
- protected, regulated, integrated gate-drive control, with zero gate–source loop inductance for reliable high-speed 2MHz switching capability to maximize application power density;
- electrostatic discharge (ESD) protection of 2kV, compared with zero for discrete GaN transistors;
- 650V continuous and 800V transient voltage capability for extraordinary application conditions;
- integrated Miller clamp (no negative gate bias, higher 3rd quadrant efficiency);
- programmable turn-on and turn-off speeds (dV/dt) to simplify EMI regulatory requirements;
- simple 4-pin device, allowing the package to be treated like a discrete GaN and requiring no additional V_{CC} pin;
- robust, thermally enhanced packaging: ultra-low $R_{Q\_JUNC\text{-}AMB}$ and board-level thermal cycling (BLTC) reliability.

In addition to the new ICs, Navitas will be offering reference design platforms based on GaNSafe TOLT for applications including data-center power supplies and EV on-board chargers. These system platforms include complete design collateral with fully tested hardware, embedded software, schematics, bill-of-materials, layout, simulation, and hardware test results.

www.navitassemi.com

QPT wins APC project grant to develop high-frequency GaN inverter demonstrator for automotive

Aim to demo first pure sine-wave GaN traction inverter at Cenex 2025

Independent power electronics company Quantum Power Transformation (QPT) Ltd of Cambridge, UK — which was founded in 2019 and develops gallium nitride (GaN)-based electric motor controls — has won a grant for the project VERDE to develop a high-frequency 400V/60kW GaN inverter demonstrator for automotive use that will help to demonstrate that GaN is now superior to silicon carbide (SiC) or silicon. Funded by the UK's Advanced Propulsion Centre (APC), the project is designed to help accelerate early-stage technologies to market that will support the shift to net-zero automotive. The other company in the project is RAM Innovations Ltd, which provides innovative packing to keep dies cool.

The demonstrator features high-frequency switching up to 1MHz to enable dramatic savings in waste, weight and power costs in the drive system. Key to this is QPT's unique pure sign-wave output that reduces harshness, noise and vibration, improving reliability and reducing power consumption.

The traction inverter market for electric vehicles (EVs) was estimated to be $17.93bn in 2023 and is projected to rise at compound annual growth rate (CAGR) of 16.9% to about $73.08bn by 2032, according to Precedence Research. Currently, half of the world's electricity is used by electric motors. QPT reckons that its technology could reduce their electricity use by 10%, which would be a significant reduction in CO_2 production.

"Our system technology enables GaN to be used for high-power, high-performance applications, overcoming the thermal and EMI problems that have stopped GaN being used in automotive in the past," notes CEO Rupert Baines. "We are already talking with automotive companies who would like to partner with us to leapfrog the market that is currently focussed on SiC and realise GaN-based inverters. Reducing waste in the inverter and in the motor not only increases range (or reduces batteries for the same range) but it also simplifies the cooling system, further reducing weight," he adds.

"This project will create a demonstrator to be shown at Cenex Expo at UTAC Millbrook, UK in September 2025, where the world's leading EV companies will be able to see the technological leap forward that this project has made possible," says RAM Innovations' CEO Peter Green. "This APC investment will accelerate bringing the technology to market by at least two years," he reckons.

"VERDE is part of Innovate UK's campaign to fund exciting British innovations so that Britain can be a major force in the new technologies that will be driving the global economy," says QPT's VP of engineering & operations Ian Stacey, who is the project leader at QPT. "As well as stimulating research and development, it will also provide around 70 UK manufacturing jobs by 2032 as the technology is turned into products," he adds. "In the drive to net-zero, the demand for electric motors will escalate and these must be as efficient as possible to minimize electricity being wasted. EVs will play an increasingly important role in achieving net zero. This project unlocks GaN and is a major step forward in achieving it, replacing legacy silicon and SiC."

www.q-p-t.com
www.precedenceresearch.com/traction-inverter-market

Cambridge GaN Devices showcases ICeGaN at ECCE 2024

Fabless firm Cambridge GaN Devices Ltd (CGD) — which was spun out of the University of Cambridge in 2016 to design, develop and commercialize power transistors and ICs that use GaN-on-silicon substrates — exhibited in at the IEEE Energy Conversion Congress & Expo (ECCE 2024) in the Phoenix Convention Center, Phoenix, AZ, USA (21–22 October). ECCE is now in its 16th year and sponsored by both the IEEE Industrial Application Society (IAS) and IEEE Power Electronics Society (PELS).

"It is important for CGD that we spread our message that GaN is the future of power electronics, in terms of energy efficiency, power density and smallest carbon footprint, and that our ICeGaN GaN power ICs are the most rugged and easiest-to-use devices available," says chief commercial officer Andrea Bricconi.

At the event, CGD showcased demos that employ ICeGaN, including:

- a 3kW PFC reference design;
- a Qorvo motor drive evaluation kit developed in partnership with CGD and utilizing ICeGaN;
- a slim 100W adaptor;
- a half-bridge, full-bridge as well as ICeGaN in parallel evaluation boards;
- a 300W PFC+LLC;
- a single leg of a 3-phase automotive inverter demo board, developed in partnership with the French public R&I institute IFP Energies nouvelles (IFPEN);
- ICeGaN versus discrete GaN circuits comparison in half bridge (daughter cards) demo board.

www.ieee-ecce.org/2024
www.camgandevices.com

Cornell and Lit Thinking working on DARPA-funded project to develop AlN-based PiN diodes with low on-state resistance

Grant part of DARPA Microsystems Technology Office's Ultra-Wide BandGap Semiconductors program

Aided by a grant from the US Defense Advanced Research Projects Agency (DARPA), researchers at Cornell University — in collaboration with Lit Thinking of Orlando, FL, USA — are working to overcome some of the key technical challenges that have limited the widespread adoption of aluminium nitride (AlN) as a next-generation semiconductor material.

As an ultrawide-bandgap semiconductor material, aluminium nitride is recognized for its thermal conductivity, high breakdown voltage and strong electric field tolerance, making it suitable for high-power and high-frequency electronic devices. Achieving ultralow resistance in PiN diodes — which help semiconductors handle high voltages and currents — is crucial for improving efficiency and performance.

The Cornell-led project will focus on developing AlN-based PiN diodes with extremely low on-state electrical resistance, reducing power loss and heat generation in high-power applications.

"Because aluminium nitride is normally an excellent electrical insulator, making it conductive holds the key to exploiting its amazing properties" says principal investigator Debdeep Jena, the David E. Burr Professor in electrical and computer engineering and in materials science and engineering. "In this DARPA program, our interdisciplinary team is investigating several new ideas to unlock the potential of this ultrawide-bandgap semiconductor."

Co-principal investigators from the Department of Materials Science and Engineering include Huili Grace Xing (the William L. Quackenbush Professor in electrical and computer engineering); Michael Thompson (the Dwight C. Baum Professor); Hari Nair (assistant research professor); and Leo Schowalter (chief technology officer of Lit Thinking and a visiting professor).

Cornell researchers in the Department of Materials Science and Engineering involved in the project, including (from left) Leo Schowalter (CTO of Lit Thinking and a visiting professor); Debdeep Jena (the David E. Burr Professor in electrical and computer engineering); Huili Grace Xing (the William L. Quackenbush Professor in electrical and computer engineering); Hari Nair (assistant research professor); and Michael Thompson (the Dwight C. Baum Professor).

The project will build on research published earlier this year by Jena and Xing, who demonstrated p–n heterojunction diodes through distributed polarization doping to achieve properties that are not possible in standard diodes.

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"Aluminium nitride semiconductor substrates have also recently enabled the realization of the very first deep ultraviolet diode lasers," notes Schowalter. "This project has the potential to enable similar revolutionary electronic devices in the near future, including cost-effective far-UVC optoelectronic sources for safe disinfection of public spaces."

The grant is part of the DARPA Microsystems Technology Office's Ultra-Wide BandGap Semiconductors program, which aims to develop materials for commercial applications including high-power radio frequency devices for radar and communications systems, high-voltage switches for power electronics, high-temperature electronics and sensors for extreme environments, and deep ultraviolet light-emitting diodes and lasers.

www.litthinking.com
https://sites.google.com/view/cornell-uwbg-nitrides
https://pubs.aip.org/aip/apl/article-abstract/124/10/102109/3270223/Ultrawide-bandgap-semiconductor-heterojunction-p-n
www.mse.cornell.edu/faculty-directory /debdeep-jena

All-GO-HEMT project gains €2m German funding to develop high-mobility gallium oxide

Charge carrier mobility in β-Ga_2O_3 to be boosted by aluminium-alloyed heterostructure

Led by Dr Andreas Fiedler at Germany's Leibniz-Institut für Kristallzüchtung im Forschungsverbund Berlin e.V. (IKZ), the 'All-GO-HEMT' project aims to develop modulation-doped β-(Al_xGa_{1-x})_O_/Ga_2O_3 heterostructures that exhibit high electron mobility. With total project funding of almost €2m, financed by the German Federal Ministry of Education and Research (BMBF), this project is expected to lead to a considerable increase in efficiency in power electronics and thus make a significant contribution to sustainable energy generation.

The All-GO-HEMT project utilizes the advantages of the ultra-wide-bandgap material gallium oxide (Ga_2O_3), which is considered to be a promising candidate for power electronics. Ga_2O_3 enables a more compact design, which not only increases the efficiency of the conversion processes but also improves the reliability of the systems. Compared with established materials such as silicon, gallium nitride and silicon carbide, Ga_2O_3 offers the potential for increasing efficiency that has not yet been fully exploited.

Even though power electronics based on Ga_2O_3 promise to be more efficient, the material is inferior to established materials in terms of charge carrier mobility.

The central aim of the project is to overcome the material limitation of Ga_2O_3 in terms of charge carrier mobility with the help of the innovative design of an aluminium-alloyed heterostructure and thus eliminate this disadvantage. "We are convinced that the efficiency of power electronics can be significantly increased through a combination of a more compact design and higher charge carrier mobility in our newly developed materials," says Fiedler.

All-GO-HEMT project manager Dr Andreas Fiedler (left, photo by Tina Merkau) and gallium oxide wafer (right, photo by Volkmar Otto).

Another goal of All-GO-HEMT is to create a reliable material basis of Ga_2O_3 and the newly developed alloy with aluminium of the highest crystalline quality for research and industry. This basis is necessary because the development of high-performance devices with compact design and optimized manufacturing processes is currently limited by the insufficient availability of high-quality material. The project partner Ferdinand-Braun Institut (FBH) will use this material base to develop new prototypes for power electronic devices. These prototypes will then be tested by industrial mentor ZF Friedrichshafen AG for their suitability for industrial applications. In addition, the entire value chain, from crystal growth to the finished device, will be analyzed industrial mentors AIXTRON and Siltronic AG in order to quantify and evaluate the economic and ecological benefits of this technology at an early stage.

The All-GO-HEMT project is being funded as part of the BMBF NanoMatFutur competition for young researchers and aims to establish sustainable research structures by supporting excellent young researchers with funding of almost €2m. The NanoMatFutur grant will enable Fiedler to set up his own independent junior research group at IKZ over a period of five years. With this grant, he plans to put together a team consisting of a postdoc and two doctoral students to work on the research project and to promote and establish new talent in this field of research.

www.ikz-berlin.de/en

Aehr's quarterly revenue falls by 36% year-on-year, but EV-related orders rebounding

For its fiscal first-quarter 2025 (to 30 August 2024), semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has reported revenue of $13.1m, down 21% on $16.6m last quarter and 36% on $20.6m a year ago.

WaferPak has risen from 55% of total revenue a year ago to 92% ($12.1m). "Our customers continue to utilize the available installed base of FOX-XP systems for new customer design wins, and purchase additional new WaferPaks from Aehr to test and burn-in these new devices," notes chief financial officer Chris Siu.

Due mainly to the favorable product mix of higher-margin WaferPaks, gross margin (on a non-GAAP basis) has risen from 48.7% a year ago to 54.7%.

Operating expenses were $5.52m, roughly flat on $5.41m a year ago. Operating income has fallen further, from $4.64m a year ago and $3.42m last quarter to $1.65m. Net income was $2.15m ($0.07 per diluted share), down from $5.2m ($0.18 per diluted share) a year ago.

Operating cash flow was $2.4m. However, total cash, cash equivalents and restricted cash fell during the quarter from $49.3m to $40.8m, reflecting $10.6m in net cash paid to acquire Fremont-based Incal Technology Inc. Aehr has no debt and continues to invest excess cash in money market funds.

Orders rebound as demand stabilizes for SiC power semi market

Order bookings have rebounded from a low of just $4m last quarter to $16.8m. Order backlog has hence recovered from $7.3m to $16.6m.

"Silicon carbide wafer-level burn-in test systems and full-wafer contactors are poised to be key contributors to revenue again this year," says president & CEO Gayn Erickson. "We are also forecasting material bookings and revenue contributions from several other markets this fiscal year, as we are successfully executing on our strategy to expand our test and burn-in products into other large and fast-growing markets such as artificial intelligence (AI) processors, gallium nitride power semiconductors, hard disk drive components and flash memory devices," he adds.

"We have been seeing a stabilization and increasingly positive discussions within the silicon carbide power semiconductor market over the past quarter. Electric vehicle (EV) suppliers are clearly moving towards silicon carbide in integrated modules, combining silicon carbide MOSFETs into single packages to meet the industry's power, efficiency and cost-effectiveness demands. Due to the need for extensive test and burn-in of these devices to ensure reliability for mission-critical applications like EVs, the benefits of conducting this screening at the wafer-level before integrating them into modules, which may sometimes contain 32 or more other devices [in a three-phase inverter module], are becoming clear. The process improves yields and reduces costs, driving demand for wafer-level burn-in. We are highly optimistic about our silicon carbide business and expect it to gain momentum over the next few quarters. Our silicon carbide customers are forecasting capacity expansion needs in calendar 2025, with several anticipating purchases of one or two systems in early 2025, followed by production volumes in the second half of the year, and ramping further into 2026," Erickson states.

"Meanwhile, we continue to see strong demand for our FOX WaferPak full-wafer Contactors for silicon carbide and other markets for our installed base of FOX-XP and FOX-NP wafer-level test and burn-in systems, driven by a record number of new device designs started this past quarter. These designs are expected to lead to additional WaferPak purchases for engineering qualification as well to volume production orders as they advance to production."

"We are also making steady progress on our previously announced benchmarks and engagements with new silicon carbide device and module suppliers. We are confident that we will add several new silicon carbide customers this year, establishing our solution as their tool of record for volume production. Additionally, silicon carbide is gaining traction in applications beyond electric vehicles, such as solar, industrial and data centers, which will expand our addressable markets."

"We are now in negotiations with our first gallium nitride (GaN) semiconductor customer for volume production wafer-level test and burn-in of their devices. This past year, this customer purchased a significant number of WaferPaks to successfully qualify a wide range of GaN device types aimed at multiple markets, including consumer, industrial and automotive. In addition, we have had increased discussions and engagements with multiple potential new GaN suppliers. We believe GaN is a significant up-and-coming technology for power semiconductors. With a forecasted CAGR of more than 40% to over $2bn in GaN devices sold annually by 2029, it has the potential to be a significant market opportunity for Aehr's wafer-level solutions."

"Last quarter, we announced that an artificial intelligence (AI) accelerator company committed to evaluating our FOX solution for wafer-level burn-in of their high-power processors. This evaluation is underway at our Fremont facility, where multiple wafers are being tested using our proprietary WaferPaks and new high-power FOX-XP and NP systems, which provide up to 3500W of power delivery and thermal control per wafer. We are delivering over 2000A of current to a single 300mm wafer, allowing us to burn-in numerous processors with our proprietary test modes. The evaluation is progressing very well and, once we demonstrate successful wafer-level test results and throughput, we anticipate they will adopt our high-power FOX-XP systems for production of their next-generation AI processors, beginning this fiscal year."

Incal's packaged-part reliability burn-in and test opens up AI semiconductor market

On 31 July, Aehr completed its acquisition of Incal Technology Inc, expanding its product portfolio to include packaged-part reliability burn-in and test solutions, particularly ultra-high-power capabilities for AI processors, GPUs, and high-performance computing processors. "These advanced high-power capabilities, combined with Aehr's industry-leading lineup of wafer-level test and reliability solutions, position us strongly to capitalize on the significant and rapidly growing opportunities in the AI semiconductor market," believes Erickson. "This acquisition greatly expands our addressable market, enabling us to provide a comprehensive turnkey solution for reliability and testing from engineering to high-volume production, to the rapidly growing AI semiconductor market," he adds.

"Customer feedback to this acquisition has been overwhelmingly positive, with several meetings held over the past few weeks where some customers indicated increased forecasts for engineering qualification as well as for volume production. Last month, we were pleased to announce the first volume production orders for Incal's new Sonoma ultra-high-power semiconductor packaged-part test and burn-in solution designed for AI accelerators, graphics processors, network processors, and high-performance computing processors. These orders were placed by a large-scale data-center hyperscaler that provides computing power and storage capacity to millions of users worldwide."

Aehr has already shipped several systems since the acquisition, and plans to consolidate personnel and manufacturing into its Fremont facility by the end of the fiscal year. The company is upgrading and re-modeling its Fremont headquarters this year, ensuring its facility infrastructure meets the needs of both companies.

Full-year guidance reiterated

"With all of these customer engagements, market opportunities, and the products to address them, we are very optimistic about the year ahead, and we are reaffirming our financial guidance for revenue growth and profitability for the year," notes Erickson.

For its fiscal full-year 2025 (ending 30 May), Aehr is reiterating its existing guidance for revenue growth to at least \$70m (up on fiscal 2024's record \$66.2m), with net profit before taxes of at least 10% of revenue.

Aehr expects about 85% of forecasted annual revenue to come from wafer-level burn-in and 15% from packaged-part burn-in, driven by its acquisition of Incal.

www.aehr.com

Keysight unveils 3kV high-voltage wafer test system

Keysight Technologies Inc of Santa Rosa, CA, USA has expanded its semiconductor test portfolio by introducing the 4881HV high-voltage wafer test system, which is said to improve the productivity of power semiconductor manufacturers by enabling parametric tests up to 3kV supporting high- and low-voltage in one-pass test.

Manufacturers have traditionally measured wafers using separate testers for high and low voltages. However, demand for power semiconductors is growing rapidly due to their multi-functionality, higher performance, and next-generation devices such as silicon carbide (SiC) and gallium nitride (GaN). As a result, customers need a solution to more accurately and efficiently test their devices and reduce time to market.

Keysight says that its new system addresses these challenges by allowing power device makers to perform process control monitoring (PCM) and wafer acceptance testing (WAT) in manufacturing. The new test system is said to deliver the following benefits:

- **High-voltage capability to meet future needs**: The high-voltage switching matrix (HV-SWM) supports up to 3kV requirements, is scalable up to 29 pins, and integrates with precision source measure units (SMUs). It enables highly flexible measurements from low current down to sub-pA resolution up to 3kV at any pins.

Additionally, high-voltage capacitance measurement and various parametric tests are supported.

- **One-pass testing increases productivity and efficiency**: The HV-SWM enables a single test system instead of separate high-voltage and low-voltage test systems. Utilizing one system is more efficient and reduces the required footprint and testing time. The system integrates with factory automation environments using Keysight's SPECS-FA software, which improves the efficiency of the entire production process.
- **Enhanced safety and reliability**: The test system has built-in protection circuitry and machine control, ensuring operators and equipment are not impacted by high-voltage surges during a test, and is compliant with safety regulations, including SEMI S2 standards.

www.keysight.com

Ohio State selects Taiyo Nippon Sanso MOCVD & HVPE platforms for nitride & oxide materials and device R&D

Reactors to be installed at Nanotech West Lab operated by Institute for Materials and Manufacturing Research

Industrial gas company Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan (part of Nippon Sanso Holdings Group) says that The Ohio State University is to purchase and use a TNSC SR4000HT-RR-LV metal-organic chemical vapor deposition (MOCVD) reactor for its nitride R&D and a halide vapor phase epitaxy (HVPE) reactor for gallium oxide applications.

The MOCVD and HVPE reactors will be installed at Nanotech West Lab, a 36,000ft^2 shared user facility servicing the Ohio State materials community. The lab is operated by the Institute for Materials and Manufacturing Research (IMR), a multi-disciplinary institute that provides infrastructure support and development, as well as management of major research facilities at Ohio State.

"Taiyo Nippon Sanso is very proud to establish a relationship with The Ohio State University for research and development of gallium nitride and gallium oxide materials and devices," says TNSC' senior corporate officer Kunihiro Kobayashi. "Taiyo Nippon Sanso is looking forward to working with professors Steven A. Ringel, Siddharth Rajan and Hongping Zhao and The Ohio State University community to further establish its reputation as a center of excellence in the field of wide-bandgap semiconductor research and development," he adds.

"The selection of the TNSC MOCVD and HVPE systems and our partnership with Taiyo Nippon Sanso enables The Ohio State University to expand its epitaxial growth facilities with these state-of-the-art growth capabilities for nitrides and oxides," says IMR executive director professor Steven A. Ringel, associate VP of research at The Ohio State University. "We are eager to leverage TNSC technology to push the boundaries of wide- and ultrawide-bandgap semiconductor research and development."

https://imr.osu.edu
www.MOCVD.jp

IQE appoints Mark Cubitt as non-executive director and chair-elect

Chairman Phil Smith stepping down from board in first-half 2025

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has appointed Mark Cubitt to its board as an independent non-executive director and (in first-half 2025, following a period of transition with current chair Phil Smith) as chair-elect.

Smith will step down from the board upon Cubitt assuming the chairmanship, having served on the board for nearly nine years, including five years as chair.

"Mark brings a wealth of expertise to the company, with a deep knowledge of the technology sector and significant board-level experience working," comments Smith. "I look forward to working with Mark."

Cubitt has experience serving in senior non-executive and chair roles across AIM-listed technology businesses. He is currently non-executive chairman of embedded processor solutions provider Concurrent Technologies plc and Beeks Financial Cloud Group plc, a provider of cloud computing services for capital markets infrastructure. He has also held a range of senior financial roles within the technology manufacturing sector, including over seven years as chief financial officer of Wolfson Microelectronics plc, which supplies chips for the digital consumer market.

www.iqep.com

Riber secures order for MBE 49 GaN system

European customer boosting capacity for GaN display components

Molecular beam epitaxy (MBE) system maker Riber S.A. of Bezons, France says that it has sold an MBE 49 GaN production system (for delivery in 2025) to a European customer that aims to enhance its capacity for producing gallium nitride components for next-generation high-brightness and low-energy displays. The MBE 49 GaN system is specifically configured for plasma-assisted GaN epitaxy on 200mm silicon wafers, offering a solution for manufacturing aluminium gallium nitride (AlGaN) and indium gallium nitride (InGaN) devices.

Riber says its MBE technology enables lower growth temperature for high-indium-content InGaN, precise control over nanowire formation, minimal residual doping, and enhanced p-type doping — crucial in optimizing technology performance.

www.riber.com

Toray develops high-speed mounting of III-V chips on silicon for silicon photonics

Firm demos first laser transfer and bonding technology to reduce data-center power loads

Toray Industries Inc of Tokyo, Japan has developed materials and technologies for mounting indium phosphide (InP) and other optical semiconductors used in silicon photonics on silicon substrates.

Artificial intelligence (AI)-driven demand for high-speed communications is fueling the construction of more data centers, raising concerns about their heavy power demands. This has accelerated the development of optical communications, whose energy losses are lower than those of conventional systems, for long-distance transmission and short-range (less than 1m) communications within data centers.

This has led to the use of silicon photonic optical circuits on silicon substrates. The challenge is that this setup requires mounting optical semiconductors made from indium phosphide and other III-V compounds onto silicon. Mass transfer technology (which shifts a large number of chips to a substrate at once and accurately positions them) is essential to do this swiftly and in large quantities.

Toray has hence worked with subsidiary Toray Engineering Co Ltd to develop a material for fast laser transfers of indium phosphide and other optical semiconductors. They also worked on a material to catch transferred chips and bond them directly to silicon substrates and a related mounting process technology.

Toray Engineering has semiconductor bonding and laser mass transfer technologies. The work with Toray has boosted optical semiconductor bonding speed to 6000 units per minute (according to Toray research, compared with about 4 units per minute with conventional flip-chip bonders). This is expected to accelerate the application of optical communications within data centers. The two companies will keep collaborating to establish technologies with actual devices by 2025 with a view to early mass production.

Developed materials and technology details

1. Transfer materials (impact resistance control)

Toray previously innovated transfer materials for micro-LEDs. In this case, the InP-based optical semiconductors are 640μm long and 90μm wide and less than 3μm thick. While longer and wider than general micro-LEDs, the chips are also extremely thin. Toray developed a new material that enables transfer with a single laser irradiation without damaging chips, which should improve yields and throughput.

2. Catch material offering improved thermal and chemical resistance

The catch material must not only capture fast-flying chips but also withstand the subsequent direct bonding of these chips to the silicon substrate after chemical cleaning and activating the bonding surface with plasma, pressurizing under high temperature more than 200°C. Release must thereafter be easy. Toray says that it employed years of expertise in designing heat-resistant polymers and controlling adhesive properties to develop a new catch material that makes this possible.

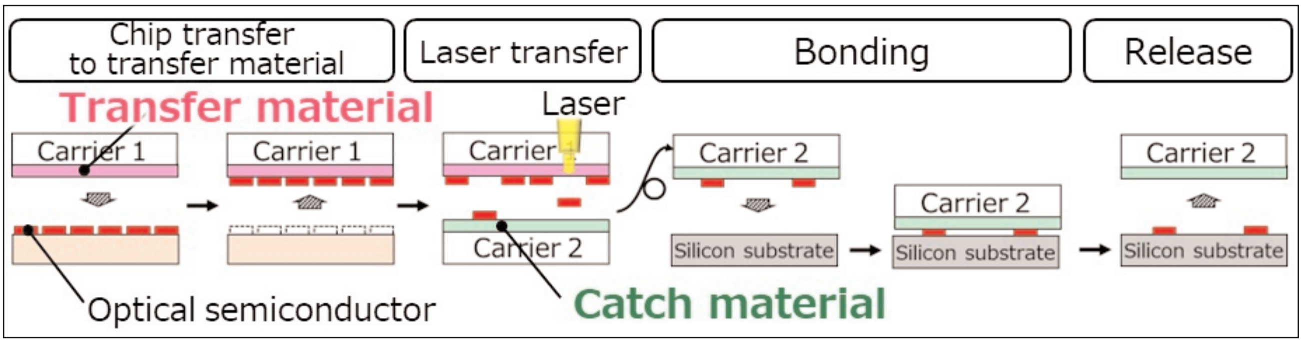
3. Process technology (demonstrating laser transfer to direct bonding)

Toray used the developed materials to collaborate with Toray Engineering in developing and demonstrating the entire process, from laser transfer to direct bonding on a silicon substrate. The company has confirmed a post-bonding positional accuracy of ±2μm and a rotational deviation of ±1°.

Toray aims to verify chip operation and use actual devices to establish its technology. It intends to enhance positional accuracy and broaden technology applications to include mass transfer of chips made from other different materials and millimeter-scale chips.

Toray developed part of this technology with a grant for the New Energy and Industrial Technology Development Organization's JPNP 20017 project, which aims to solidify the foundations of post-5G information and communications systems.

www.electronics.toray
www.toray.com



Toray's high-speed mounting process for optical semiconductors.

Comptek completes installation of Kontrox-powered 200mm wafer pilot line

Passivation for power electronics and opto chip making funded by EIC

Comptek Solutions Oy of Turku, Finland (which specializes in III-V compound semiconductor quantum surface engineering) has completed the installation of its pilot line, after a two-year project funded by the European Innovation Council (EIC).

The pilot line integrates Comptek's proprietary Kontrox passivation technology with other widely used industry techniques such as atomic layer deposition (ALD), delivering a proven, scalable solution for industrial manufacturing specifically targeting power electronics and optoelectronic applications.

Designed to validate Comptek's Kontrox passivation technology on up to 200mm substrates, this cluster tool integrates the Kontrox passivation process with industry-standard methods, featuring a plasma-enhanced ALD (PE ALD) module, along with advanced functionalities for wet etching and chemical processing in a controlled inert gas atmosphere. With continuous processing that maintains vacuum between different process steps, the system offers flexibility in developing complex passivation solutions that meet the most demanding requirements, it is claimed, ensuring superior chip performance and long-term reliability for high-performance semiconductor applications.

"The pilot line we've developed through the EIC-funded 'Enlight' project is a testament to our commitment to pushing the boundaries of passivation technology," says CEO & co-founder Vicente Calvo Alonso. "The possibility to combine our unique Kontrox passivation technique with advanced ALD capabilities allows us to deliver highly customizable and optimized solutions, designed to overcome the challenges and fulfill the needs of power electronics and optoelectronic manufacturers," he adds. "With this pilot line, we are

Comptek's pilot line.

excited to offer our customers the opportunity to tailor the processes to their exact production requirements, helping them achieve unprecedented performance for their device applications."

The pilot line integrates Comptek's Kontrox process with ALD technology, implemented using Veeco's PE-ALD FIJI 200 system. This combination provides what is said to be a transformative approach to minimizing surface defects and creating a sharp III-V dielectric interface. The result is said to be superior interface quality, crucial for maximizing chip performance and optimizing yields in a wide range of semiconductor applications, from sidewall passivation layers for micro-LEDs to complex gate stack dielectrics for power transistors.

Through the EIC Accelerator funding, the Comptek was able to refine its core processes and validate its passivation technology for large-scale industrial manufacturing. "The EIC's funding and guidance have enabled us to build a turnkey passivation solution for larger substrates, allowing Comptek Solutions to advance the applicability of our technology to the industrial scale," comments Vicente. "This achievement would not have been possible without the EIC's belief in the potential of our innovations and their commitment to driving technological breakthroughs in Europe."

The compound semiconductor substrate market is reckoned to be growing at 17% annually from 2023 to US$3.3bn in 2029, driven by increasing demand from sectors such as automotive, communications and consumer electronics, with growth in power electronics fuelling the transition to larger substrates like 200mm wafers for silicon carbide (SiC) and gallium nitride on silicon (GaN-on-Si). Meanwhile, the rising use of 150mm indium phosphide (InP) in datacoms and 200mm gallium arsenide (GaAs) and sapphire in micro-LED displays is driving further demand for advanced semiconductor technologies, Comptek notes. These trends underscore the need for high-quality passivation to ensure optimal performance and reliability in power and optoelectronic applications while promoting sustainable semiconductor manufacturing, the firm adds.

Comptek says that its EIC-funded pilot line, with its potential for next-level compound semiconductor-based substrate passivation, has already attracted significant interest. Several major manufacturers have already scheduled trial runs to explore its top-tier capabilities for their specialized production needs, and the company's capacity for 2025 is already fully booked.

www.comptek-solutions.com

Samsung exiting mainstream LED market

Focus shifting to power semiconductors and micro-LEDs

Market research firm TrendForce notes that, according to a report by China's CCTV Finance, South Korea's Samsung Electronics has begun restructuring its business, as the semiconductor division has decided to withdraw from the mainstream LED market, due mainly to the firm's overall performance falling short of expectations.

According to preliminary unaudited financial results for third-quarter 2024, both profit and revenue fell below market expectations. Sales were KRW79 trillion, up 17.2% year-on-year but below the market estimate of KRW81.57tr. Operating profit was KRW9.1tr, up 274.5% but down 12.8% on the prior quarter, and below analysts' expectations of KRW11.5tr.

Samsung entered the LED lighting business in 2012 by merging with Samsung LED, but in recent years the business has been gradually losing its competitive edge in the international market, says TrendForce. Although annual sales from this business reached about RMB10.4bn, its contribution to Samsung's overall sales was too small to ensure the desired profitability.

Samsung has hence decided to divest the LED business to focus more on areas with better growth prospects, such as micro-LED technology and power semiconductors (e.g. power conversion and current control in electric vehicles, smartphones, energy storage, and home appliances).

Expanding power semiconductor business

At the beginning of 2023, Samsung established a special task force for power semiconductors, and by the end of the year it further reorganized its operations, transforming the LED division into the Power Semiconductor Division, notes TrendForce.

At its Foundry Forum in July 2023, Samsung announced that it would launch 8-inch gallium nitride (GaN) power semiconductor foundry services by 2025, targeting applications in consumer electronics, data centers, and automotive markets. Most recently, as part of this strategic plan, in second-quarter 2024 Samsung installed a metal-organic chemical vapor deposition (MOCVD) system from Germany-based Aixtron in its Giheung factory, which specializes in 8-inch wafer foundry.

Challenges facing Samsung's semiconductor business

Despite being one of its strongest sectors, Samsung's semiconductor division is also facing increasing challenges.

In terms of wafer foundry, Samsung has long aimed to compete with Taiwan's TSMC. However, there is still a noticeable gap in market share between the two. According to the latest rankings from TrendForce in early September, TSMC held a dominant 62.3% market share in second-quarter 2024, while second-place Samsung had a share of 11.5%.

Moreover, Samsung's plans to build a wafer foundry in the USA have faced repeated delays. According to Reuters, Samsung has postponed the procurement of equipment for its Texas-based Taylor wafer plant due to difficulties in securing clients willing to collaborate.

The Taylor plant, with an investment of $17bn, was originally intended to produce advanced chips for markets such as artificial intelligence and smartphones, which require extreme ultraviolet (EUV) lithography equipment. Each standard EUV system costs about $150m, and it is currently unclear how many units Samsung had originally planned to order from supplier ASML. Both Samsung and ASML have declined to comment on the delayed equipment orders.

Earlier this year, media reports indicated that Samsung had delayed the mass-production timeline for the Taylor plant from 2024 to 2026. However, without securing any cooperative clients, the plant's prospects remain challenging, even with the delayed production schedule.

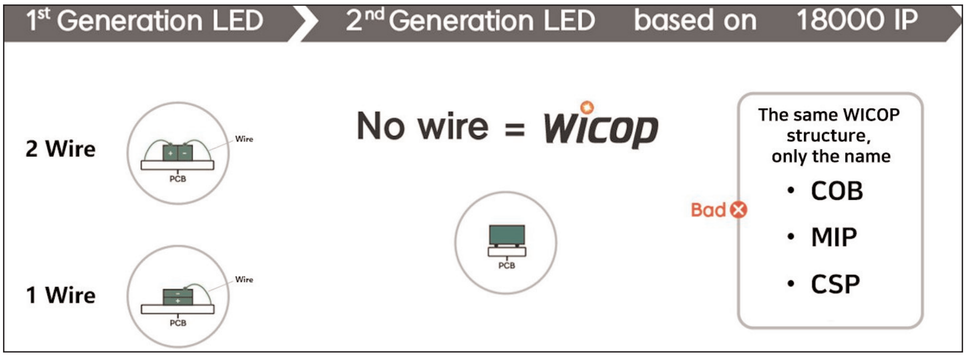
Some analysts suggest that if Samsung does not finalize orders for the necessary production equipment by early 2025, the production timeline could be further delayed, considering the time required from chip production to delivery.

Samsung Electronics plays a critical role in South Korea's economy. As noted by China's CCTV Finance, Samsung's exports accounted for about 18% of South Korea's total export volume last year. A decline in Samsung's performance not only affects the competitiveness of South Korea's semiconductor exports but also has a ripple effect on numerous upstream and downstream companies that collaborate with Samsung.

www.trendforce.com

Seoul Semi wins Unified Patent Court case against Expert e-Commerce

Sales ban, recall and destruction of products infringing 'No Wire' LED patent ordered in eight European countries



South Korea-based Seoul Semiconductor Co Ltd and its affiliate Seoul Viosys says that the Unified Patent Court (UPC) has issued a judgment ordering a sales ban, recall and destruction of products infringing Seoul's 'No Wire' (WICOP) patent in eight European countries.

According to the judgment, Expert e-Commerce (the third largest European online retailer, with about $14bn in annual revenue) has been ordered to stop selling infringing products in eight European countries, and to retrieve and destroy infringing products.

Since the foundation of the UPC, Seoul is the first non-European patent holder to win a judgment in the main patent infringement proceedings. The judgment also set a record for the highest number of countries subject to the UPC's order for injunctions and recall and destruction of infringing products, says Seoul Semi.

In the past, patent infringement decisions were only effective on a country-by-country basis,, forcing patent holders to spend significant time and cost in enforcing patents across different European countries, notes the firm. Seoul adds that it also confronted LED companies that evaded enforcement by merely changing product names and then continuing to sell infringing products, along with large corporations that knowingly purchased such products.

However, the UPC decision will result in a comprehensive sales ban against infringing products across various European countries, and confirm the validity of Seoul's No-Wire patent, says the firm, which anticipates swift enforcement against infringers.

Seoul's No Wire technology enables LED miniaturization and improves light extraction efficiency by enhancing light reflection and current spreading. These are advantages for high-efficiency LEDs in applications such as mobile phone flash, micro LED displays, automotive headlamps, and high-power lighting.,

www.SeoulSemicon.com

ams OSRAM adds new 3535 UV-C LED for disinfection

115mW output and 5.3% wall-plug efficiency at 265nm wavelength

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has unveiled its new OSLON UV 3535. Serving the growing demand for mercury-free and efficient UV-C disinfection and treatment solutions, the UV-C LED offers 115mW output power from a single chip at 265nm, which is the emission wavelength providing the highest germicidal effectiveness. Combined with what is said to be outstanding wall-plug efficiency (WPE) of 5.3%, the optimized system solution has been specifically designed for the UV-C disinfection market.

"Our advancements in package design and semiconductor technology are leading the way in UV-C solutions that blend efficiency with quality and performance," claims Nina Reiser, senior product manager for UV-C. "Meeting the efficiencies desired while maintaining a long lifetime [an R70B50 lifetime of more than 20,000 hours] and superior price performance becomes more challenging at 265nm, the ideal wavelength to achieve the maximum germicidal effectiveness to fight pathogens."

With a standard 3.5mm x 3.5mm footprint, the LED supports versatile, compact designs with high cumulative radiant flux within a 120° emission angle. The enhanced performance of the OSLON UV 3535 LEDs is attributed to innovations in package design and semiconductor technology using the latest flip-chip generation in an open 3535 ceramic package. The AlGaN-based flip chip is a more multi-faceted radiation source than traditional UV-C sources, offering flexibility in wavelength, output power and instant-on functionality. Its open package design and integrated frame technology increase efficiency while reducing costs. The highly reflective frame improves light outcoupling and forward-directed radiation, positioning the products on a strong performance trajectory in the rapidly growing UV-C market, ams OSRAM reckons.

www.ams-osram.com/products/leds/uv-c-leds

ams OSRAM adds LEDs based on new IR:6 technology to boost performance in security and biometrics

OSLON P1616 and OSLON Black series LEDs available in 850nm, 940nm and new 920nm wavelengths

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has introduced its new IR:6 infrared (IR) LED chip technology, which increases brightness by up to 35% and efficiency by up to 42% compared with the existing chip technology used in ams OSRAM IR LED emitters.

The new IR:6 thin-film chip technology will enable manufacturers of products such as security cameras and biometric authentication systems in PCs and smart doorbells to achieve better illumination for improved image quality as well as the faster, more accurate recognition of individual biometric markers, while saving power and extending battery run-time between charges, says the firm.

In medical equipment such as light therapy fixtures for the treatment of tissue damage, the higher optical power output from the IR:6 chip can enable equipment makers to use fewer LEDs while producing the same therapeutic effect, saving space and reducing bill-of-materials cost.

The first products to take advantage of the new chip are the OSLON P1616 series of high-power LEDs in a compact 1.6mm x 1.6mm package — and the OSLON Black family, which offers various viewing angle options, including a new rectangular field of illumination which is suitable for use with IR cameras.

"Customers that replace their existing IR LEDs with new IR:6-based LEDs can instantly achieve better performance in their application with lower power consumption," says product marketing manager Dominic Bergmann.

IR:6 next-generation infrared LED technology

To achieve its performance, the new IR:6 chip technology implements various improvements in

materials, structure and design, including:

- improvements to the intrinsic chip efficiency;
- a new central bond pad for better current spreading and a lower forward voltage;
- better roughening of the chip's surface for higher decoupling efficiency and higher brightness.

In addition, the new IR:6 technology adds the capability to emit light at a 920nm dominant wavelength, as well as the familiar 850nm and 940nm wavelengths. The new 920nm option offers a higher signal-to-noise ratio (SNR) than the 940nm option because of photodiodes' higher sensitivity to shorter wavelengths, and a weaker visible red glow effect than at 850nm.

At the time of its launch, IR:6 technology is available in the following 'B' designated versions of the existing OSLON P1616 products, which are aimed at space-constrained applications:

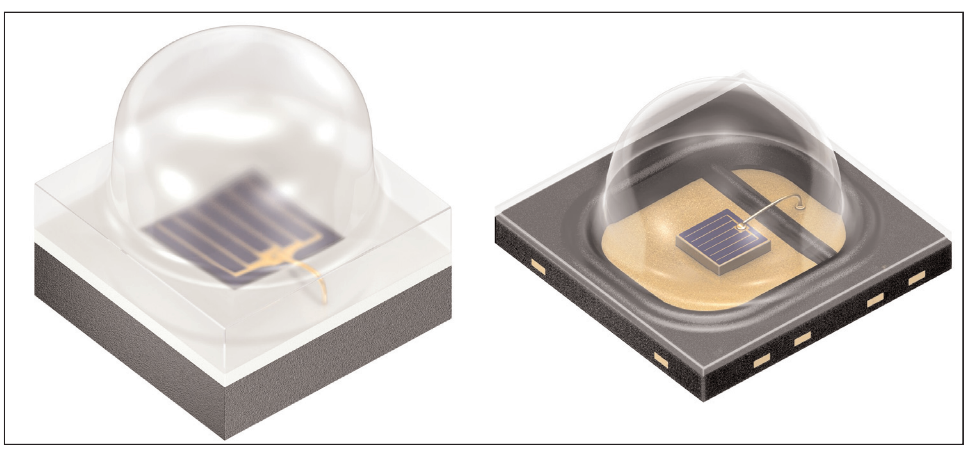
- OSLON P1616 SFH 4180BS — 920nm/940nm-wavelength options, 1485mW radiant flux, 130° viewing angle;
- OSLON P1616 SFH 4181BS — 920nm/940nm-wavelength options, 1550mW radiant flux, 70° viewing angle;
- OSLON P1616 SFH 4182BS — 920nm/940nm-wavelength options, 1650mW radiant flux, 130° optimized viewing angle.

The technology is also available in new versions of existing OSLON Black emitters:

- OSLON Black SFH 4713B — 850nm wavelength, 980mW radiant flux, 80° viewing angle;
- OSLON Black SFH 4714B — 850nm wavelength, 940mW radiant flux, 150° viewing angle;
- OSLON Black SFH 47167B — 850nm wavelength, 940mW radiant flux, 110° x 130° rectangular field-of-illumination.

The IR:6 chip is manufactured by ams OSRAM at its plant in Regensburg, Germany. The entire supply chain for OSLON P1616 and OSLON Black LEDs, from chip to packaging, is fully controlled by ams OSRAM to give customers full confidence in the product's high-volume availability, the firm adds.

www.ams-osram.com/innovation/technology/irled-ir6 —



ams OSRAM's OSLON P1616 (left) and OSLON Black (right) LEDs.

ams OSRAM launches new EVIYOS multi-pixel LED

EVIYOS HD 25 gen2 boosts brightness and reduces stray light emission

At the Société des Ingénieurs de l'Automobile's SIA Vision 2024 international congress in Paris, France (16–17 October), ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has launched EVIYOS HD 25 gen2 as the latest generation of its EVIYOS LED technology.

The first generation of the EVIYOS multi-pixel LED for adaptive driving beam (ADB) and projection headlamps was launched in 2023 It was first implemented by Volkswagen in its Touareg and Tiguan models equipped with headlamps made by Marelli, each of which featuring 19,200 pixels (whereas the EVIYOS light source itself can provide up to 25,600 individually controllable pixels).

Intelligent EVIYOS-based headlamps improve night driving by lighting up much more of the road ahead without dazzling drivers of oncoming vehicles. The EVIYOS LED can also be used to project symbols and pictures on the road, opening up new potential for car-to-environment communication (mainly for safety warnings and other messages). ADB headlamps also bring new features to Advanced Driver Assistance Systems (ADAS), and enable car makers to create distinctive new design and styling effects in the front of the car.

The EVIYOS HD 25 gen2 has now introduced improvements made in response to market requirements. These include:

- Enhanced brightness specification — the original EVIYOS HD 25 gen1 produces a typical brightness of 85mNits, whereas the new EVIYOS HD 25 gen2 has been improved this to a minimum brightness of 85mNits.
- Reduced stray light emission — making the headlamp's optical system easier to design and manufacture.
- A more resilient supply chain — using ams OSRAM's in-house capabilities ensures the continuous supply and quality of the companion ASIC that controls the LED component.

EVIYOS LED development roadmap

ams OSRAM says that the rapid development of the enhanced product features in EVIYOS HD 25 gen2, hardly a year after the launch of the first product in the EVIYOS product family, reflects its commitment to the roadmap that it has shared with the automotive industry. The launch of EVIYOS HD 25 gen2 accordingly be followed by further product announcements and introductions in the coming years, including a version of the EVIYOS LED for low-end and mid-range vehicles.

ams OSRAM will also be announcing new customer design wins. While Volkswagen was the first to take advantage of the high-resolution projection capability of the EVIYOS LED, other car makers are following, benefiting from the customer appeal of a headlamp that improves night-time vision and road safety while providing greater freedom to shape the appearance of the vehicle and enable the creation of unique design signatures such as welcome home/leave home 'light carpets' and distinctive front styling.

The innovations introduced in EVIYOS LED technology have also been recognized by the federal government of Germany, which in September nominated ams OSRAM for the German Future Award – Federal President's Award for Technology and Innovation. Following a multi-stage assessment process, the EVIYOS engineering team was named as one of three finalists. The ams OSRAM engineers named in the award citation are Dr Norwin von Malm (senior director New Technologies) and Stefan Groetsch (who leads the System Solution Engineering team), alongside Dr Hermann Oppermann of the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin.

www.sia.fr/evenements/343-sia-vision-2024

www.ams-osram.com

Lynred acquires New Imaging Technologies

Lynred of Grenoble, France, which designs and makes infrared (IR) sensors for aerospace, defense and commercial applications, has bought Paris-based New Imaging Technologies (NIT), which designs and makes shortwave-infrared (SWIR) imaging sensors and modules based on indium gallium arsenide (InGaAs) focal plane arrays. Lynred's portfolio will expand to include high-definition large-array SWIR sensors in small pixel pitch, bolstering its product range across all wavelength bands (short to very longwave). The transaction should close in fourth-quarter 2024, subject to customary conditions.

The deal includes NIT's portfolio of SWIR products (imaging sensors and modules) and a portfolio of wide-dynamic-range patents. This enables Lynred to offer global customers large-format SWIR sensors with advanced capabilities for applications in markets where artificial intelligence (AI), deep learning and multi-spectral imaging are driving growth.

New Imaging Technologies (NIT) is reckoned to be the only European firm to manufacture and market a SWIR HD1080p array and associated module at a pixel size of 8μm, a key asset for several applications that Lynred will now leverage.

"Lynred's acquisition of NIT is a growth accelerator. We will shorten time to market and leverage synergies in offering state-of-the-art SWIR products," says Lynred's executive president Hervé Bouaziz. "The global market for SWIR infrared imaging for machine vision is growing fast, as well as for defense applications, such as laser detection and in new space," he adds. "NIT brings to Lynred the agility of a small, innovative organization, with an extensive product offering able to cater to our large customer base. As we share complementary industrial supply chains and technical skills, we can deliver highly competitive SWIR imaging sensors and modules to customers."

In parallel to the strategic acquisition of NIT, Lynred is also investing significantly in its ongoing Campus project, which includes the construction of cleanrooms that will double Lynred's existing capacity.

www.new-imaging-technologies.com
www.lynred.com

Lynred completes biggest space contract

Lynred has completed its biggest space contract so far, worth tens of millions of euros. Beginning in 2004 with pre-development technology studies followed by a design and production phase in 2011, the firm has delivered to Thales Alenia Space the last of 26 IR detector flight models destined for the more than 20-year operational lifespan of the MTG (Meteosat Third Generation) mission, a European Space Agency (ESA) program for storm prediction and enhanced weather forecasting.

Operated by EUMETSAT (the European operational satellite agency for monitoring weather), the mission is to guarantee continuity of data for weather forecasting from geostationary orbit for the next two decades. It focuses on near-forecasting of severe weather events amid current climate change. The system is based on two types of satellite: four MTG-Imagers (MTG-I) and two MTG-Sounders (MTG-S).

Lynred produced the flight models for all satellites in the MTG program, comprising the MTG-I satellites (in 2018), an Earth spectral imaging instrument used for multi-purpose imagery and wind derivation by tracking clouds and water vapor features, and Earth atmosphere analysis (MTG-S) satellites.

Imaging from SWIR to VLWIR

Over the past four decades, Lynred has developed and delivered IR detectors for various space programs and seen them deployed in missions. Key to its space-grade IR detectors is leveraging its production-proven MCT (mercury cadmium telluride) technology and hybridization process, and harnessing its experience in designing IR detectors.

Challenges overcome while developing the IR detectors for the MTG satellites included excelling in signal-to-noise ratio, linearity, operability, spectral response accuracy and modulation transfer function across the electromagnetic spectrum — shortwave band (SWIR) to very longwave band (VLWIR). Other achievements include, in particular, the operation of IR detectors in the VLWIR spectral range up to 15 μm with low dark current and ultimate detector operability at nominal system operating temperature.

Next steps

In December 2022, ESA launched the first MTG-I satellite. The first MTG-S satellite will be launched in summer 2025. The second MTG-I is scheduled for summer 2026, to complete the MTG in-flight full operational configuration. Two other MTG-I satellites and another MTG-S will then be launched. These will enable the MTG program to fulfill its 20-year operational requirement into the early 2040s and provide data for meteorological forecasting. In the meantime, the next-generation meteorological satellite studies will be initiated.

Lynred says it has a heightened capacity to provide its expertise in space IR detector development, especially for next-generation meteorological satellites. The first studies are expected to start in the second half of this decade, so the satellites will be ready for launch around 2040, to replace the existing generation of MTG satellites.

www.thalesaleniaspace.com/en
www.esa.int/Applications/Observing_the_Earth/Meteorological_missions/meteosat_third_generation

TriEye and HLJ unveil joint SWIR sensing and imaging solution

Collaboration demonstrates CMOS-based SWIR sensors and 1135nm VCSEL technology

TriEye Ltd of Tel Aviv, Israel — which claims to have pioneered the first CMOS-based shortwave infrared (SWIR) image-sensing solutions — and HLJ Technology of Hsinchu, Taiwan — which was founded in 2001 and provides vertical-cavity surface-emitting laser (VCSEL) and photodiode solutions for consumer electronics, optical connectivity, and automotive markets — have announced the joint demonstration of a VCSEL-powered SWIR sensing and imaging solution.

Combining TriEye's SWIR sensor with HLJ's 1135nm VCSEL technology has yielded a solution that balances cost, eye-safety and performance. Leveraging high-volume, scalable manufacturing platforms, the technologies are said to provide cost-effective solutions for both consumer and industrial market demands.

Designed to enable SWIR imaging in industries including industrial machine vision, robotics and consumer electronics, the high sensitivity and resolution of TriEye's new TES200 CMOS-based SWIR image sensor is claimed to represent a step forward in mass-market SWIR imaging technology.

Complementing this, HLJ Technology has introduced its 1135nm high-power VCSEL, produced using its high-volume 6-inch gallium arsenide (GaAs) fabrication line. This provides what is said to be the most cost-effective SWIR laser solution while providing the benefits of eye-safety and environmental immunity.

"Welcoming a key laser partner into our SWIR sensing ecosystem enables us to unlock new applications and markets, empowering industries to leverage SWIR imaging in ways that were previously out of reach," says TriEye's CEO Avi Bakal.

A live demonstration of the VCSEL-powered SWIR sensing and imaging solution was given in TriEye's booth 8A08 at the VISION 2024 exhibition in Stuttgart, Germany (8–10 October).

www.messe-stuttgart.de/vision/en
www.hlj.com.tw
www.TriEye.tech

PhotonVentures Fund I receives €5m investment from Invest-NL

National financing and development institution joined by group of new private investors

Netherlands-based independent deep-tech venture capital fund PhotonVentures has received investment from national financing and development institution Invest-NL and a group of new private investors, with Invest-NL contributing €5m. This not only strengthens the fund's capital base but also underscores the importance of the photonics industry for the Netherlands, as well as its competitive position in Europe and globally, says PhotonVentures. Integrated photonics is one of the key technologies in which Europe, and particularly the Netherlands, plays a significant role. To maintain this position, substantial investments from both the private and public sectors are essential, it adds.

Invest-NL joins a group of tech investors, family offices, the Brabant Development Agency (BOM), PhotonDelta, Oost NL, the University of Twente, and TNO, who have previously invested in the fund. The final close of PhotonVentures Fund I, with a targeted fund size of €100m, is planned for the end of 2024.

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.

PhotonVentures is a specialized deep tech fund that invests in photonics startups in the Netherlands and Europe. By investing from an ecosystem perspective, young companies in the portfolio are better positioned in the rapidly developing photonics market, gain quicker access to customer feedback, and benefit from an international network for further growth. The fund currently has 14 investments in companies, including Smart Photonics, Effect Photonics, Phix, PhotonFirst, and VitreaLab.

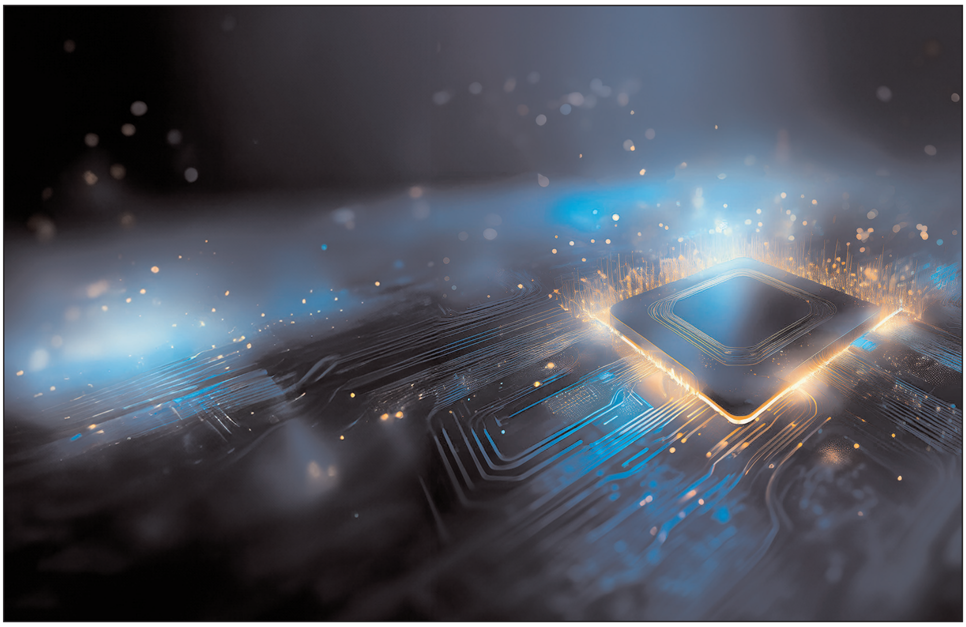
Invest-NL's involvement as a new investor "not only reflects confidence in this specialized fund but also highlights the immense potential of integrated photonics and the crucial role it plays in technological progress in the Netherlands and beyond," says Ewit Roos, general partner at PhotonVentures.

"Photonics is a key technology for the Netherlands and a priority in the national technology strategy," notes Liz Duijves, investment manager at Invest-NL. "As one of the few photonics funds in Europe, PhotonVentures is a vital player in the further development of this sector. Our investment makes a significant contribution to the growth and innovation of the integrated photonics industry in the Netherlands."

www.photonventures.vc

PhotonDelta launches engineering contest to drive photonic chip applications

imec, LioniX, SMART Photonics, PHIX Photonics Assembly, Epiphany and Bright Photonics to transform winning idea into reality



Photonic chips industry accelerator PhotonDelta of Eindhoven, the Netherlands (which connects and collaborates with an ecosystem of photonic chip technology organizations worldwide) is launching a global engineering contest in collaboration with engineering community and knowledge platform Wevolver to stimulate the creation of new applications for photonic chips that tackle global challenges.

The contest is a global competition for innovative ideas for photonic integrated circuit (PIC)-based solutions that address some of the most pressing societal and technical challenges, from combating climate change and advancing healthcare to addressing energy sustainability challenges. The competition invites engineers to use the characteristics of photonic ICs to revolutionize fields like healthcare, autonomous vehicles, AI and agriculture by enabling advanced sensors for earlier diagnostics, safer infrastructure, or more efficient food production. The ultimate goal of the contest is to discover future applications in segments that are yet to be invented.

The contest is backed by a €60m fund from PhotonDelta, set up to stimulate the creation of new start-ups and innovative applications in the PIC industry. By offering favorable loans to (pre-)seed companies, the fund supports entrepreneurs and researchers in turning their ideas into viable businesses. The initiative aims to foster innovation at the earliest stages, encouraging the development of new technologies and applications that can shape the future of the PIC ecosystem.

The winner will receive €50,000 worth of services to bring their idea to life as well as global exposure at an industry event. Also, participating in the challenge will provide the opportunity to position the company for raising a favorable loan of up to €2m by PhotonDelta. The contest is supported by imec, SMART Photonics, LioniX International, Bright Photonics, Epiphany and PHIX Photonics Assembly.

"One of the most exciting and compelling aspects of PIC technology is the sheer breadth of applications it can be used for and its capacity to tackle some of the most pressing problems we face as a society," says PhotonDelta's CEO Eelko Brinkhof. "We want to encourage people to come forward with their most innovative ideas. We will provide the winner with significant support to get their ideas off the drawing board and into production."

The contest is a global competition for innovative ideas for PIC-based solutions that address some of the most pressing societal and technical challenges, from combating climate change and advancing healthcare to addressing energy sustainability

The Global Photonics Engineering Contest is open to startups, established companies, engineers, researchers, students and academic organizations working on innovative photonic chip applications.

The contest was launched officially at PIC Summit 2024 in Eindhoven on 15 October. Submissions will be open until the 3 March 2025, with the winner and runners up announced on the 2 April.

Contest entries will be judged on the level of innovation, technical and commercial feasibility, and how effectively the design addresses current industry challenges. Participants are required to submit detailed descriptions of their projects, including team information and supporting visuals or videos. A jury panel of experts from the integrated photonics industry will review the submissions, with the winners announced on 8 April 2025.

www.wevolver.com/article/global-photonics-engineering-contest
www.photondelta.com

NUBURU secures strategic $65m funding program to accelerate commercialization

Funding includes $15m PIPE investment and $50m equity line of credit

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — has announced a funding program of about $65m, comprising $15m of direct private investment in public equity (PIPE) and $50m equity line of credit, enabling it to accelerate commercialization with predictable access to capital.

Specifically, the firm has entered into a master transaction terms agreement with Liqueous LP, a Delaware limited partnership pursuant to which NUBURU and the investor established a strategic financing framework for short-term and long-term financing for the firm. The master agreement provides for:
(i) an immediate capital infusion from the investor of $3m at the current market price,
(ii) subsequent weekly capital infusions of $1,250,000 at market price until an additional $10m has been invested;
(iii) the acquisition and conversion of certain outstanding notes;
(iv) an adjustment to current market price of certain outstanding pre-funded warrants held by the investor having a current cash value of about $2.2m; and
(v) the implementation of a $50m equity line of credit pursuant to which NUBURU may require the investor to purchase common stock from time-to-time in the amounts and for the prices determined in accordance with the terms of the equity line of credit which includes an optional advancement of $2.5m through a convertible note with an 8% annual interest rate and with a conversion rate at a 10% discount to the lower of the previous day's closing price or the prior five-day average.

No issuances pursuant to the financing plan will be made to the extent such issuances would:
(a) cause the investor to hold greater that 4.99% at any time; or
(b) result in the issuance of greater than 19.9% of NUBURU's outstanding common stock, unless any stockholder approval that is required under NYSE American rules is first obtained.

Strategic partnerships

NUBURU notes that its blue laser technology is protected by 233 patents and includes both public and private sector applications. Strategic partnerships include past and active contracts with NASA and the US Air Force.

Long-term growth alignment

This financing provides both an immediate capital infusion and access to a long-term capital facility to support NUBURU's strategic goal of long-term, sustainable growth. The firm reckons that these infusions, combined with its IP portfolio, position it to achieve commercialization and continue to advance and expand its IP portfolio.

www.liqueous.com
www.nuburu.net

BluGlass secures AUS$1.2m order for first phase of multi-year JDA with Uviquity

Follow-on master supply agreement to produce heterogeneously integrated photonic integrated circuits

BluGlass Ltd of Silverwater, Australia — which develops and manufactures gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has secured an AUS$1.2m order for the first phase (lasting about 12-months) of a three-phase joint development agreement (JDA) with Uviquity of Raleigh, NC, USA, a venture-backed start-up pioneering wide-bandgap integrated photonics.

The multi-year development agreement will see BluGlass and its collaboration partner develop novel photonic chips that combine highly complementary technologies for the production of heterogeneously integrated photonic integrated circuits (HIPIC).

"This agreement leverages BluGlass' core epitaxy, wafer fabrication, custom device capabilities, and our ability to solve our customers' greatest challenges," says CEO Jim Haden.

"BluGlass has developed leading blue semiconductor laser technology and production capabilities that enhance our next-generation wide-bandgap photonic integrated circuits," comments Uviquity's CEO Scott Burroughs. "That combination makes BluGlass an ideal partner."

The multi-phase, potentially three-year JDA has the potential for a minimum of two additional phases of non-recurring engineering (NRE), each with a similar revenue potential for BluGlass. The parties agree to execute a follow-on master supply agreement to produce the HIPIC devices, six months before the completion of the development phases, with significant commercial potential.

https://uviquity.ai
www.bluglass.com.au

UK project to facilitate secure quantum key distribution with high-performance OEM receiver modules

Phlux to provide Noiseless InGaAs APD sensors for four-channel single-photon avalanche detector

Backed by funding from Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation) under the 'Scalable Quantum Network Technologies: Collaborative R&D' program, the £1.5m MARCONI project on quantum key distribution (QKD) is developing and demonstrating high-fidelity modular and scalable receiver modules. QKD is a secure communication method that leverages the principles of quantum mechanics to generate and distribute cryptographic keys between two parties, ensuring that any attempt at eavesdropping can be detected. The MARCONI initiative is expected to not only strengthen the UK's position in addressing the challenge of bringing scalable quantum network technologies to market but also enhance national security and economic growth.

Specifically, the project aims to introduce two new OEM QKD receivers based on different technologies, which are interchangeable at the optical connection point. These receivers will be constructed using UK components, ensuring a robust domestic supply chain for critical quantum networking technologies.

For smaller setups and short-distance communications, a four-channel single-photon avalanche detector (SPAD) system will feature Noiseless InGaAs (indium gallium arsenide) avalanche photodiode (APD) infrared sensor technology from Sheffield University spin-off Phlux Technology, packaged by Bay Photonics Ltd of Paignton, UK. For larger, long-distance applications, a superconducting nanowire single-photon detector (SNSPD) system will be employed, incorporating enhanced SNSPDs from the University of Glasgow, cooled by a novel 1K system from Sheffield-based Chase Research Cryogenics Ltd, and coupled with a new compact timetagger from Redwave Labs Ltd of Didcot, UK. Redwave Labs will optimize the control electronics and timetaggers for both systems, which will be coupled with an optical receiver module from the Fraunhofer Centre for Applied Photonics (CAP) of Glasgow, Scotland, UK.

The University of Cambridge will showcase these receivers in entanglement-based discrete variable-QKD transmission across both metro and long-haul networks, using the BBM92 protocol. This demonstration will highlight the scalability and performance of the MARCONI receivers.

The MARCONI project addresses two critical needs: establishing a UK-led supply chain for quantum networking components and enhancing the scalability of quantum networks. The QKD market is forecasted to grow to about $5bn by 2028. By developing high-performance OEM receiver modules for both small and large installations, MARCONI aims to disrupt the market and reduce reliance on single-source suppliers.

It is reckoned that MARCONI's innovations promise economic and security advantages, including job creation and safeguarding within the UK supply chain, enhanced national security through the adoption of more secure QKD systems, reduced import dependency for high-performance photonics systems, and boosting the reputation and impact of the UK photonics industry. As system integrator, Redwave Labs will lead the commercialization efforts for the QKD receiver modules.

The project is expected to generate substantial revenue and growth opportunities for all consortium partners.

www.bayphotonics.com
www.redwavelabs.com
www.chasecryogenics.com
www.cap.fraunhofer.co.uk
www.phluxtechnology.com
www.ukri.org/opportunity/scalable-quantum-network-technologies-collaborative-rd

Infinera allocated $93m of proposed US CHIPS Act funding

$200m in funding and investment tax credits to expand semiconductor fabrication and packaging for critical US infrastructure and AI applications

The US Department of Commerce have signed a non-binding preliminary memorandum of terms for Infinera Corp of San Jose, CA, USA — a vertically integrated manufacturer of open optical networking systems and optical semiconductors — to receive up to $93m in direct funding as part of the CHIPS and Science Act. This proposed direct funding, when combined with investment tax credits available under the CHIPS and Science Act, could result in more than $200m in total federal incentives as well as potential state and local incentives.

The proposed funding would support the expansion and modernization of Infinera's semiconductor capabilities in two US locations:

- San Jose, Silicon Valley, California: Construction of a new, modernized fab and foundry with over 40,000ft^2 of cleanroom space to expand its indium phosphide (InP) photonic integrated circuits (PICs) manufacturing capacity ten-fold to meet future capacity and capability demands.
- Bethlehem, Lehigh Valley Pennsylvania: Construction of a new advanced test &packaging facility focused on meeting the increasing demand for InP PICs. This project would also help to bolster the domestic and global packaging supply chains while keeping a domestic packaging base for Infinera's defense and intelligence customers and the commercial and AI sectors. Additionally, this facility would include dedicated R&D space focused on newer optical packaging technologies, such as 2.5D and 3D packaging and co-packaged optics.

Combined proposed funding for these two projects could create up to 1700 jobs (500 in manufacturing and 1200 in construction) while strengthening the USA's supply chain, economic and national security, it is reckoned.

"We are grateful for the bipartisan efforts under the CHIPS and Science Act to increase semiconductor fabrication and packaging in the US and protect our national and economic security," states Infinera's CEO David Heard. "The proposed CHIPS funding will enable us to better secure our supply chain and compete more effectively with foreign adversary nations," he adds. "Our unique photonic semiconductors address the increased demand for bandwidth from consumers while opening new markets inside the data center, driven by the explosive growth in AI workloads."

www.chips.gov
www.infinera.com

Celestial AI buys Rockley's silicon photonics patents

Celestial AI of Santa Clara, CA, USA, the creator of the Photonic Fabric, has acquired silicon photonics intellectual property from Rockley Photonics Ltd (including worldwide issued and pending patents).

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

The combination of Celestial AI and Rockley IP in the field of silicon photonics for optical compute interconnect brings the total IP portfolio to more than 200 patents globally. The acquired patent portfolio consists of three main technology categories, including optoelectronic systems-in-package, electro-absorption modulators (EAMs) and optical switch technology, relevant for multiple AI data-center infrastructure applications.

Rockley was an early pioneer in silicon photonics with foundational IP that dates back to 2014, predating the foundation of many market competitors. In 2022, the firm exited the datacoms market to focus on photonics-based health-monitoring devices.

The acquired IP directly aligns with Celestial AI's core technology roadmap and enhances the deployment and commercialization strategy of its Photonic Fabric technology platform. This IP complements Celestial AI's existing portfolio. The firm is focused on delivering solutions to hyperscale data-center customers, both directly and through their ecosystem partners, that enable transformational performance, scalability and energy-efficiency advantages at the forefront of next-generation AI compute and network connectivity.

"The addition of Rockley's IP into our technology platform further accelerates the growth of Celestial AI's highly valuable intellectual property portfolio and amplifies the strength of our position," says Celestial AI's founder & CEO Dave Lazovsky. "These patents fit well into our expanding Photonic Fabric patent portfolio spanning advanced packaging, thermally stable silicon photonics, and system architectures for optical compute interconnect," he adds. "This acquisition reflects Celestial AI's commitment to protecting Photonic Fabric-based solutions that are being implemented in our customers' AI data-center infrastructure."

www.celestial.ai

PIC Summit stresses need for deeper European cooperation and government support to accelerate photonic chip industry growth

Initiative unveiled to help close skills gap by attracting new talent

Organized by non-profit photonic chip industry accelerator PhotonDelta (which connects and collaborates with an ecosystem of photonic chip technology organizations worldwide), PIC Summit Europe 2024 in Eindhoven, The Netherlands (15–16 October) covered a range of issues and opportunities surrounding photonic chip technology and its applications. Senior leaders debated how photonic and electronic chip industries can work together to further integrate chips by standardizing processes and breaking down barriers.

Attended by more than 700 business, government and academic leaders (from organizations including IBM, Sony, Nokia Bells Labs, Global Foundries, Unilever and NVIDIA), the summit featured keynotes and panels with leaders including Gustav Kalbe (acting director Enabling and Emerging Technologies of the EU Commission), Tjerk Opmeer (acting director-general of Economic Affairs), Sytze Kampen (Airbus' head of technology), Faisal Kamran (principal technology analyst at Sony), and Nicolas Fontaine (head of silicon photonics at Nokia Bell Labs).

"You can see how ubiquitous applications for integrated photonics are becoming. They're becoming a fundamental building block," said Gustav Kalbe in his address. "The need is ever-increasing, and ever-critical because photonics underpins so many other technologies," he added. "Integrated photonics remains a key European focus. But it's important that we come together to coordinate and collaborate – between member states and across the industry."

PhotonDelta also unveiled a new initiative to encourage much needed talent into the integrated photonics industry. A new jobs board, information portal and online campaign aims to promote opportunities within the sector to help it reach its potential. It follows PhotonDelta and Wevolver's announcement of a new €50,000 Global Photonic Engineering Contest to find photonic chip applications that tackle global challenges.

"Photonic chip technology offers solutions to big societal challenges in areas such as mobility, energy, climate change, food and health. The hurdle we need to overcome is bringing these solutions to market faster," said PhotonDelta's CEO Eelko Brinkhoff. "To do this we need a holistic approach which combines public and private funding, entrepreneurship and international cooperation. This is why PIC Summit Europe has placed a strong focus on stimulating cooperation between photonic and electronic chip industries, academics, industry leaders, policymakers, and value chain partners, from material suppliers to end-users," he added.

"The Summit has generated a wealth of new ideas and initiatives that cover everything from photonic chip technology and its applications, integration with semiconductors, through to standardization, public and private funding and government support. I would call on European companies, government bodies and academic organisations to listen to these ideas and work together to drive the industry forward," Brinkhoff concludes.

www.picsummiteurope.com
www.photondelta.com

AZUR's 35% solar cell production capacity increase surpasses 30% targeted for 2024

Another 30% capacity increase planned by end-2025

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada says that its subsidiary AZUR SPACE Solar Power GmbH of Heilbronn, Germany has completed its previously announced 2024 production capacity program ahead of schedule and expanded its capacity by 35%, surpassing its initial 30% increase target. By the end of 2025, AZUR intends to increase its solar cell production capacity by a further 30%, with minimal additional investments as most of the equipment has been purchased and delivered.

Completion of this program and actions being taken to further increase capacity through next year will enable AZUR to meet the growing needs of strategic client-partners, and to maintain momentum in generating revenues and increased profitability. "Since becoming a 5N+ company in late 2021, AZUR has already significantly boosted sales compared with previous years, which reflects both sustained demand in the space sector and AZUR's leadership as a longstanding and sought-after provider of advanced solar cell technology," says 5N+'s president & CEO Gervais Jacques.

The 2024 capacity program, which began in early 2023, enhanced production in all AZUR departments, including epitaxy growth, cell production, assembly and testing. The program included the implementation of an additional shift across all departments in 2023, moving the operation to a 24/7 production schedule. It also involved the installation and commissioning of new equipment to increase overall production yield and capacity, as well as automation.

The additional 30% capacity increase through 2025 will be achieved by the newly installed and commissioned epitaxy reactors for front-end production to grow multi-layer semiconductor crystals utilizing an MOVPE technique... Equipment to be commissioned soon will bring additional automation

The additional 30% capacity increase through 2025 will be achieved by the newly installed and commissioned epitaxy reactors for front-end production to grow multi-layer semiconductor crystals utilizing a metal-organic vapor phase epitaxy (MOVPE) technique, a core process in producing AZUR's high-efficiency solar cells for space conditions. As part of the program, the capacity of several tools, such as those used for the deposition of metals and dielectrics, have been increased. Also, equipment to be commissioned soon will bring additional automation.

"We will continue to work diligently to complete our 2025 production capacity program, as we seek to continually strengthen our position as a partner of choice and to meet the evolving needs of our customers," concludes Jacques.

www.azurspace.com
www.5nplus.com

AZUR solar cells head to Jupiter aboard Europa Clipper

Same solar cells previously used on ESA's Jupiter Icy Moons Explorer

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada says that solar cells produced by its subsidiary AZUR SPACE Solar Power GmbH of Heilbronn, Germany are enabling the Europa Clipper, NASA's largest spacecraft ever built for planetary exploration. The spacecraft took flight on 14 October with the mission to determine whether Jupiter's icy moon Europa has the potential to support life.

"The world's leading space agencies continue to choose AZUR as a trusted partner and our high-performing solar cells which enable the generation of solar power in the extreme cold, dark and harsh conditions of Jupiter as well as many other environments, such as missions close to the sun and various Earth orbits," says 5N+'s president & CEO Gervais Jacques.

AZUR's triple-junction solar cells (3G-LILT) were embedded in the Europa Clipper spacecraft's solar arrays. These solar-cell-covered 'wings' are critical for utilizing the maximum amount of sunlight possible to generate power, as Europa Clipper will receive only 3–4% of the sunlight that reaches Earth due to Europa's distance from the Sun. The selected AZUR solar cells are specifically designed to function in one of the most extreme environments in our solar system, with conditions characterized by intense particle radiation, low sunlight intensity and low temperature (LILT). Prior to NASA, the European Space Agency also relied on these same solar cells for its Jupiter Icy Moons Explorer (Juice) mission spacecraft, which launched in 2023.

Defect-free AlGaInP native red micro-LEDs by wet chemical etching

Mike (M.C.) Yoo, CEO of Verticle Inc, highlights how undercut-free wet etching is ready for the mass production of phosphide-based micro-LEDs.

To realize true commercialization of the high-resolution micro-LED displays, reducing LED chip size without losing efficiency is one of the key challenges to be solved urgently, especially for the phosphide-base red micro-LED which – due to material characteristics – is more vulnerable to efficiency drop than blue and green as chip size shrinks.

The main reason for the micro-LED efficiency drop is the chip sidewall defects generated by energetic plasma during dry etching of the mesa. Nevertheless, there have been no reliable options to replace the dry etching up to now. As a result, most effort has been focused on post-dry etching recovery, such as chemical treatment, annealing, and passivation deposition. However, they are helpful for partial recovery only. More importantly, they are not effective for tiny chips used for high-resolution displays because sidewall defect penetration depth is close to or exceeding the micro-LED chip dimension.

As a result, 'defect-free' etching has been sought for a long time. While wet etching is promising as it is 'defect-free', its fatal disadvantage is the isotropic etching characteristic, which leads to detrimental undercut. For this reason, wet etching has been perceived to be not suitable to etch small chips like micro-LEDs.

Recently, however, Verticle Inc of San Francisco, CA, USA — which specializes in R&D and production of inorganic LEDs and related display technologies — has made a breakthrough in developing mesa etching of the aluminium gallium indium phosphide (AlGaInP) native red micro-LED by 'defect-free' wet chemical etching.

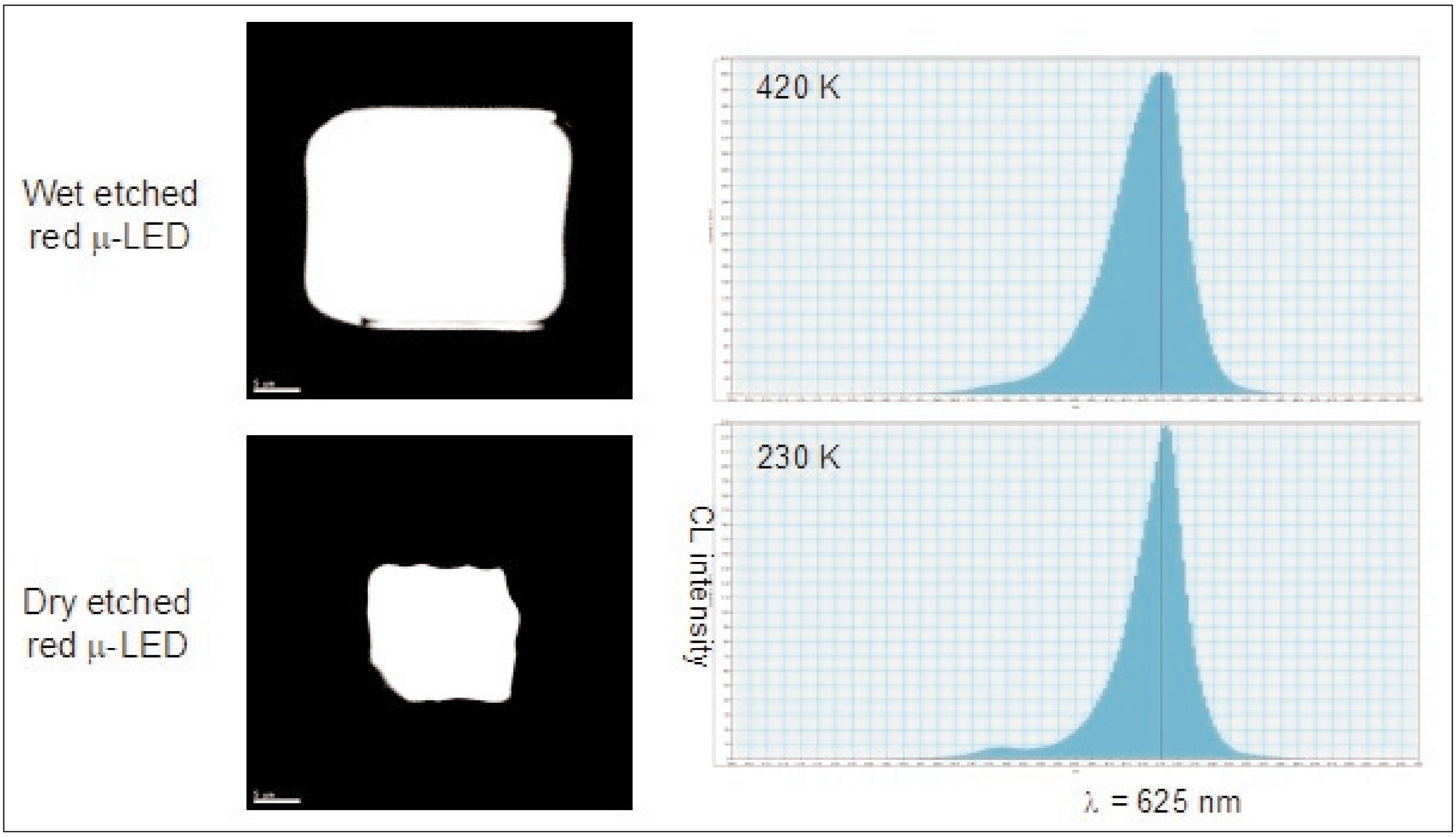


Figure 1. CL emission and spectra of the mesa etched 30μm x 30μm AlGaInP red micro-LEDs; wet vs dry etching.

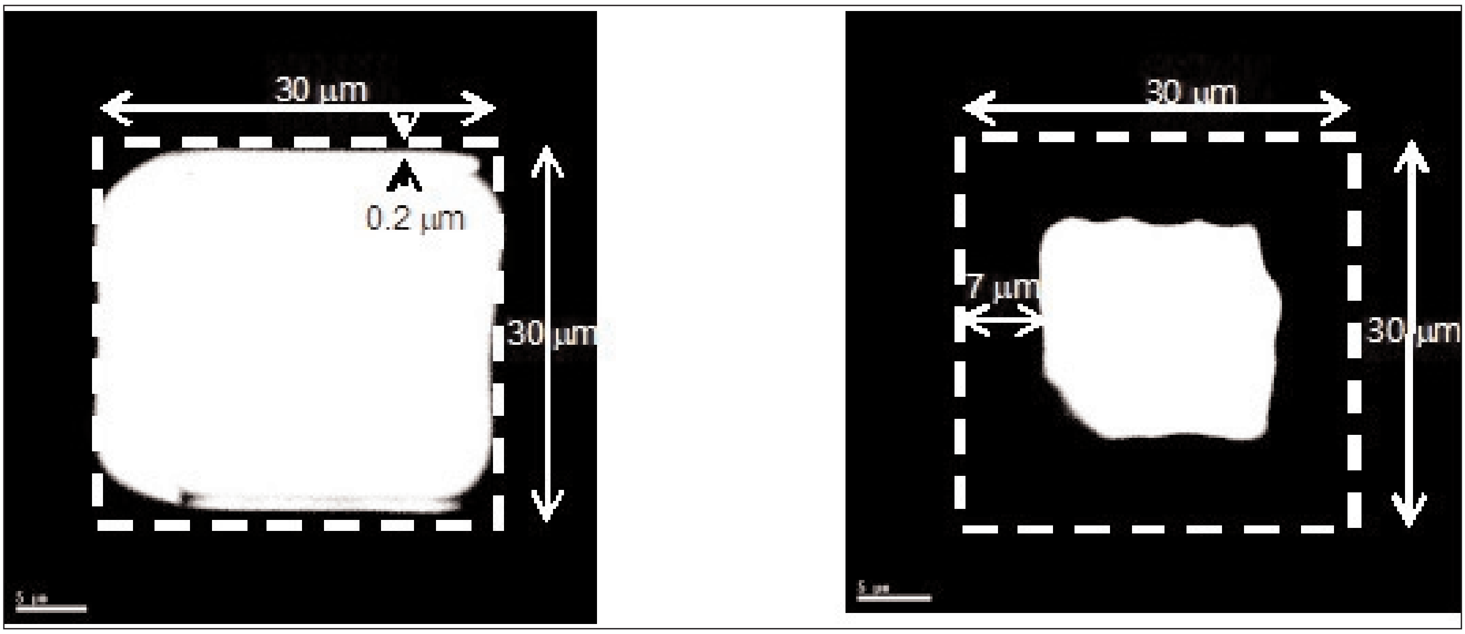


Figure 2. Sidewall defect penetration depth of the 30_m x 30_m AlGaInP red micro-LEDs after mesa etching; wet (left) versus dry (right) etching.

Comparing sidewall defect penetration depth and effective mesa area between wet-etched and dry-etched AlGaInP red micro-LEDs

Sidewall defects in the wet- and dry-etched AlGaInP red micro-LEDs are observed and compared using cathodoluminescence (CL). During CL operation, an electron beam bombards the micro-LED surface and produces electron–hole pairs. Radiative recombination takes place from the electron–hole pairs in the undamaged crystal, hence bright emission images can be obtained. In contrast, non-radiative recombination takes place in damaged crystal, hence yielding little or no luminescence from the damaged portion of the micro-LED.

CL emission images and spectra in Figure 1 show a clear difference between the wet- and dry-etched AlGaInP red micro-LEDs. CL emission from the wet-etched micro-LED is significantly brighter and more than three times bigger than that of the dry-etched micro-LED. In particular, the sidewall defect penetration depth of the dry-etched micro-LED is ~7µm, compared with almost zero or less than 0.2µm for the wet-etched micro-LED (Figure 2). Accordingly, the effective mesa area of the dry-etched red micro-LED is only 28% of the wet-etched LED. The CL results show that there are almost zero or a negligible number of defects in the wet-etched AlGaInP red micro-LED.

These results indicate that there is a distinct difference in the etching mechanisms between wet and dry etching. Wet etching removes material by chemical reaction so no defects are formed, whereas dry etching physically

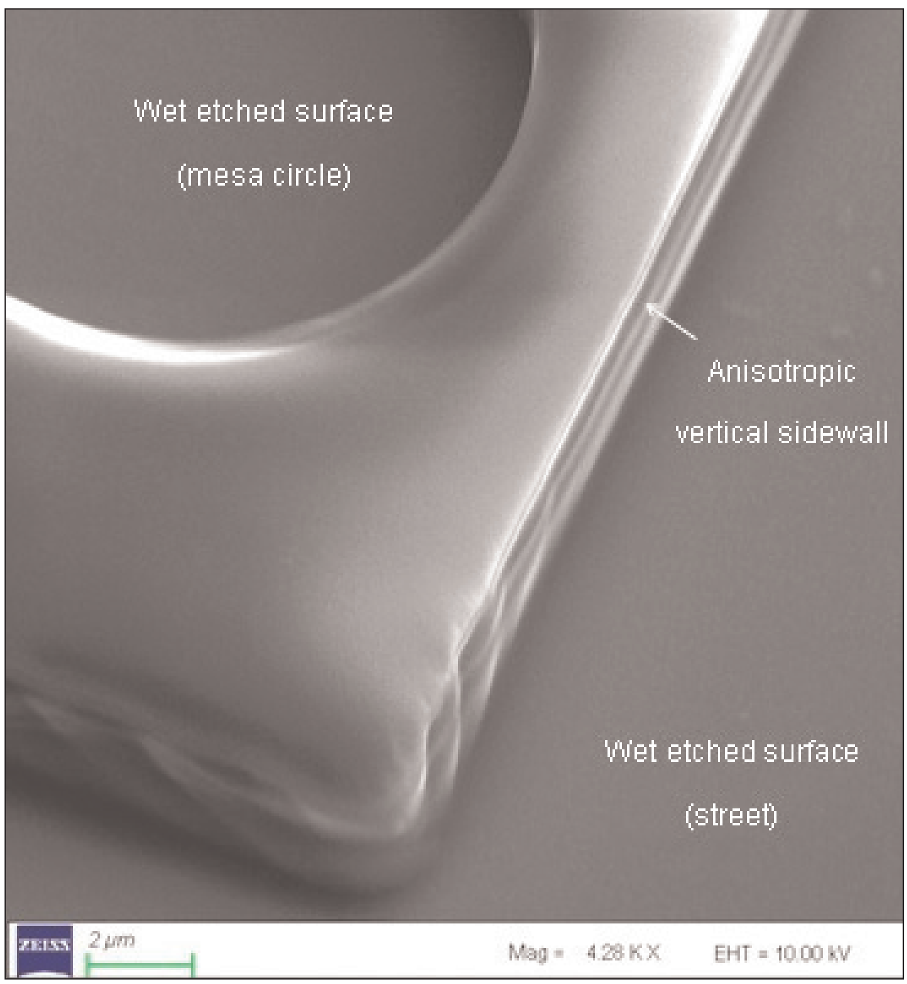


Figure 3. Surface morphology and sidewall etch profile of the wet-etched AlGaInP red micro-LED.

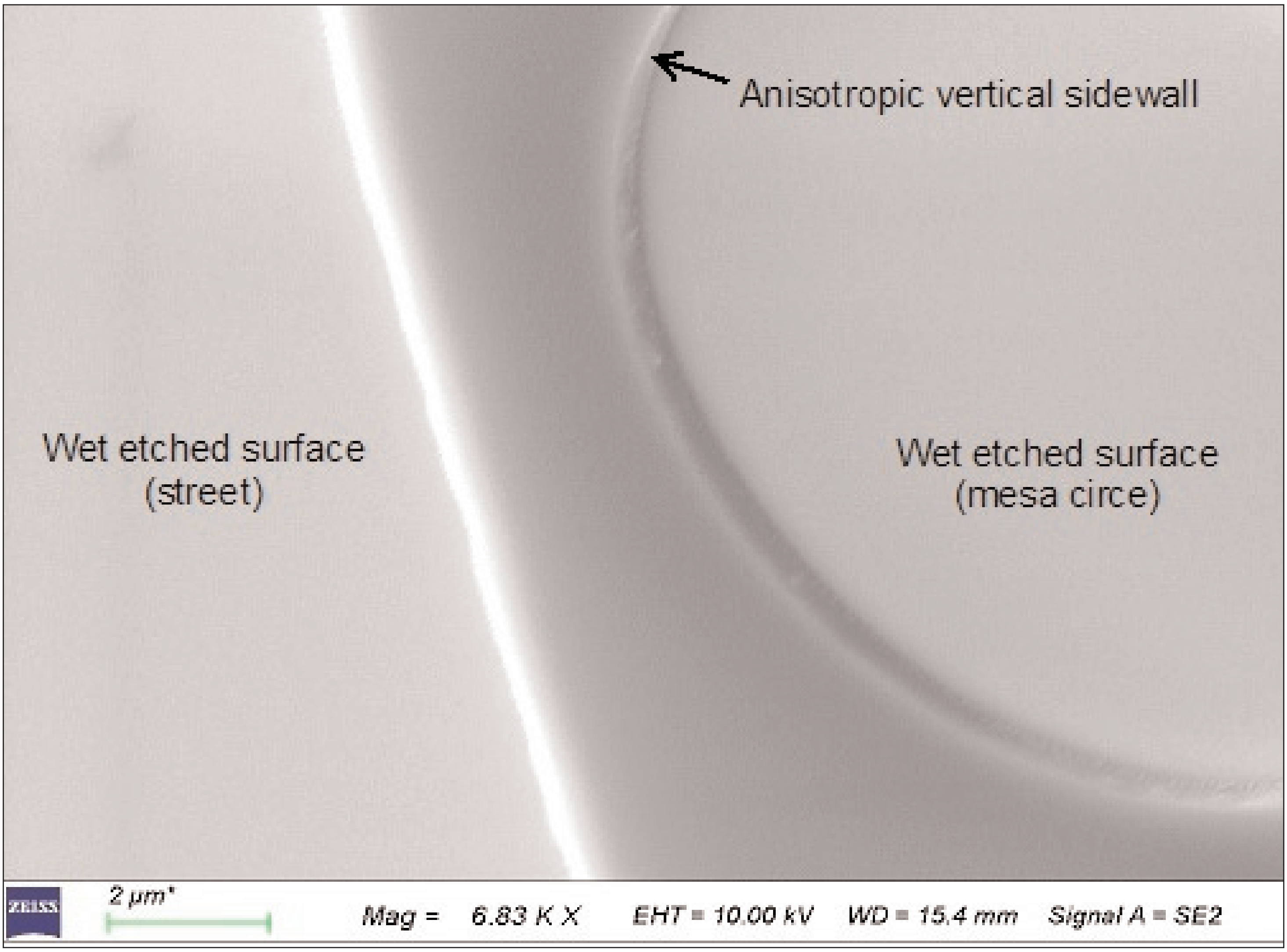


Figure 4. Enlarged morphology and etch profile of the wet-etched AlGaInP red micro-LED.

removes material by energetic plasma that causes defect generation on the chip sidewall.

Surface morphology and etch profile of the mesa wet-etched red micro-LED

Figures 3 and 4 illustrate the etch profile of the AlGaInP red micro-LEDs after 1.4µm-deep mesa wet etching. Wet-etched surfaces either on the mesa circle or on the street are mirror-like smooth, indicating that they are ideal for forming metal contacts.

In particular, the chip sidewall is highly vertical and anisotropic, so no undercuts are observed. From the fact that the smallest feature size is ~3µm and that the chip sidewall is highly anisotropic and undercut-free, it would be possible to etch less than 10µm AlGaInP micro-LED chips.

Verticle is ready to apply the developed wet-etching technology to mass production of AlGaInP red micro-LEDs in order to accelerate commercialization of the entire range of micro-LED displays, ranging from large-screen to near-eye displays

Both defect-free and undercut-free etch profile results indicate that the Verticle's wet-etching technology appears to be ready to be applied for the mass production of phosphide-based native red micro-LEDs.

Besides the performance enhancement, cost benefits are huge with wet etching. Unlike single-wafer processing in the case of dry etching (for wafer diameters over 6-inches), wet etching is capable of etching multiple large-diameter wafers in one batch, resulting in massively high throughput and hence extremely fast takt time. Furthermore, wet-etching capital investment is incomparably lower than that of dry etching as there is no need for multiple extra high-cost process tools, such as ICP RIE (inductively coupled plasma reactive-ion etch) and ALD (atomic layer deposition).

Verticle is ready to apply the developed wet-etching technology to mass production of AlGaInP red micro-LEDs in order to accelerate commercialization of the entire range of micro-LED displays, ranging from large-screen to near-eye displays. ■

www.verticleinc.com

Micro-LEDs maintain momentum despite Apple's withdrawal

New advances are needed in die technology, transfer equipment and micro-LED manufacturing, says Yole Développement.

The cancellation of Apple's project at the beginning of 2024 has shaken confidence in micro-LED technology, leaving the industry at a critical juncture. As delays continue and organic light-emitting diode (OLED) technology advances, the value proposition of micro-LEDs is shrinking, notes market analyst firm Yole Group. In response, companies are rethinking their strategies — some are slowing down or stopping, while others are accelerating their efforts, taking advantage of less competition. Alliances are forming along geographic lines, with about 30 fabs or pilot lines still moving forward.

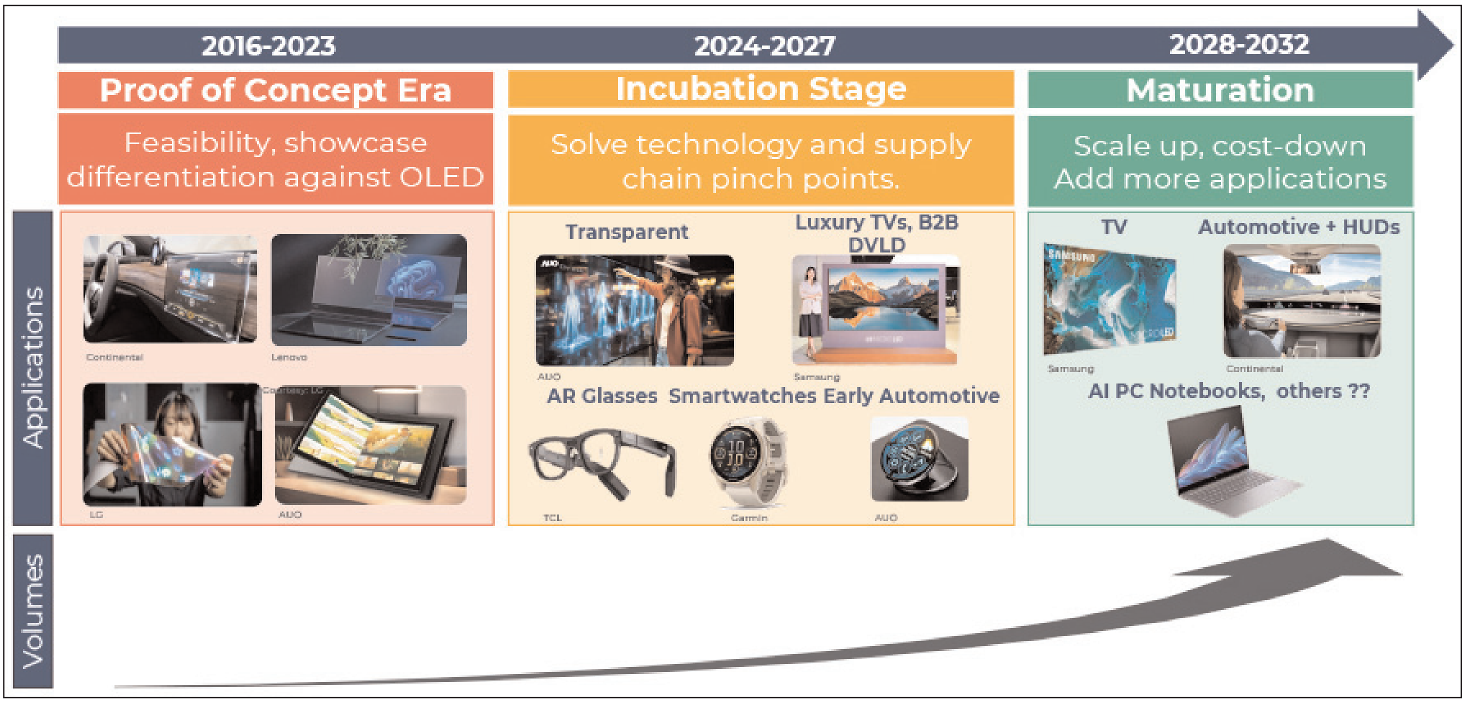
"The industry now faces the challenge of moving from proof-of-concept to mass production," says Eric Virey PhD, principal analyst, Display, at Yole Group. "It must prove it can deliver high-performance, defect-free displays at scale while achieving economies of scale to remain viable."

The immediate growth driver for micro-LEDs is LEDoS (micro-LED on silicon) micro-displays for augmented reality (AR), with artificial intelligence (AI) reigniting optimism after the 2021–2023 'AR winter', says Yole.

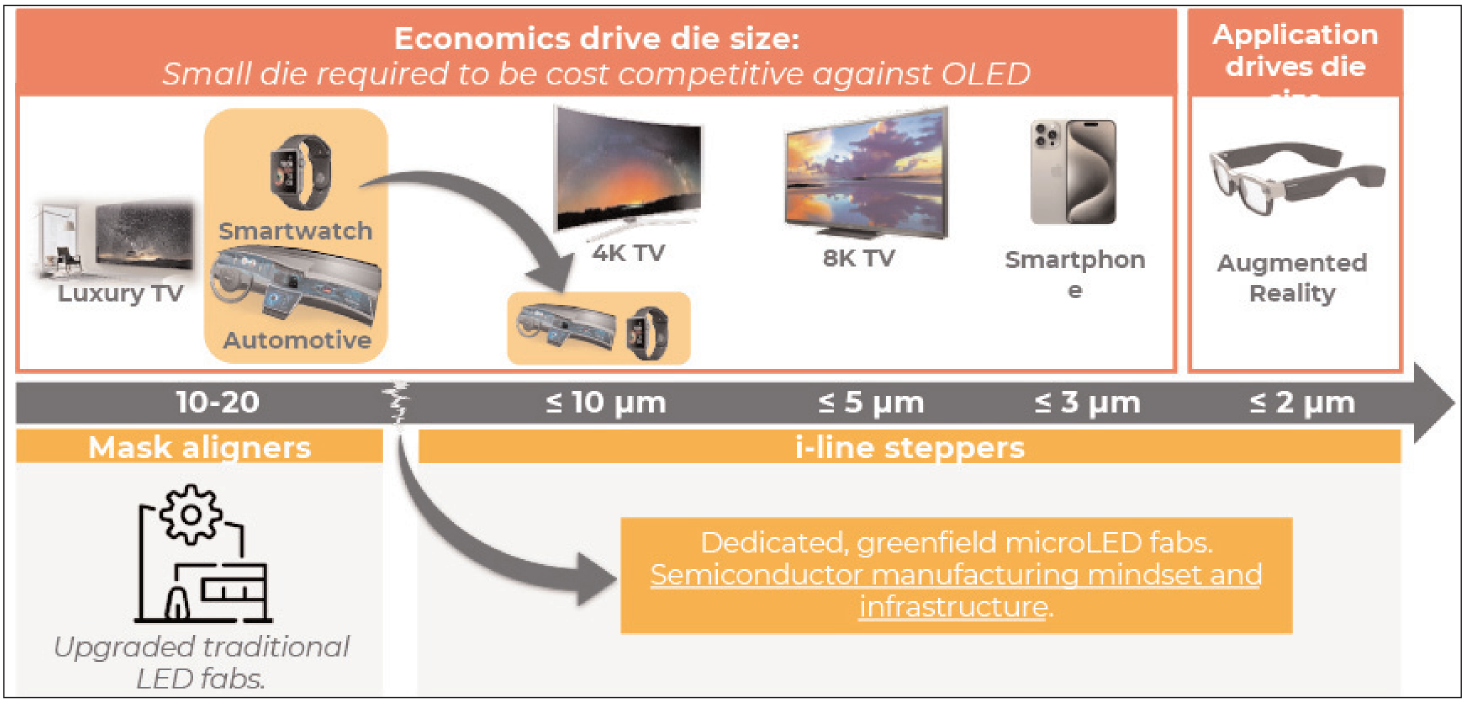
AUO is supplying smartwatch samples to Tag Heuer and Garmin, while Century Display is setting up a pilot line. However, OLEDs dominate the smartphone market, leaving little room for micro-LEDs to compete. Without Apple, no company seems capable of pushing micro-LEDs forward in smartphones or creating a suitable supply chain, says Yole. In TVs, OLEDs and mini-LEDs also overshadow micro-LEDs, though there is potential for ultra-large screens over 100-inches, it adds.

In parallel, automotive applications hold promise, but high costs and an immature supply chain are delaying adoption. The transparency and modularity for micro-LEDs offer potential for niche applications in areas like retail, transportation and military simulators, Yole reckons.

To succeed, micro-LEDs must deliver superior performance at a cost comparable to OLEDs. "This requires breakthroughs in efficiency for small die sizes and a robust supply chain, including specialized fabs,"



Micro-LED industry roadmap, 2016–2032.



Micro-LED costs drive the need for small die sizes.

says Virey.

With the closure of Osram's micro-LED fab and Apple's exit, the industry faces a familiar dilemma: mass production will require significant investment to drive prices down and make the technology viable.

However, Apple is unlikely to re-enter the micro-LED space unless third-party solutions meet its high standards, concludes Yole. ■

www.yolegroup.com/product/report/microled---manufacturing-2024

Micro-LEDs on freestanding GaN

An optimized InGaN multi quantum well structure has increased the external quantum efficiency from 7.9% to 14.8% at 10A/cm^2 injection current.

Researchers based in China have been exploring the benefits of using freestanding (FS) gallium nitride (GaN) as a substrate for micro light-emitting diodes (LEDs) [Guobin Wang et al, Optics Express, v32, p31463, 2024]. In particular, the team developed an optimized indium gallium nitride (InGaN) multiple quantum well (MQW) structure with improved performance at lower current injection (~10A/cm^2) and lower driving voltages as suitable for the advanced micro-displays used in augmented (AR) and virtual reality (VR) setups where the higher cost of FS-GaN can be compensated by improved efficiency.

The researchers were associated with the University of Science and Technology of China, Suzhou Institute of Nano-Tech and Nano-Bionics, Jiangsu Institute of Advanced Semiconductors, Nanjing University, Soochow University, and Suzhou Nanowin Science and Technology Co Ltd. The team sees opportunities for such micro-LEDs in displays with ultra-high pixels per inch (PPI) sub-micro or nano-LED configurations.

The researchers compared the performance of micro-LEDs fabricated on freestanding GaN and GaN/sapphire templates (Figure 1).

The metal-organic chemical vapor deposition (MOCVD) epitaxial structure included a 100nm n-type aluminium gallium nitride (n-AlGaN) carrier diffusion/spreading layer (CSL), a 2μm n-GaN contact layer, a 100nm low-silane unintentionally-doped (u-)GaN high-

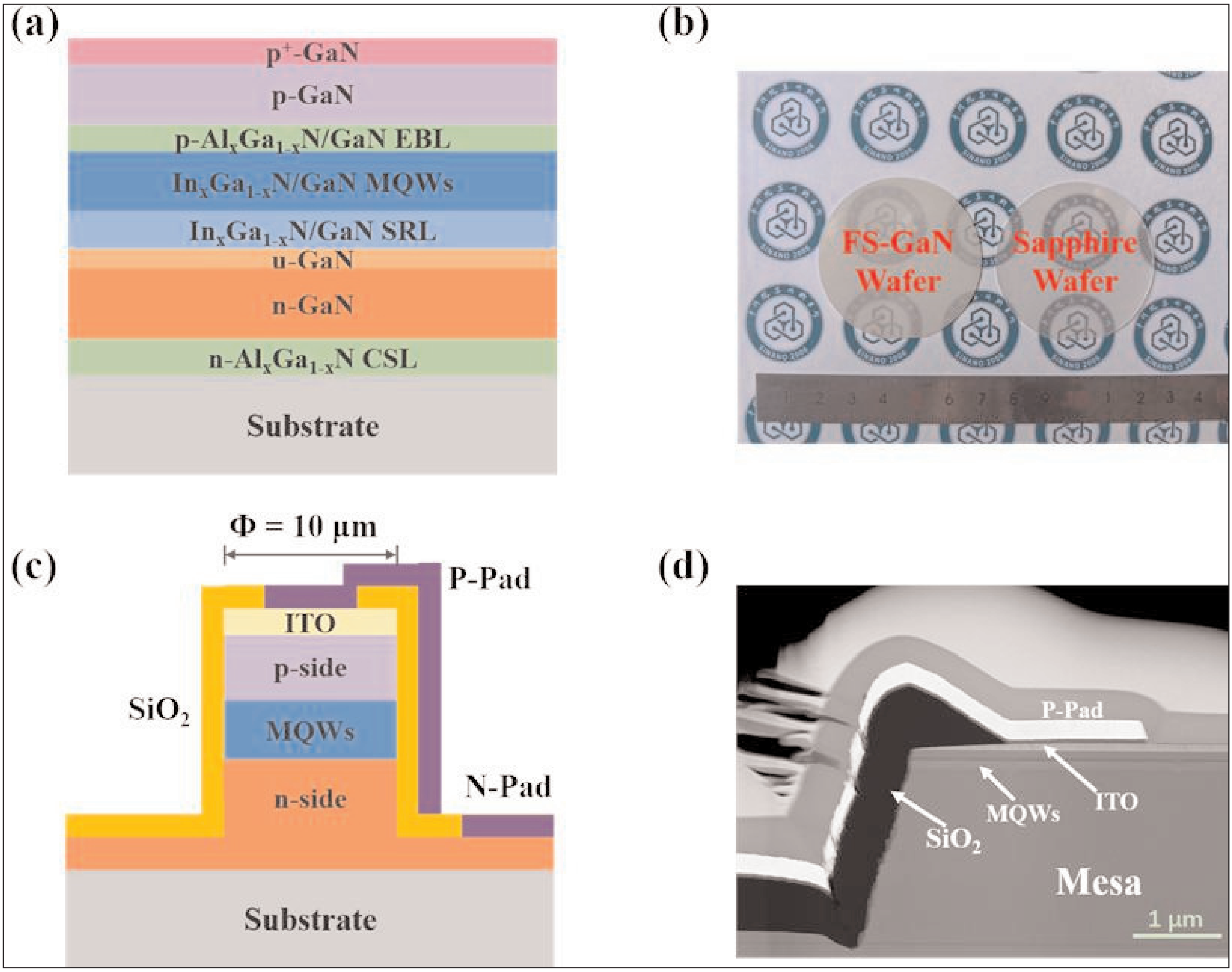


Figure 1. a) Micro-LED epitaxial scheme, b) micro-LED epitaxial wafers, c) micro-LED chip structure, and d) cross-sectional transmission electron microscope (TEM) image.

electron-mobility layer, a 20x(2.5nm/2.5nm) $In_{0.05}Ga_{0.95}/GaN$ strain-release layer (SRL), 6x(2.5nm/10nm) blue InGaN/GaN MQW, a 8x(1.5nm/1.5nm) p-AlGaN/GaN electron-blocking layer (EBL), an 80nm p-GaN hole injector, and a 2nm heavily doped p^+-GaN contact layer.

The materials were fabricated into 10μm-diameter LEDs with indium tin oxide (ITO) transparent contact and silicon dioxide (SiO_2) sidewall passivation.

Chips from the heteroepitaxy GaN/sapphire template showed much wider variations in performance. In particular, the intensity and peak wavelengths varied much more according to position within the chip. One chip on sapphire showed a 6.8nm wavelength shift between the center and edge at $10A/cm^2$ current density. Two chips sourced from the sapphire wafer had one with only 76% intensity compared with the other.

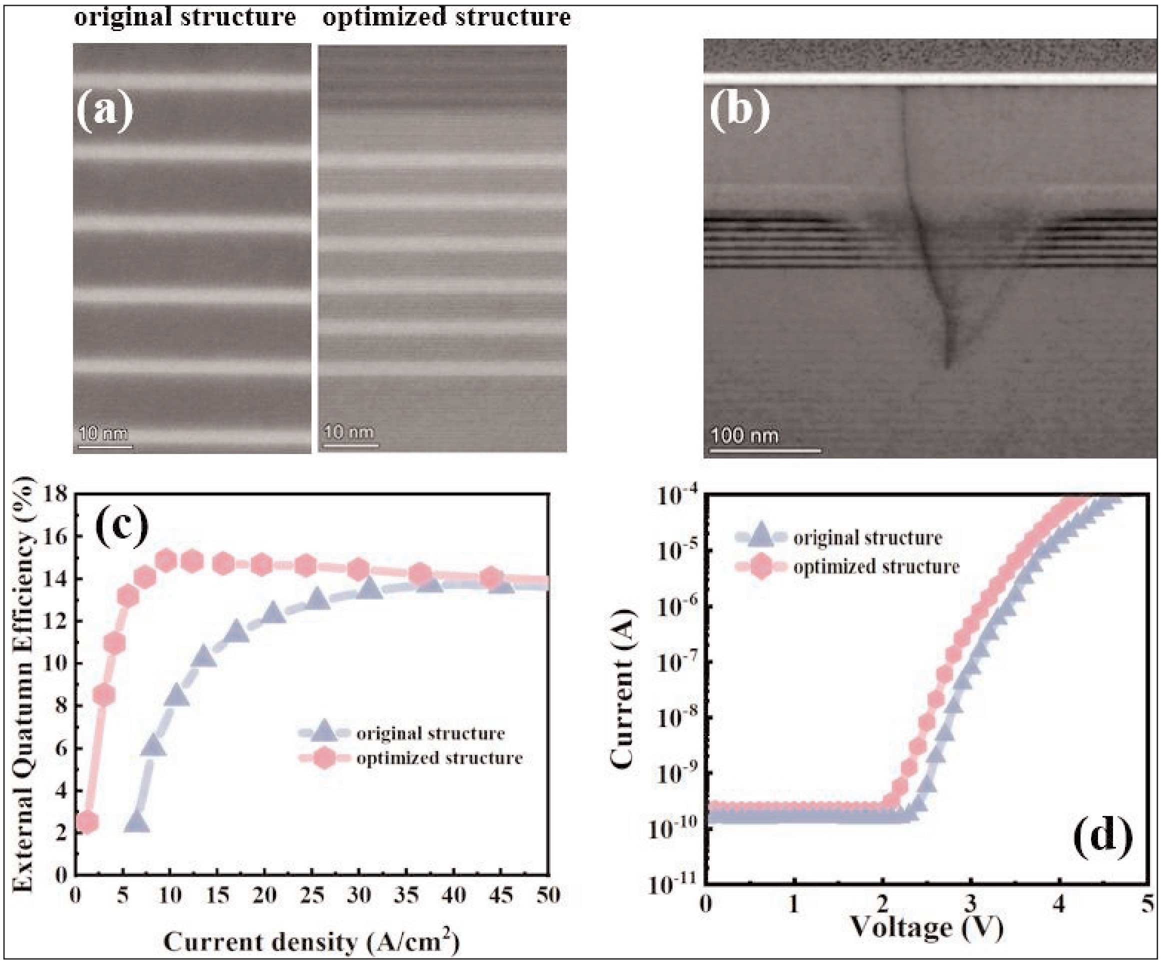


Figure 2. TEM images of MQW regions for a) original and optimized homoepitaxial structures, b) optimized structure implemented in heteroepitaxy, c) EQE and d) current–voltage curves of homoepitaxial micro-LED chips.

For chips fabricated on FS-GaN the wavelength variation was reduced to 2.6nm, and two different chips showed much more comparable intensity performance. The researchers attribute the wavelength uniformity variation to the different stress states in the homo- and hetero-structures: the residual stresses were 0.023GPa and 0.535GPa, respectively, according to Raman spectroscopy.

Cathodoluminescence showed dislocation densities of $\sim10^8/cm^2$ for heteroepitaxial wafers and $\sim10^5/cm^2$ for homoepitaxial wafers. "Lower dislocation density can minimize the leakage pathways and enhance luminous efficiency," the team comments.

Although the reverse leakage current was reduced for the homoepitaxy LEDs, the current response under forward bias was also reduced, relative to the heteroepitaxy chips. Despite the lower current, the chips on FS-GaN showed higher external quantum efficiency (EQE): in one case, 14%, compared with 10% on the sapphire template. By comparing photoluminescence performances at 10K and 300K (room temperature), the internal quantum efficiencies (IQEs) were estimated to be 73.2% and 60.8%, respectively.

Based on simulation work, the researchers designed and realized an optimized epitaxial structure on FS-GaN that improved EQE and voltage performance at the lower current injections of micro-displays (Figure 2). In particular, the homoepitaxy enables thinner barriers with sharp interfaces, while the same structure implemented in heteroepitaxy shows more blurred outlines under TEM examination.

The thinner barriers to some extent emulates what happens with V-pits that tend to form around dislocations. V-pits have been found to have beneficial performance effects in heteroepitaxial LEDs, such as improved hole injection into the light-emitting region, partly due to barrier thinning in MQW structures around the V-pit.

The homoepitaxial LEDs showed an EQE increase from 7.9% to 14.8% at $10A/cm^2$ injection. The voltage needed for driving 10μA current was reduced from 2.78V to 2.55V. ■

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Author: Mike Cooke

DBR-free thin-film InGaN VCSELs

Device achieves lasing without lateral confinement under optical pumping.

University of Hong Kong, China, reports on a thin-film indium gallium nitride (InGaN) vertical-cavity surface-emitting laser (VCSEL) structure using high-contrast gratings (HCGs) rather than distributed Bragg reflectors (DBRs) to confine the vertical electromagnetic radiation modes [Wai Yuen Fu et al, Optics Letters, v49, p4505, 2024]. The researchers are hoping to improve lasing performance while reducing fabrication costs by omitting DBRs. A further simplification came through dropping the need for microdisk or implanted aperture structures to suppress lateral radiation modes.

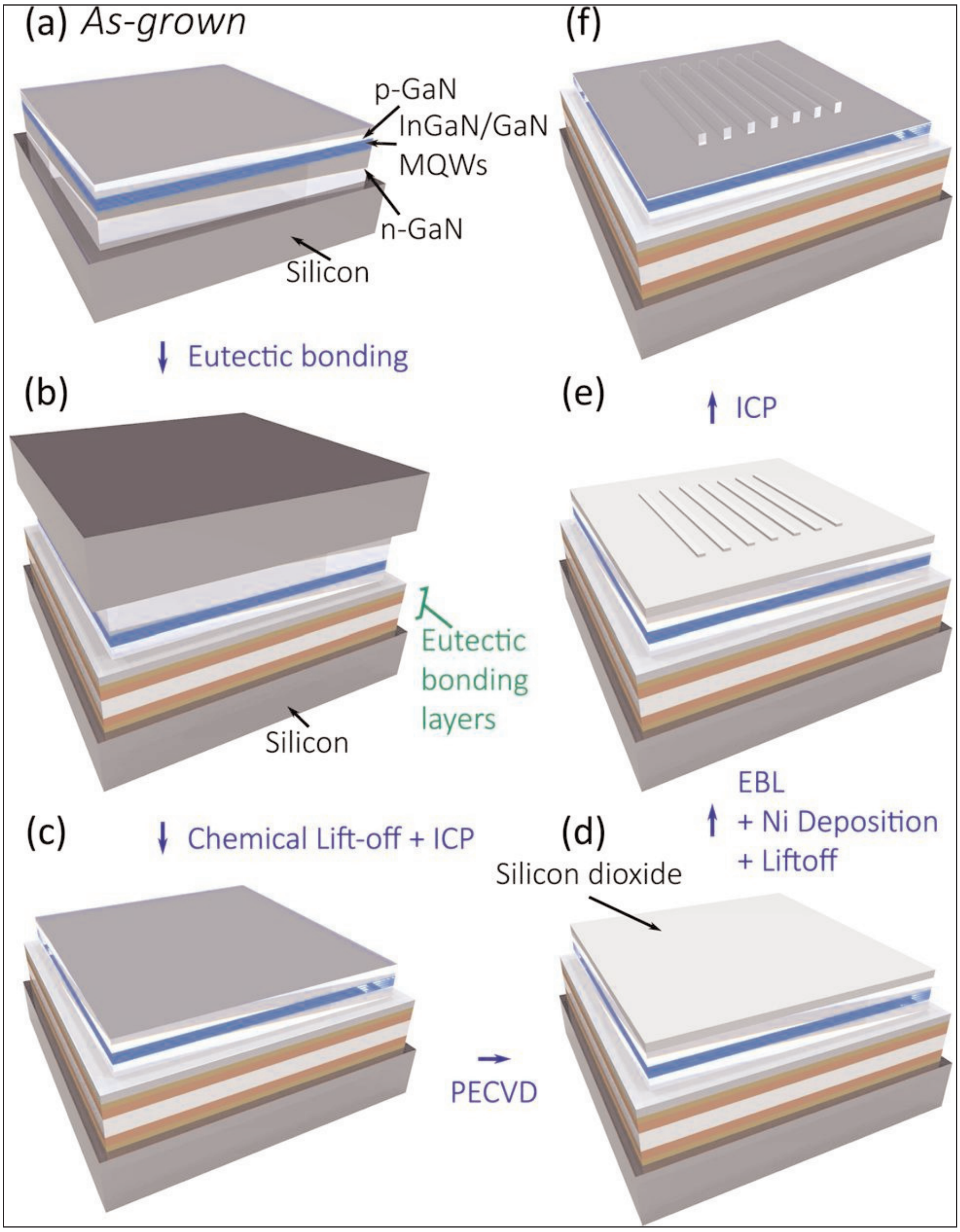

Figure 1. Process flow: (a) as-grown wafer; (b) eutectic bonding to silicon substrate; (c) silicon substrate removed by chemical lift-off and ICP; (d) PECVD oxide deposition; (e) grating patterning, Ni deposition followed by lift-off; (f) ICP etch of grating.

The team explains: "Traditional laser diodes utilize pairs of DBRs or waveguiding layers, grown inside the epitaxy to form laser cavities—a process that can be cost-intensive."

The researchers see future potential for photonic integrated circuit (PIC) and light detection and ranging (LiDAR) systems. InGaN-based laser systems are also key in optical storage (Blu-ray), high-resolution laser display technology, and visible light communication (VLC).

The researchers used a 440nm blue LED wafer, supplied by Enkris Semiconductor Inc, for the VCSEL fabrication process (Figure 1). Enkris produces its wafers by metal-organic chemical vapor deposition (MOCVD) on silicon (Si) substrates. The active light-generating region of the LED wafer consisted of 6 pairs of 5.9/7.0nm InGaN/GaN layers constituting a multiple quantum well (MQW) structure.

The fabrication began with electron-beam deposition of nickel/silver/nickel/gold (Ni/Ag/Ni/Au) on the p-GaN cap as a reflective metal layer. The wafer was then prepared for eutectic bonding to another silicon substrate with deposition of titanium/gold (Ti/Au) and electroplating of copper/tin (Cu/Sn) on the LED and target wafers. The eutectic bond was made through applying high pressure and temperature to the assembly.

The original substrate was removed using hydrofluoric acid chemical lift-off of the silicon, and inductively coupled plasma (ICP) etching of the GaN buffer and undoped GaN layers to a suitable thin-film thickness for the flipped VCSEL resonant cavity on the silicon handle wafer.

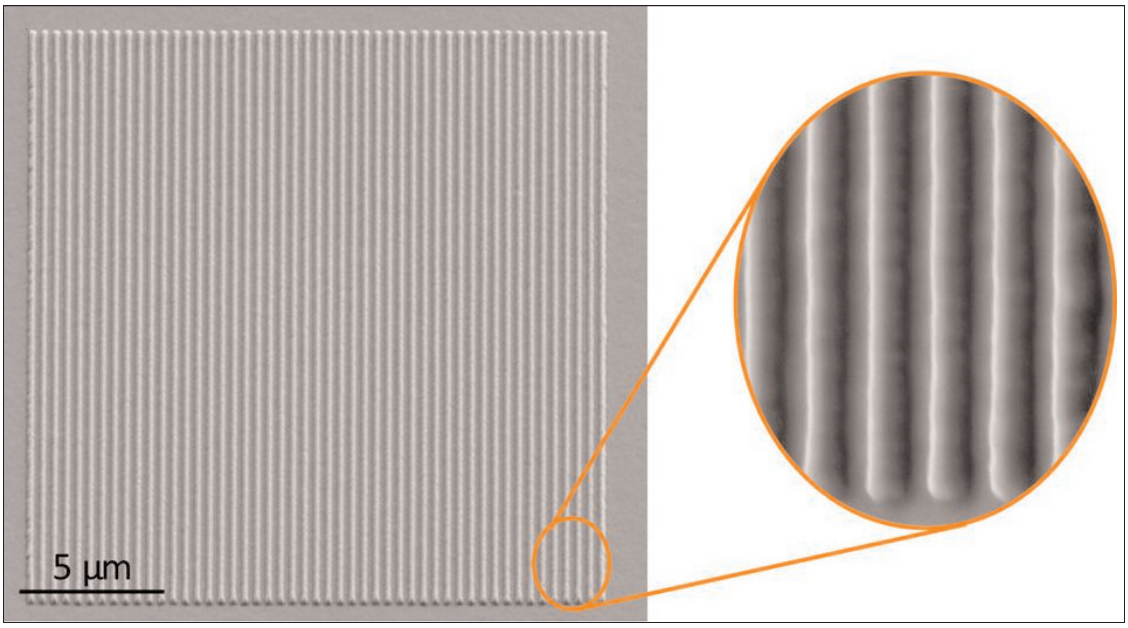

Figure 2. Scanning electron microscope (SEM) image of fabricated grating, with zoom-in circular inset.

The grating (Figure 2) was formed in the n-GaN by ICP through a 30nm Ni mask and a plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide pattern transfer layer. The Ni mask was patterned by electron-beam lithography (EBL). The grating region extended in a 20µmx20µm square. The grating depth was 250nm, and the period ~360nm. These choices were determined by intensive simulation work.

The researchers report: "We refrained from any geometric shaping of the laser cavity, thus relying solely on the newly implemented top surface grating reflector and the existing bottom metallic reflecting layer without any DBR, using the thin-film GaN platform."

The simulations suggested that there would be three relatively broad vertical reflection peaks reaching to almost 100% reflectivity in the wavelength range 400–460nm, around 407nm, 429nm and 449nm. The simulations also showed a couple of narrower peaks, representing laterally-propagating light. The researchers comment: "These lateral modes appear in the simulation due to the implementation of periodic boundary conditions and are not anticipated to occur in the actual device."

The simulated peak separation suggested that the structure would be sufficient to suppress side-mode competition and to boost the quality factor (Q). Without the grating, a reflectivity around 17.8% was expected across the wavelength range.

With a 500nm cavity length between the bottom metallic layer and the top surface grating, the simulations suggested that a 432nm wavelength reflection with 73,000 Q-factor could be achieved. The 500nm cavity would also align the main resonance antinode with the active MQW region.

The fabricated structure was subjected to micro-photoluminescence measurements (µ-PL) with increasing excitation power from a 393.32nm 29.25ns/50kHz pulsed laser (Figure 3). The lasing peak was around 436nm, close to the 432nm simulation. The team attributes the minor discrepancy tentatively to the use of 2D instead of 3D simulations.

The laser threshold was around 5.5kW/cm^2 power density. The measured Q-factor was 4600. In regions without the grating there was no lasing up to 30kW/cm^2 excitation, when the power density began to physically damage the thin-film material.

Despite the absence of lateral confinement structures such as etched micro disks or implanted apertures, the lateral resonance modes were effectively suppressed, giving vertical-cavity laser emissions.

The researchers comment: "Although the demonstrated lasing threshold of 5.5kW/cm^2 marks an improvement over earlier studies on InGaN-based VCSELs, which reported thresholds exceeding 100kW/cm^2, it understandably does not yet match the performance of state-of-the-art VCSELs equipped with refined DBRs that typically lase at well below 100W/cm^2. However, the successful demonstration of room-temperature lasing under optical pumping conditions confirms the feasibility of the VCSEL operation without DBRs, providing a low-cost solution for lasing devices."

The team hopes that optimization of the HCG reflector will result in competitively reduced thresholds with a more economical fabrication process than DBR-based VCSELs. ■

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Author:
Mike Cooke

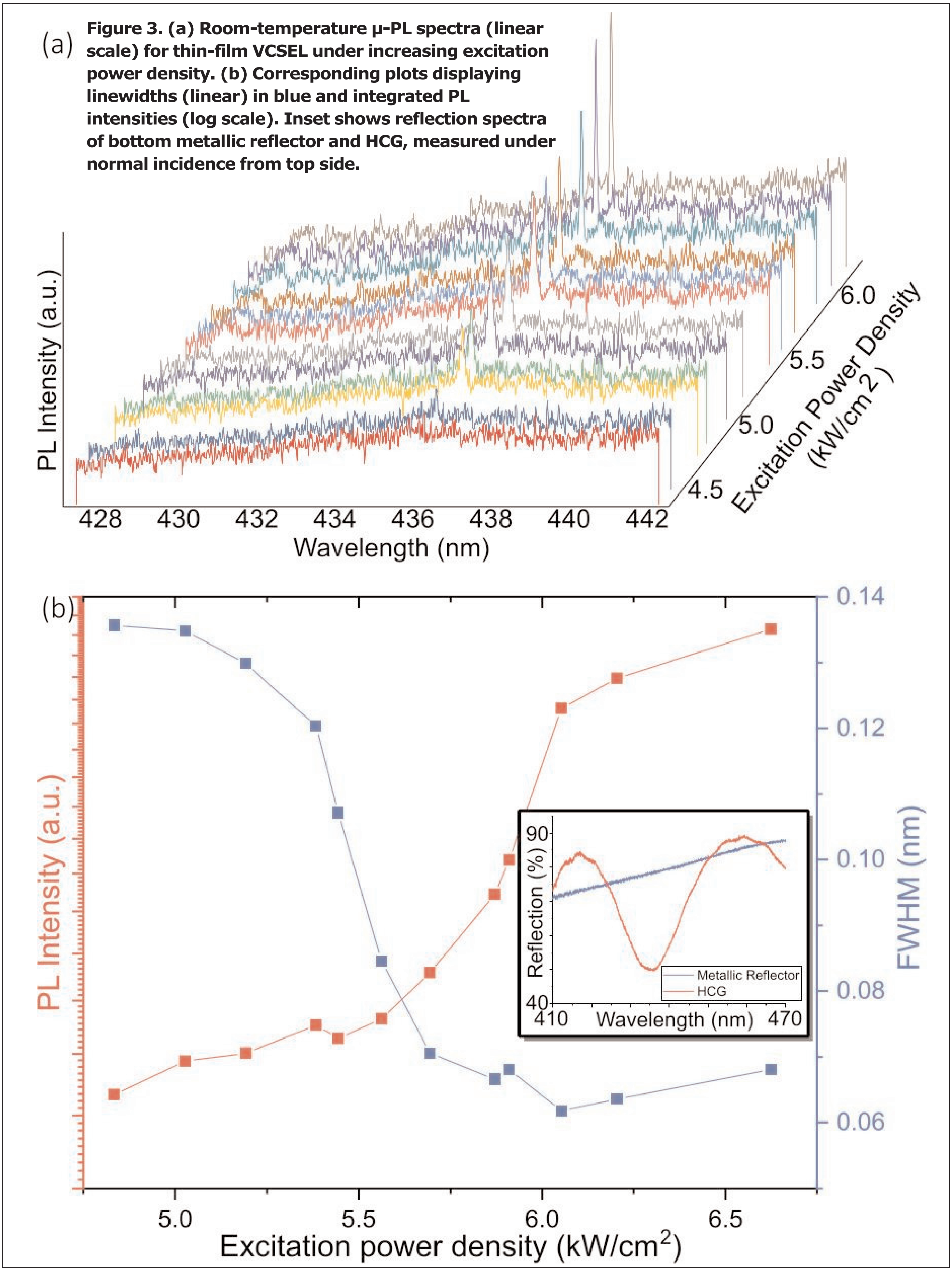

Figure 3. (a) Room-temperature μ-PL spectra (linear scale) for thin-film VCSEL under increasing excitation power density. (b) Corresponding plots displaying linewidths (linear) in blue and integrated PL intensities (log scale). Inset shows reflection spectra of bottom metallic reflector and HCG, measured under normal incidence from top side.

Transfer-printed lasers on silicon photonics

Ireland's Tyndall National Institute and Intel have improved alignment by fabricating InP lasers after, rather than before, transfer printing to SOI waveguides.

Ireland's Tyndall National Institute and Intel Corp in the USA report on a transfer printing method to apply indium phosphide (InP)-based epitaxial material to silicon-on-insulator (SOI) waveguides as a route to integrating O-band (1260–1360nm) lasers with silicon (Si) photonics circuits [Samir Ghosh et al, Appl. Phys. Lett., v125, p081104, 2024].

Target applications include data/telecoms, along with light distance and ranging (LiDAR), 5G telecoms, artificial intelligence (AI) and neuromorphic, programmable photonics, quantum computing, spectroscopy, and metrology.

The researchers see their approach as having potential for high-volume production over competing methods such as flip-chip integration, wafer bonding, and direct growth on silicon.

The team explains: "Transfer printing is an emerging technology for heterogeneous integration where massively parallel integration is a key attribute, which opens a path for high-volume manufacturability. It creates minimal waste of expensive epitaxial material, lowering the overall production cost and saving rare materials like indium."

The lasers were fabricated after rather than before the transfer of III–V material to the silicon photonics wafer. This improved the alignment accuracy of the fabricated devices to the waveguide structures. The technique resulted in devices with a typical lasing threshold of 100mA at 20°C.

The integrated laser was built on top of 400nm silicon waveguides on 1μm buried oxide (BOx) (Figure 1). The researchers comment: "The thickness of the BOx layer is chosen to be as small as possible to achieve better heat dissipation through the silicon substrate."

The team designed adiabatic tapers of both the underlying silicon waveguide and InP laser structure to

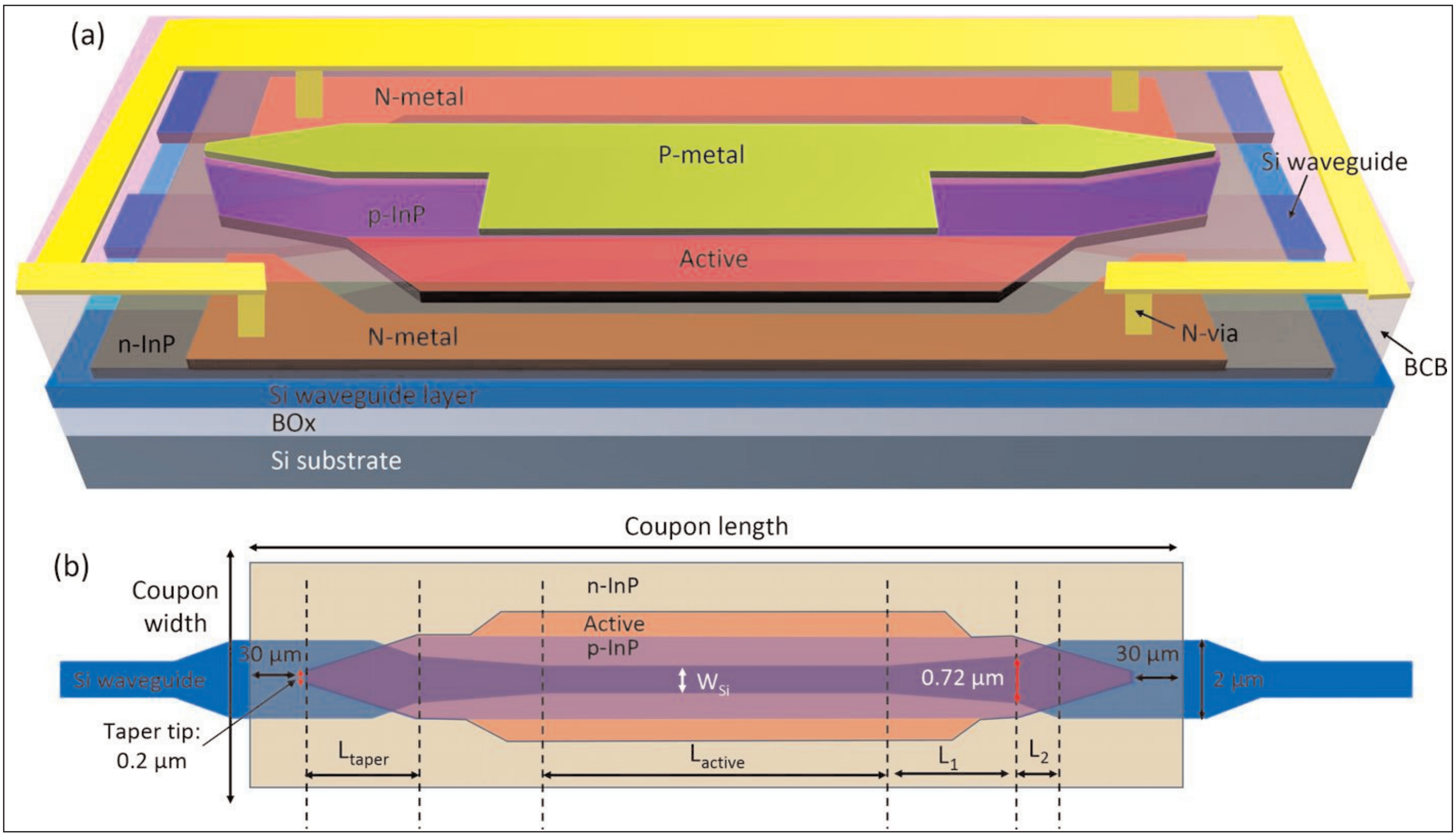

Figure 1. (a) Perspective view of integrated laser and (b) top-down view InP waveguide on silicon waveguide (only waveguide layers are shown for simplicity). Feedback structures (DBR grating or loop mirrors) and grating couplers are not shown.

facilitate smooth light transfer by evanescent coupling. The silicon waveguide taper structure used two steps to ensure adiabatic power transfer between 2μm and 0.5μm without mode crossing.

The researchers designed three types of laser — Fabry–Pérot (FP), distributed Bragg reflector (DBR), and discrete mode laser (DML) — on the platform.

The FP lasers were realized using light mirror feedback loops from the outputs of a 1x2 multimode interference (MMI) coupler. A directional coupler tapped 12% of the power for external collection.

The DML used 200nm-deep slots etched into the silicon waveguide to provide mode selection. The slots were 306nm long, corresponding to an odd integer multiple of the quarter-wavelength of ~1310nm output. The team comments: "The main parameter here is the total number of slots with a higher number better to lower the threshold gain for a particular mode."

The DBR laser used 24nm-deep etching to achieve a grating with a period of 210nm and 50% duty cycle. The reflectivity of the grating increased, in simulations, between 25% and 90%, as the number of periods increased from 150 to 500.

The waveguide widths in the active regions of the various structures were 600nm for the FP and DML, and 500nm for the DBR lasers.

The gain structure of the lasers was grown on 50mm InP substrates using metal-organic vapor phase epitaxy (MOVPE). The structure contained indium gallium arsenide (InGaAs) and indium aluminium arsenide (InAlAs) dual-release layers. The researchers explain: "This compound release layer approach reduces the undercut time considerably while providing a smooth surface for direct bonding."

The epitaxial design included an 8-period multiple quantum well (MQW) active region.

The material was prepared into 1000μmx60μm 'coupons' which were released from the InP growth substrate and transfer printed onto the silicon waveguide target wafer. Before transfer the silicon waveguide surface underwent an oxygen plasma treatment. The coupon–SOI bond strength was tested by dipping in deionized water, and 95% of the coupons remained in place. This was the only yield loss during the whole fabrication process.

Further fabrication included optical lithography of the process window, electron-beam lithography (EBL) of the laser, metalization of n-side of the devices,

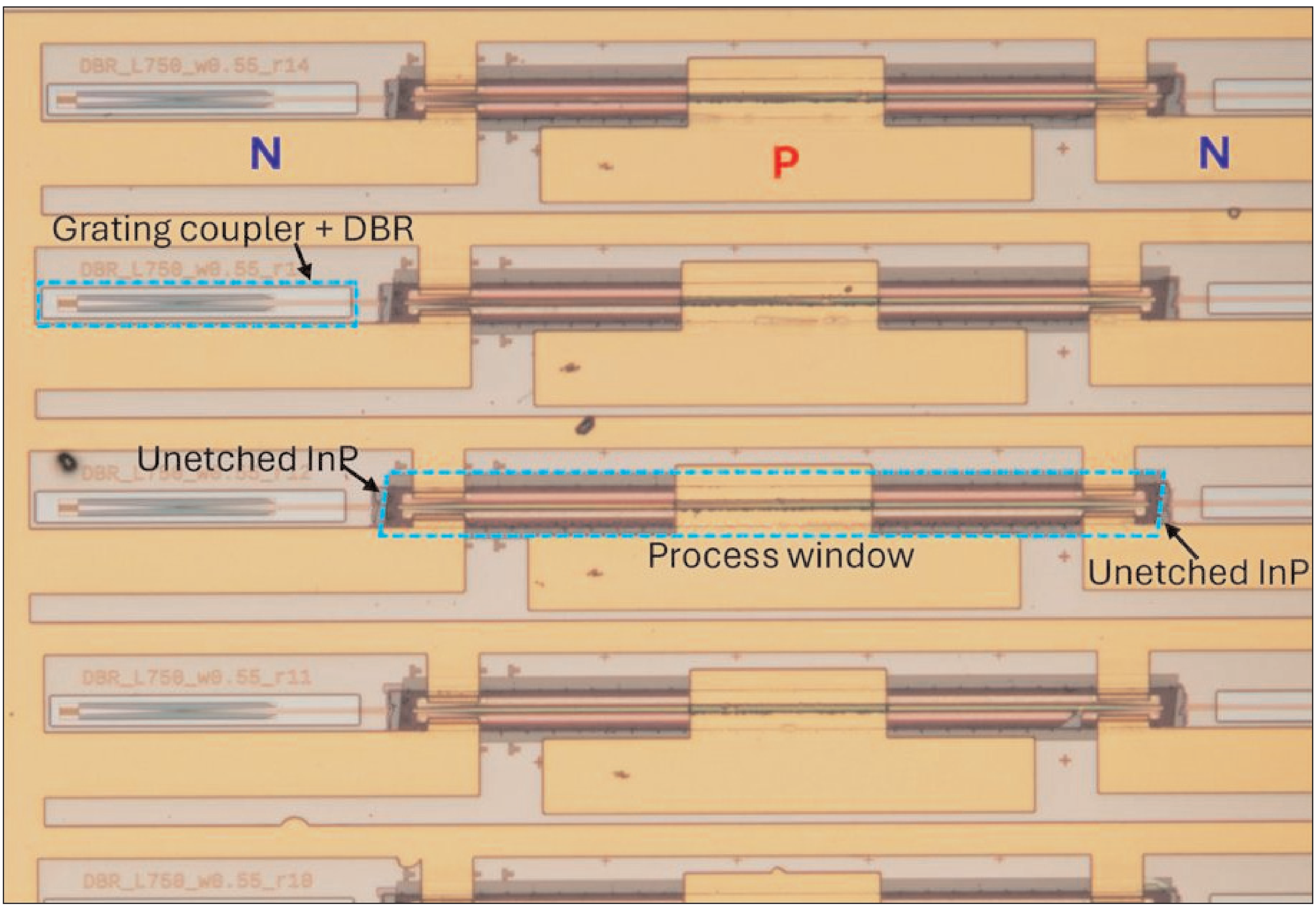

Figure 2. Optical microscopic image of few fabricated devices. All dielectric layers were cleared from grating coupler + DBR window.

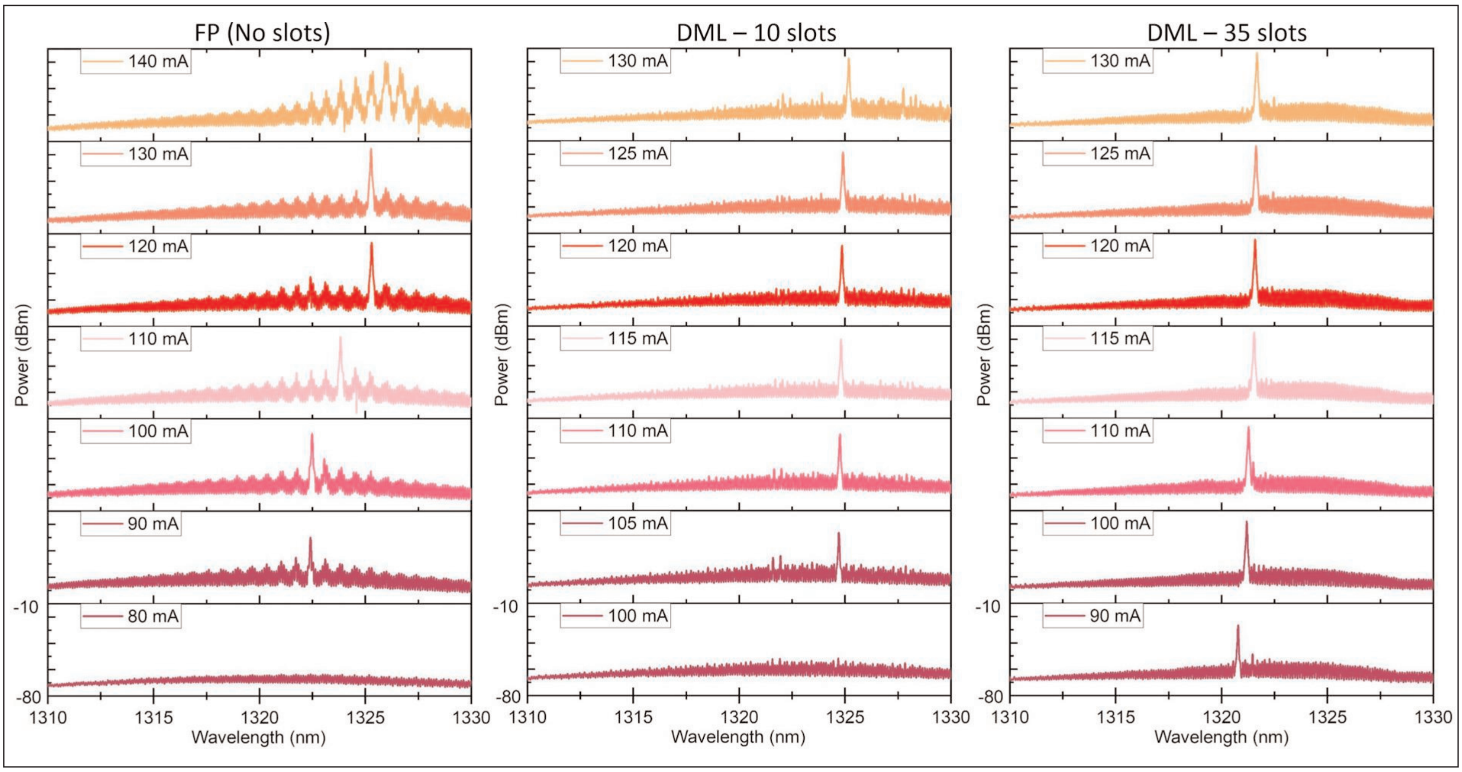

Figure 3. Measured spectra of FP and DM lasers for various bias currents at 20°C, plotted with 70dB vertical axis offset. Grating coupling loss is not subtracted.

planarization with benzocyclobutene (BCB) polymer, p-side metalization, via-opening, bond-pad metalization, and etch removal of the dielectric layers from the gratings and loop mirrors (Figure 2).

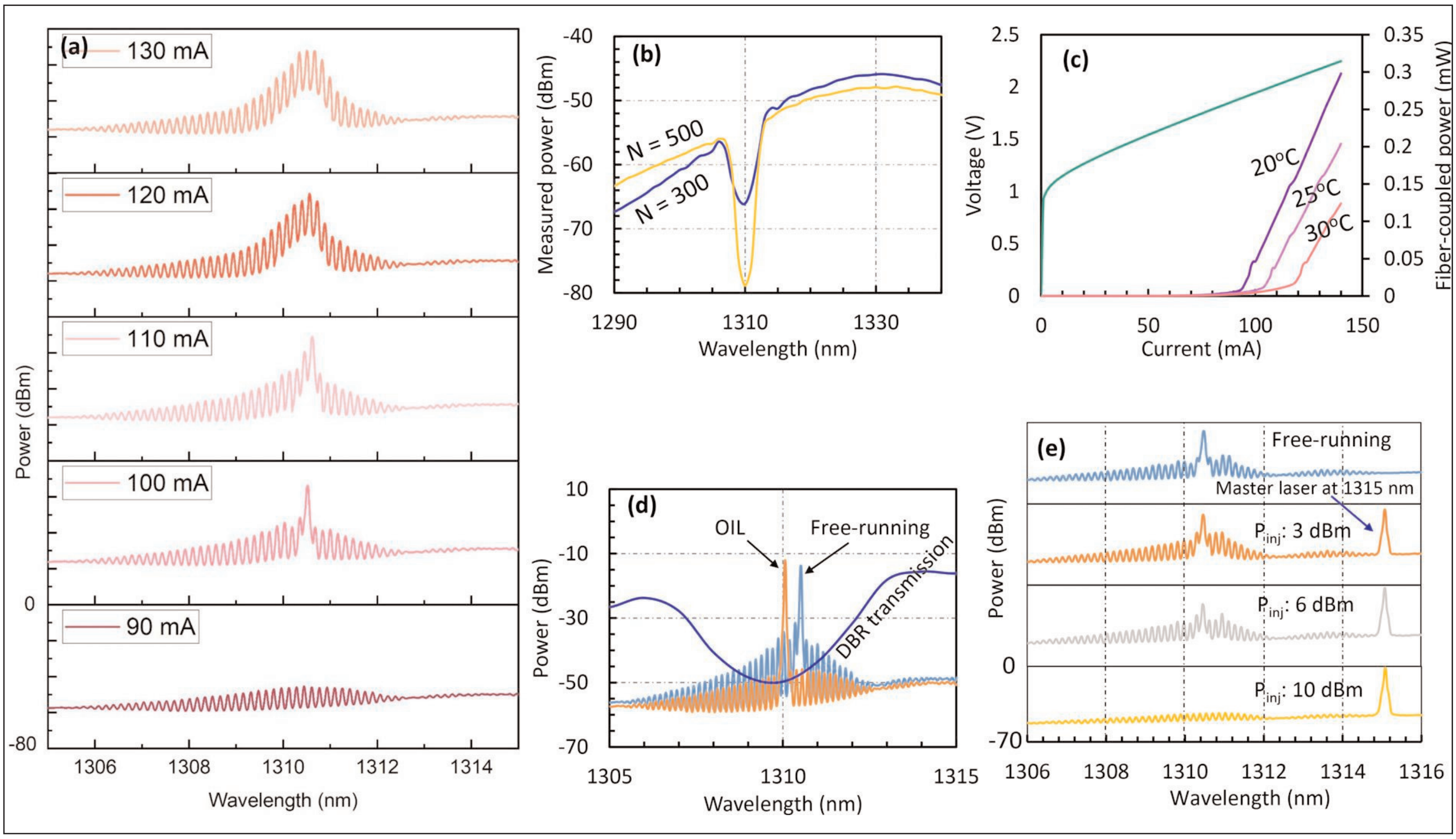

Figure 4. (a) DBR laser spectra with 200-pair front and 350-pair rear mirrors. (b) Transmission spectra for different N. (c) Light output–current–voltage curves. (d+e) Optical injection locking (OIL) experiments for (d) 1310nm-wavelength master laser and 100mA slave laser and (e) different levels of injected power (P_{inj}) at 1315nm-wavelength master laser, with slave at 110mA current.

EBL charging effects in the dielectric resist surface resulted in a 300nm alignment accuracy. This compares with a 500nm typical alignment accuracy for transfer printing of already fabricated lasers. Better alignment for the Tyndall/Intel method could be achieved by applying a thin conductive polymer coating on top of the EBL resist.

The FP and DM lasers were tested at room temperature in continuous wave (CW) operation (Figure 3). The free spectral range (FSR) between the FP peaks was about 110pm, corresponding well to the 2μm cavity length.

For the DMLs the best side-mode suppression ratio (SMSR) was 35dB at 120mA current injection for the 35-slot device. The DML-35 slot wavelength shift rate due to current-induced heating was 0.01nm/mA. The 10 slot device showed mode hopping outside a linear single-mode regime.

The team reports on the 10-slot DML: "Mode-hop-free red shift is 0.42nm, which translates into a temperature tuning of 0.084nm/°C."

The DML-10 delivered orders-of-magnitude lower power (10s of μW) than expected. This is attributed to silicon waveguide damage during fabrication with both grating coupler and feedback mirrors impacted by over-etching.

The DBR lasers showed a 170nm FSR, corresponding to a 1350μm cavity length (Figure 4). The best SMSR was 20dB. "Single-mode lasing with higher SMSR will be possible by incorporating narrowband mirror or high-Q resonator," the researchers say.

Although the fiber-coupled output power was higher than for the DML-10 at 0.3mW, the researchers see this as low due to the same factors of silicon waveguide damage. This damage also increased the lasing threshold. The researchers estimate that the on-chip power could reach beyond 1mW at 100mA injection after compensating the ~8db grating coupling loss.

The researchers recognize that data-centers require lasers that can operate beyond 80°C. They comment: "Our lasers have high-thermal impedance, which restricts their maximum operating temperature. A suitable path to improve temperature budget will be using a thermal shunt by connecting InP ridge to silicon substrate through a metal via. Alternatively, a thin layer of AlN or similar dielectric with high thermal conductivity can be used as an intermediate layer between the coupon and SOI to dissipate the heat generated in the InP ridge." ■

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Author: Mike Cooke

Planned 8-inch silicon carbide wafer fabs worldwide reach 14

ST, Onsemi, Infineon, Wolfspeed, ROHM, BOSCH, Fuji Electric, Mitsubishi Electric, VIS/EPISIL, Silan, UNT and FT1 all plan SiC plants, notes TrendForce.

Over the past few years, major companies around the world have been investing in 8-inch silicon carbide (SiC) production lines, and these investments are now gradually becoming operational, notes market research firm TrendForce in a recent summary.

Global spread: 14 new 8-inch silicon carbide factories

Globally, companies such as STMicroelectronics (ST), Onsemi, Infineon, Wolfspeed, ROHM, BOSCH, Fuji Electric, Mitsubishi Electric, Vanguard International Semiconductor (VIS) and EPISIL, Silan Microelectronics, and UNT have all announced plans to build 8-inch SiC chip factories. Many of these companies are also making strides in the upstream substrate and epitaxial material segments, TrendForce adds.

● STMicroelectronics (ST): On 31 May, ST announced the construction of a new 8-inch SiC plant in Catania, Italy, consolidating all aspects of the SiC production process. The new plant is expected to start production in 2026 and reach full capacity by 2033, with a maximum capacity of 15,000 wafers per week and an estimated total investment of about €5bn.

The 8-inch SiC manufacturing plant in Chongqing, China, jointly established by ST and China's Sanan Optoelectronics, will become ST's third SiC production center. The project was announced in June 2023 and is expected to begin production in fourth-quarter 2025, with full completion anticipated by 2028.

● Onsemi: Onsemi's SiC wafer plant in Bucheon, South Korea, completed its expansion in 2023 and plans to transition to 8-inch production by 2025 after completing technology verification. By then, capacity will be expanded to 10 times the existing scale.

● Infineon: It was announced on 8 August that the first phase of Infineon's 8-inch SiC power semiconductor wafer plant in Kulim, Malaysia, has officially begun operation, with large-scale production expected by 2025.

● Wolfspeed: Wolfspeed has the world's first and largest 8-inch SiC plant, located in Mohawk Valley, New York, which officially opened in April 2022. As of June 2024, the factory has achieved a 20% wafer utilization rate.

In January 2023, Wolfspeed and automotive parts supplier ZF announced plans to build the world's largest and most advanced 8-inch SiC device manufacturing factory in Saarland, Germany. This project has been delayed and is now expected to start at the earliest in 2025.

● ROHM: ROHM built a new SiC plant in Chikugo, Fukuoka Prefecture, Japan, which began mass production in 2022 and plans to transition from 6-inch to 8-inch wafer production by 2025. In July 2023, ROHM announced plans to start producing 8-inch SiC substrates at its second factory in Miyazaki Prefecture, Japan, by the end of 2024.

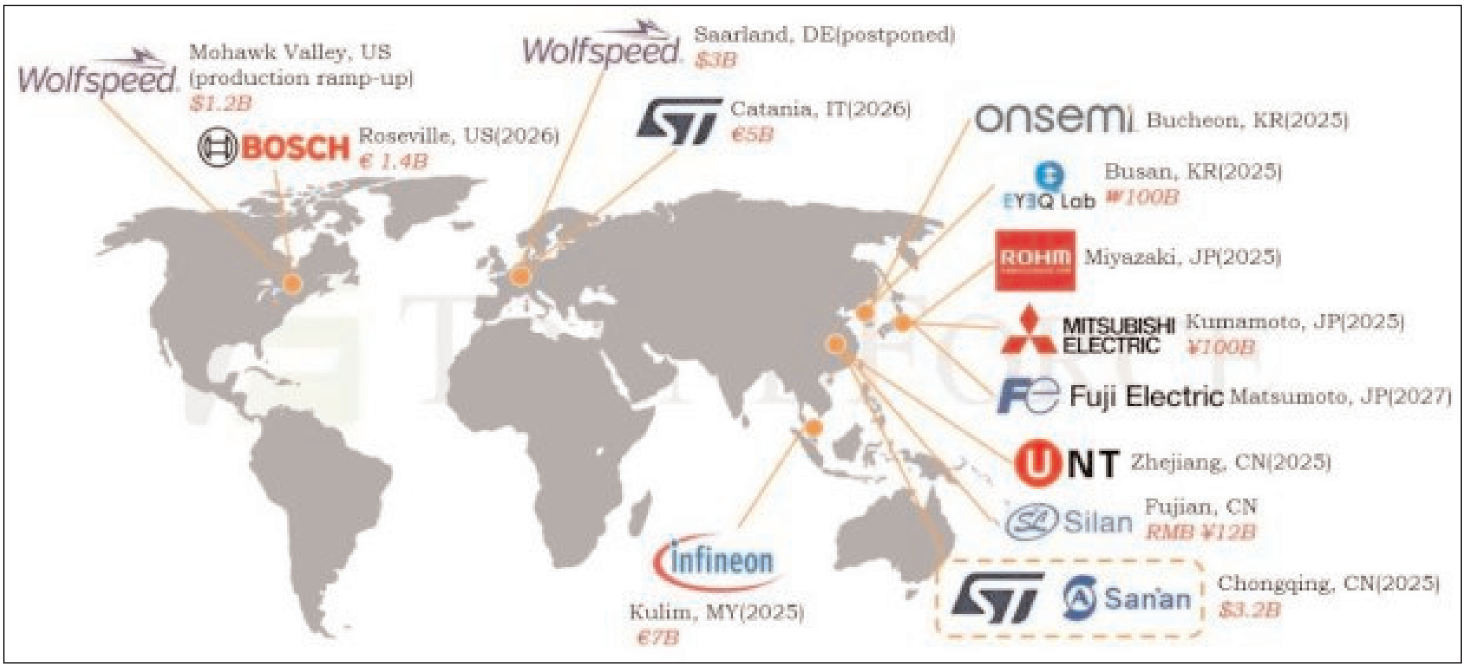
● BOSCH: BOSCH's factory in Reutlingen, Germany, began 6-inch SiC wafer production in 2021, with 8-inch SiC wafers currently also produced at this factory. The factory in Roseville, CA, USA, is expected to start 8-inch SiC wafer production by 2026.

● Mitsubishi Electric: It was announced in late May that Mitsubishi Electric's 8-inch SiC plant in Kumamoto Prefecture, Japan, will be completed by September 2025, with production brought forward from April 2026 to November 2025.

● Fuji Electric: In January, Fuji Electric announced a 200bn yen investment over the next three years (fiscal 2024–2026) for SiC power semiconductor production, including an 8-inch SiC capacity at its Matsumoto factory in Japan, expected to start production in 2027.

● UNT: China-based United Nova Technology (UNT) has built its first 8-inch SiC MOSFET wafer production line in Yuecheng District, Shaoxing, and completed the engineering batch in April this year, with mass production expected in 2025.

● Silan Microelectronics: Silan officially launched China's first 8-inch SiC power device chip manufacturing line project in Xiamen on 18 June this year, with a total investment of RMB12bn. The project will be built in two phases, with an annual production capacity of 720,000 8-inch SiC power device chips. The first-phase investment is RMB7bn, which is expected to complete initial connection by the end of third-quarter 2025, with trial production in fourth-quarter 2025 and an annual yield target of 20,000 wafers. The second-phase investment



is about RMB5bn.

●Vanguard International Semiconductor (VIS) & EPISIL: On 10 September, VIS announced a plan to invest NTD2.48bn to acquire a 13% stake in EPISIL. The two companies will collaborate on the development and production of 8-inch SiC wafer technology, with mass production expected in second-half 2026.

●Thailand's first SiC factory: Recently, the FT1 Corp joint venture in Thailand invested THB11.5bn (US$350m) to build Thailand's first SiC factory using technology transferred from a Korean chip manufacturer to produce 6-inch and 8-inch wafers. The factory is expected to start production in first-quarter 2027 to meet the growing demand in automotive, data-center and energy storage markets.

Summary

Of the above-mentioned 14 silicon carbide factories (12 under construction), only Wolfspeed's Mohawk Valley plant can currently provide 8-inch SiC wafers in the short term. Other manufacturers are expected to begin supplying 8-inch SiC wafers gradually from next year, concludes TrendForce. ■

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High-current vertical diamond MOSFETs

Researchers achieve drain currents above 1A by connecting two devices.

Waseda University in Japan reports on vertical metal-oxide-semiconductor field-effect transistors (MOSFETs) constructed from diamond with up to 0.7A maximum drain current [Nobutaka Oi et al, IEEE Electron Device Letters, vol.45, issue 9 (September 2024), p1554]. The team claims the 0.7A drain current as the largest reported so far for diamond FETs. Two of the five researchers involved are also affiliated with Japan-based Power Diamond Systems Inc.

Diamond FET devices are potentially a p-type complement for the n-channel devices that are fabricated in silicon carbide (SiC), gallium nitride (GaN) and gallium oxide (Ga_2O_3) material systems that are being developed for power electronics applications. Complementary MOSFETs would enable the use of CMOS circuit designs, which enable higher-speed operation and smaller gate drive requirements. In the power domain, efficient complementary inverters are wanted for DC/AC conversion of renewable and stored energy sources.

Diamond material properties suitable for power applications include a high breakdown field (10MV/cm), high thermal conductivity (22W/cm-K), and high hole mobility (2000–3800cm^2/V-s).

Two epitaxial diamond layers, 0.5μm undoped and 1.0μm n-type, were added to a 3mmx3mmx0.3mm p+-type boron-doped diamond substrate (Figure 1) by microwave plasma chemical vapor deposition (MPCVD). The carbon came from a mix of methane (CH_4) and carbon dioxide (CO_2). The n-type nitrogen doping was sourced from nitrogen gas (N_2).

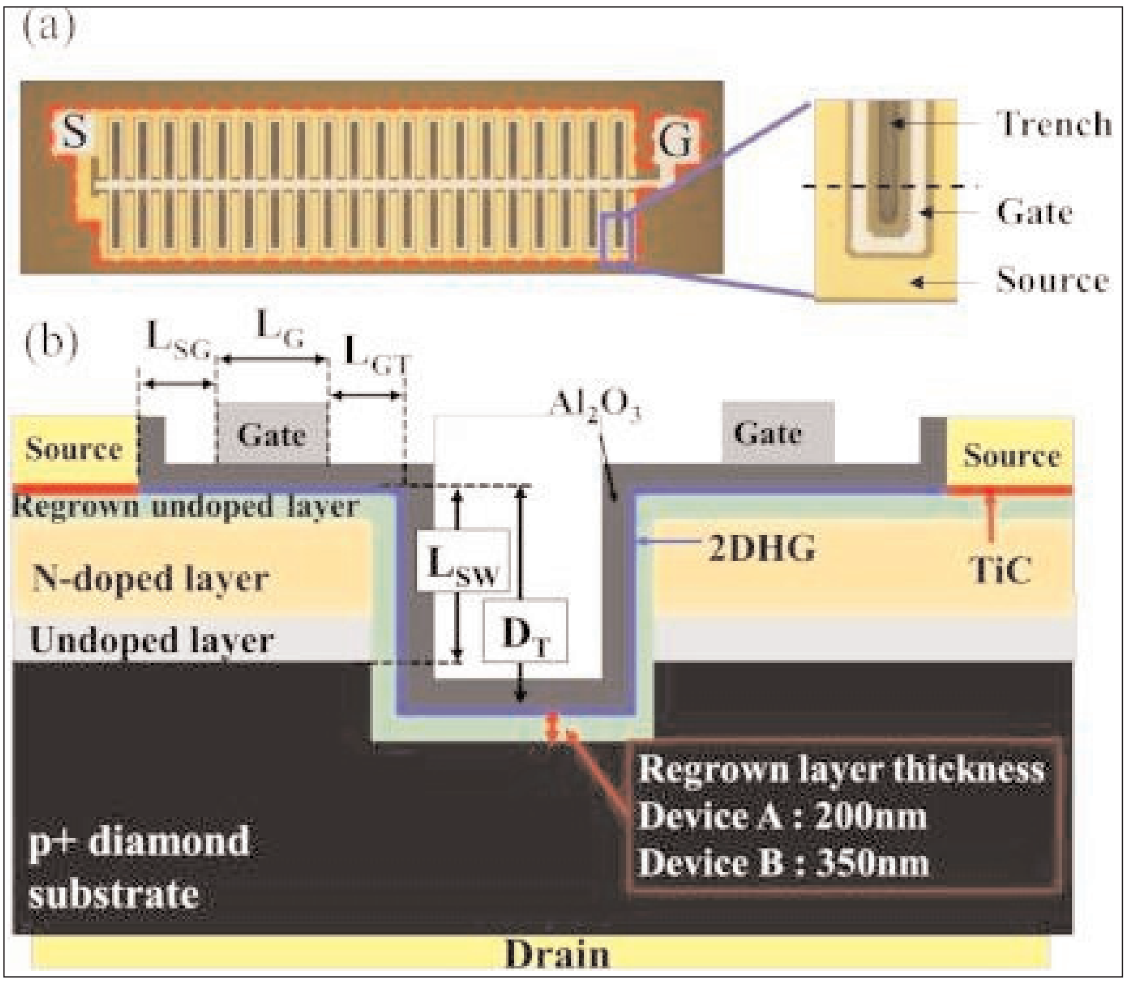

Figure 1. (a) Optical microscope image and close-up of device with gate width of 5mm (S: source, G: gate) (b) Cross-sectional schematic of dash line area.

The vertical FET structure was fabricated by inductively coupled plasma reactive-ion etch (ICP-RIE), MPCVD diamond regrowth, electron-beam evaporation of the source electrode, plasma treatments for hydrogen termination and device isolation, 450°C atomic layer deposition (ALD) of 200nm aluminium oxide (Al_2O_3), tetramethylammonium hydroxide (TMAH) Al_2O_3 etch, dual ion beam sputtering of the backside drain contact, and thermal evaporation of the gate and source contact pad.

The ICP-RIE to a depth of 2.2μm created 60μm-wide trenches. The trench length was 5μm. The vertical channel consisted of a two-dimensional hole gas (2DHG) that formed near the interface between the

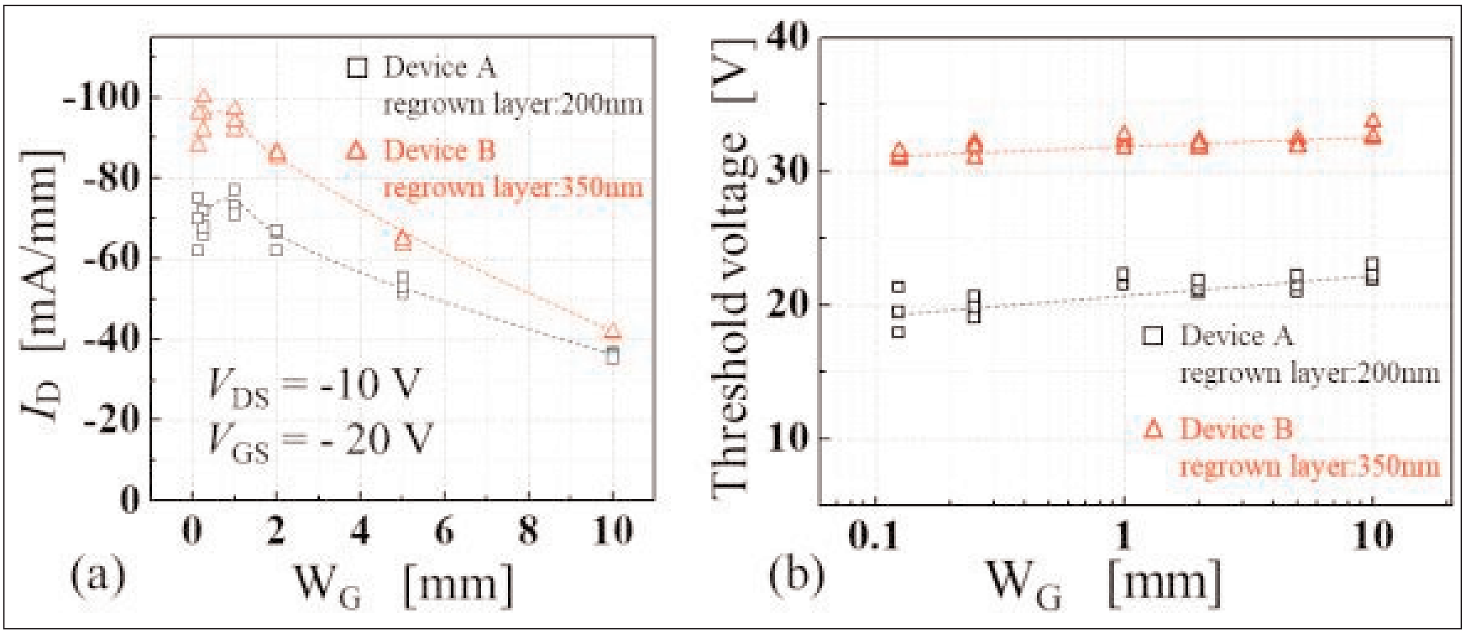

Figure 2. (a) Drain current density (I_D) versus gate width (W_G) at −10V V_{DS} and −20V V_{GS}. (b) Threshold voltage dependence on gate width.

regrown diamond and Al_2O_3 layers.

The source electrode consisted of titanium/platinum/gold (Ti/Pt/Au), annealed to form titanium carbide (TiC) as the diamond source contact. The drain was Ti/Au. The gate and source pad were Al.

The gate length (L_G) was 4μm. The gate widths, the perimeters of the trenches, were varied on a millimeter scale. The distances of the gate from the source (L_{SG}) and trench (L_{GT}) were 2μm and 3μm, respectively.

A device with 10mm gate width achieved a maximum drain current of −0.7A at −20V drain bias, and −20V gate potential. The regrown layer thickness was 200nm (i.e. device type 'A').

The on/off current ratio was around 9.5 orders of magnitude with the off-current reaching down to the measurement limit of the team's equipment (~10^{-11}A) when the gate was at 35V.

With a −1V drain bias, the threshold voltage was +21.2V, so the device operated in a normally-on (when the gate potential is 0V) depletion mode. For many power applications, a normally-off mode is preferred.

Another device A, with 0.1mm gate width, achieved an off-state (+30V V_{GS}) breakdown voltage of 225V. The drain current was less than 10^{-10}A almost up to

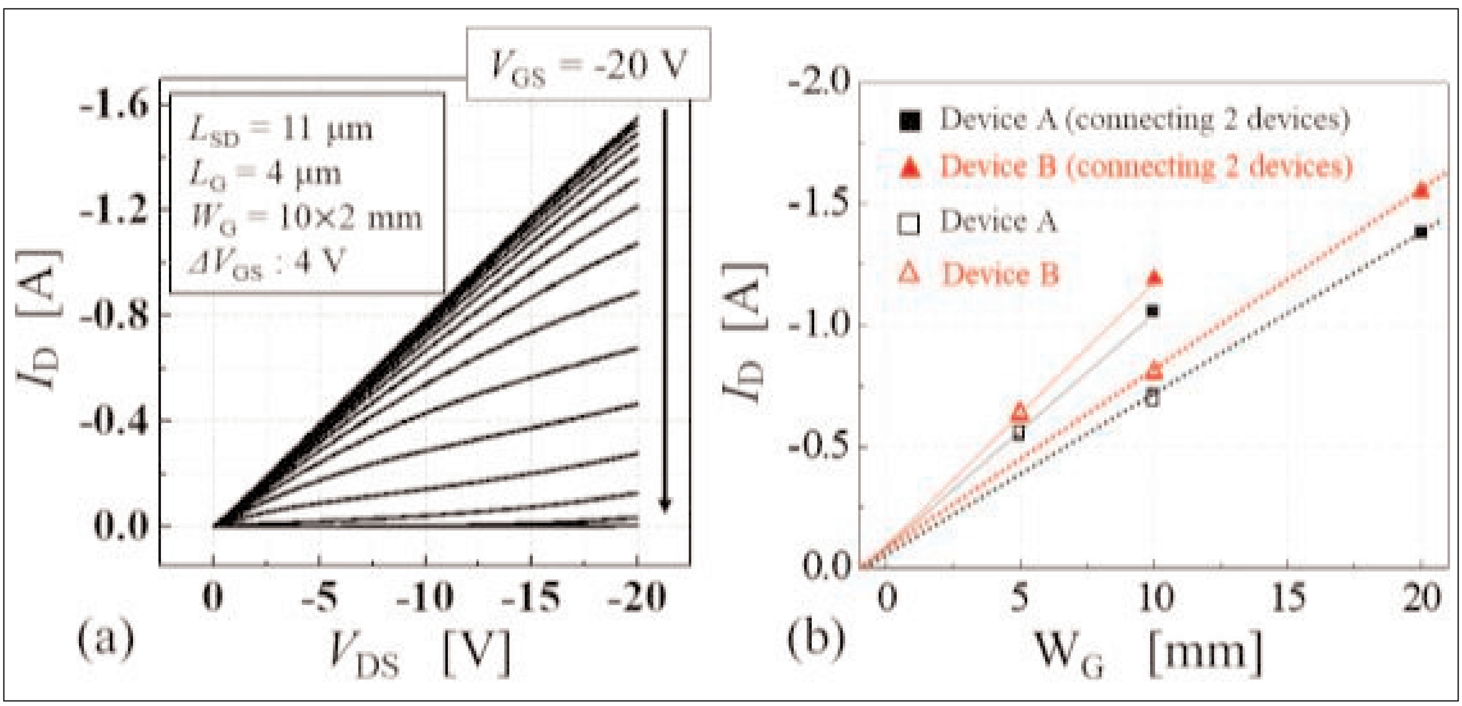

Figure 3. (a) I_D–V_{DS} pulse mode characteristics of two connected B devices with V_{GS} ranging from −20V to +36V. (b) Relationship between drain currents of single and double devices at −20V V_{DS} and −20V V_{GS}.

the breakdown point.

The team comments: "Breakdown voltage is expected to be lower for devices of larger gate width because of inhomogeneous distribution of device characteristics due to process non-uniformity."

The drain current density normalized by the gate width tended to fall for the wider devices (Figure 2). Also, a thicker 350nm ('B') regrown layer gave around 30% higher drain current for the 1mm-wide FETs tested.

The researchers comment: "The tendency for the drain current density to decrease as WG increases suggests the presence of additional resistances such as substrate resistance and source electrode resistance, with the latter expected to play a more significant role."

For devices wider than 2mm, the measurements were made in pulse mode to avoid self-heating effects.

The threshold voltages were larger for the B series, meaning that they were deeper into depletion-mode territory. The specific on-resistances were 48.4mΩ-cm^2 and 36.7mΩ-cm^2 for 2mm WG devices A and B, respectively. These values were reduced by subtracting the effect of the source electrode area from the total active area to 17.7mΩ-cm^2 and 13.8mΩ-cm^2, respectively. The team suggests that the electrode contact resistance could be improved through use of an interlayer dielectric and reduction of device dimensions.

To achieve more than 1A drain current, the researchers connected two devices (Figure 3). For 10mm wide device B, two devices enabled −1.5A to be reached with an on-resistance of 12.7Ω, just over half the value for a single FET. The maximum drain current for type A was −1.3A. ■

Visit: https://doi.org/10.1109/LED.2024.3427423

Author: Mike Cooke

suppliers' directory

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E-mail: cyberstar@cyberstar.fr
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E-mail: sales@tecdia.com
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5 Deposition materials

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7 Wafer processing materials

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9 Materials & metals

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10 Gas and liquid handling equipment

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12 Inspection equipment

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www.gelpak.com

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18 Chip foundry

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21 Computer hardware & software

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Contact Person: Cathy W. Hung
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24 Resources

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France
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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

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

4–6 November 2024
11th IEEE Workshop on Wide Bandgap Power Devices and Applications (WiPDA 2024)
Dayton, Ohio, USA
E-mail: WiPDAreg@ieee.org
https://wipda.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

7–11 December 2024
70th annual IEEE International Electron Devices Meeting (IEDM 2024)
Hilton San Francisco Union Square Hotel, San Francisco, CA, USA
E-mail: iedm-info@ieee.org
www.ieee-iedm.org

16–20 February 2025
ISSCC 2025: IEEE International Solid— State Circuits Conference
San Francisco, CA, USA
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www.isscc.org

19–21 February 2025
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www.semiconkorea.org/en

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www.asiaphotonicsexpo.com

16–20 March 2025
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E-mail: apec@apec-conf.org
www.apec-conf.org

30 March – 3 April 2025
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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

6–8 May 2025
PCIM 2025
(Expo & Conference on Power Electronics, Intelligent Motion, Renewable Energy and Energy Management)
Nuremberg, Germany
E-mail: pcim_visitors@mesago.com
www.mesago.de/en/PCIM/main.htm

27–30 May 2025
2025 IEEE 75th Electronic Components and Technology Conference (ECTC)
Gaylord Texan Resort & Convention Center,
Dallas, TX, USA
www.ectc.net

Microwave Week

15–17 June 2025
IEEE Radio Frequency Integrated Circuits Symposium
(RFIC 2025)
San Francisco, CA, USA
E-mail: support@mtt.org
www.rfic-ieee.org

15–20 June 2025
2025 IEEE/MTT-S International Microwave Symposium
(IMS 2025)
San Francisco, CA, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/about-ims/past-and-future-ims

22–27 June 2025
World of PHOTONICS CONGRESS — International Congress on Photonics in Europe
ICM — International Congress Center,
Messe München,
Munich, Germany
E-mail: info@photonics-congress.com
www.photonics-congress.com/en

6–11 July 2025
15th International Conference on Nitride Semiconductors
(ICNS-15)
Malmö, Sweden
E-mail: info@icns15.com
https://mkon.nu/icns-15

22–25 July 2025
ALD/ALE 2025:
AVS 25th International Conference on Atomic Layer Deposition (ALD 2025) featuring the 12th International Atomic Layer Etching Workshop (ALE 2025)
Jeju Island, South Korea
E-mail: della@avs.org
www.ald2025.avs.org

21–26 September 2025
28th European Microwave Week
(EuMW 2025)
Jaarbeurs, Utrecht, the Netherlands
E-mail: eumwreg@itnint.com
www.eumweek.com

28 September – 2 October 2025
ECOC 2025:
51st European Conference on Optical Communication
Bella Center, Copenhagen, Denmark
E-mail:ecoc2025@cap-partner.eu
www.ecoc2025.org

7–9 October 2025
SEMICON West 2025
Phoenix, AZ, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

15–19 February 2026
2026 IEEE International Solid- State Circuits Conference
(ISSCC 2026)
San Francisco, CA USA
E-mail: Isscinfo@yesevents.com
www.isscc.org