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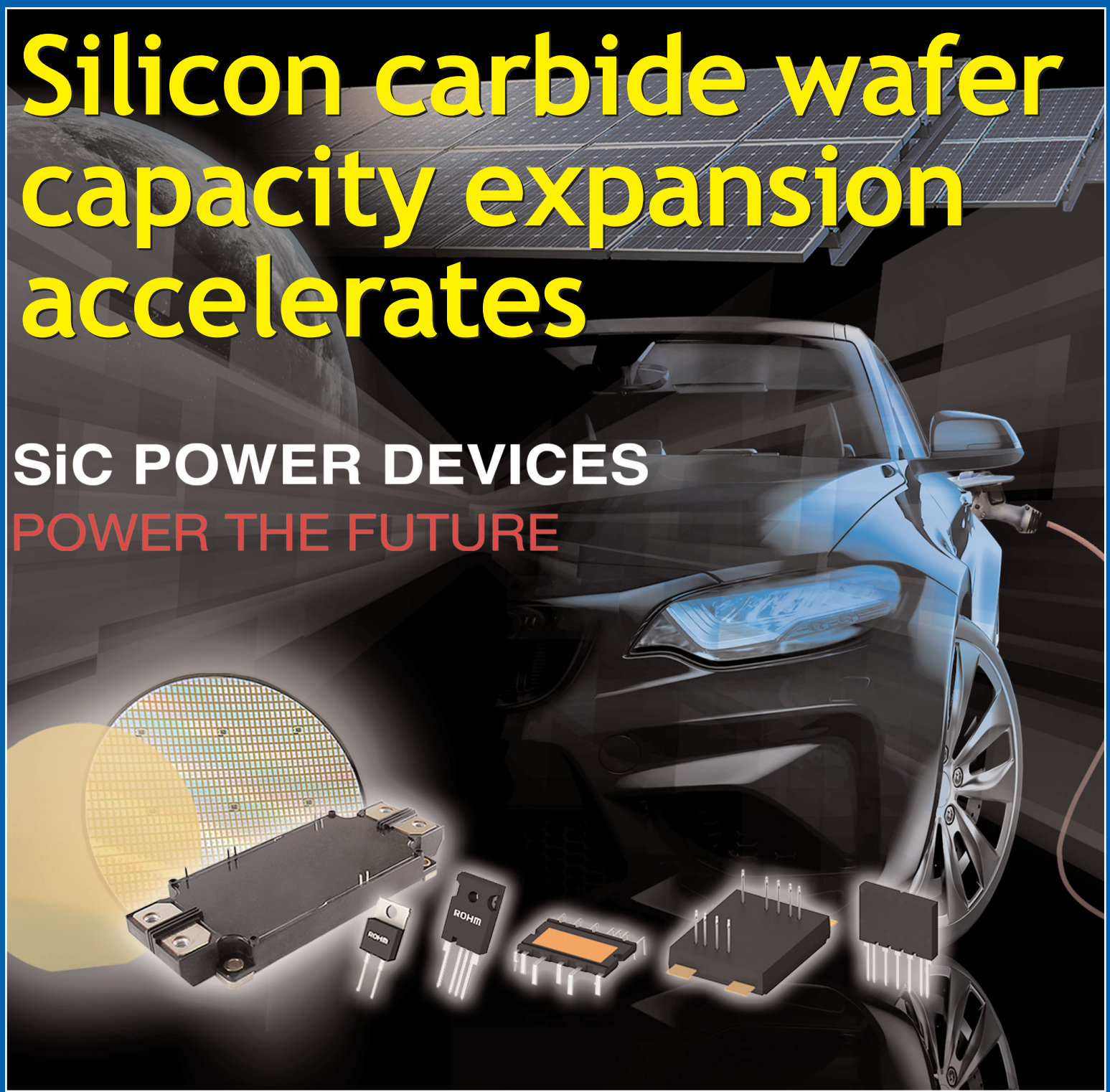
COMPOUNDS & ADVANCED SILICON

Vol. 17 • Issue 8 • October/November 2022 www.semiconductor-today.com

Silicon carbide wafer capacity expansion accelerates



Vishay buys MaxPower • CGD raises $19m • SweGaN raises €12m • Avicena acquires Nanosys' GaN micro-LED fab

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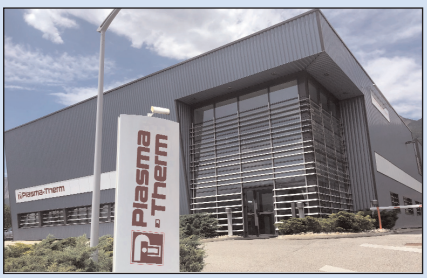

p45 Plasma-Therm's site in Grenoble, France is to serve as its regional EMEA headquarters.

p74 First Solar is investing $270m in a dedicated R&D innovation center near its existing manufacturing facility in Perrysburg, Ohio.

Cover image: Japan's ROHM has signed a joint development agreement with Mazda Motor and Imasen Electric Industrial for inverters and silicon carbide power modules to be used in the electric drive units of electric vehicles, including e-Axle. **p17**

editorial

National security AND investment

Over 16 months after Nexperia in July 2021 acquired the remaining 86% of the shares of the UK's largest chip maker Newport Wafer Fab (NWF) in South Wales, on 16 November the UK Government's Secretary of State for Business, Energy & Industrial Strategy (BEIS) issued a Final Order requiring that the Netherlands-based firm (a subsidiary of China's Wingtech Technology) sells at least 86% of what is now Nexperia Newport Ltd (NNL) — see page 7.

This follows the UK Government on 25 May telling Nexperia that it was exercising its statutory power to retroactively 'call in' the acquisition by using the National Security and Investment Act 2021, which only came into effect this January. Previously, reviews by BEIS and the UK's National Security Advisor had both found no substantive national security concerns to block the acquisition, notes Nexperia.

Now, the acquisition is deemed to be a "risk to national security" since: (1) technology and know-how from the potential reintroduction of compound semiconductor activities at Newport could undermine UK capabilities; (2) Newport's links with the South Wales-based compound semiconductor cluster CSconnected could preclude the latter from engaging in future projects relevant to national security.

Nexperia says it had offered to BEIS's Investment Security Unit that it would not conduct the compound semiconductor activities of potential concern and would provide the UK Government with direct control and participation in Newport's management, but its proposal was ignored. Nexperia is lodging an appeal against the order.

The decision puts over 500 jobs and £100m of taxpayers' money at risk, says Nexperia, "undermining the UK's semiconductor industry, as we brought new production [involving hundreds of millions of pounds of foreign direct investment] to Newport". Nexperia also has 1000 staff at its site in Manchester.

The UK's order mirrors US Government policy to restrict access of China-based firms to semiconductor manufacturing technology/assets deemed to be sensitive to national security, affecting firms not only in the USA but elsewhere too. In 2016, Fujian Grand Chip Investment's acquisition of Germany-based MOCVD system maker Aixtron (whose US subsidiary comprised 20% of both the firm's staffing and revenue) was blocked by the Committee on Foreign Investment in the United States (CFIUS). Most recently, in early November, the German government blocked the sale (agreed last December) of automotive silicon chip maker Elmos' fab in Dortmund to Silex (a Swedish subsidiary of China's Sai MicroElectronics) to "protect infrastructure and prevent technology leakage".

This came after the USA in early October announced further restrictions on exporting semiconductor manufacturing equipment to China without a license. While this will diminish US exports, the US Government aims (through funding from the CHIPS Act) to boost domestic semiconductor manufacturing.

The UK's revocation of the Newport acquisition is similarly in the interest of national security. However, it may be counter to national economic interest if the loss of Nexperia's investment is not replaced by another buyer. It is partly the UK government's tardiness in developing its 'Semiconductor Strategy' (two years in the making and still not published by the targeted Autumn) that has driven criticism of the national-security-driven order among both regional authorities and industry stakeholders. As many countries are experiencing during the current period of reassessment of international relations, national security and economic independence are not cost-free.

Mark Telford, Editor

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

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- news (funding, personnel, facilities, technology, applications & markets);
- feature articles (technology, markets, regional profiles);
- conference reports;
- event calendar and event previews;
- suppliers' directory.

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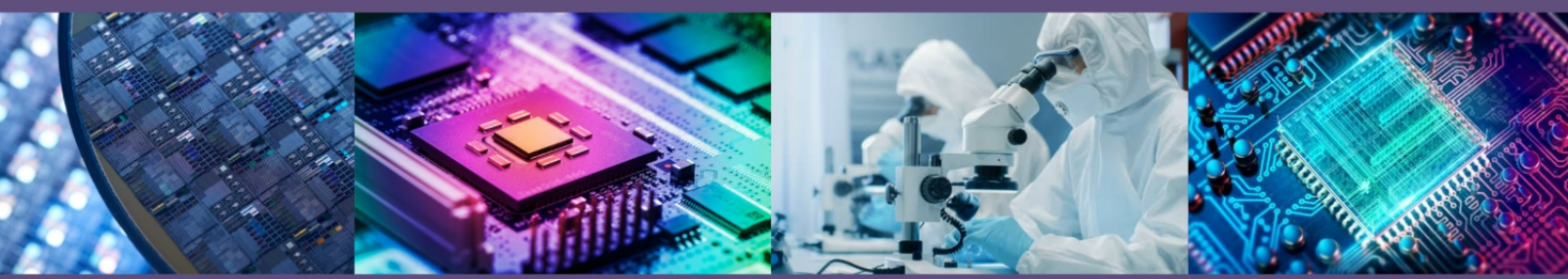

CSconnected is home to the world's first regional ecosystem based on the manufacture of compound semiconductor enabled hardware, located in south Wales

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EV powertrain semiconductor market to grow at 31% CAAGR to $27bn in 2029

Silicon carbide power semiconductor demand to grow at 39% to $8.3bn, overtaking silicon

Driven by consumer awareness and government regulations and mandates related to climate change and the need to reduce emissions and reverse the impacts of global warming, electric vehicle production is growing at a compound annual average growth rate (CAAGR) of 26% from 2021 to 2026, and volumes will approach 54.1 million units by 2029, forecasts the report 'xEV Semiconductor Demand Outlook 2021–2029' from the Strategy Analytics Electric Vehicles Service (EVS). This in turn will drive demand for corresponding xEV powertrain semiconductors, which is forecast to grow at a CAAGR of 31% to $27.3bn by 2029.

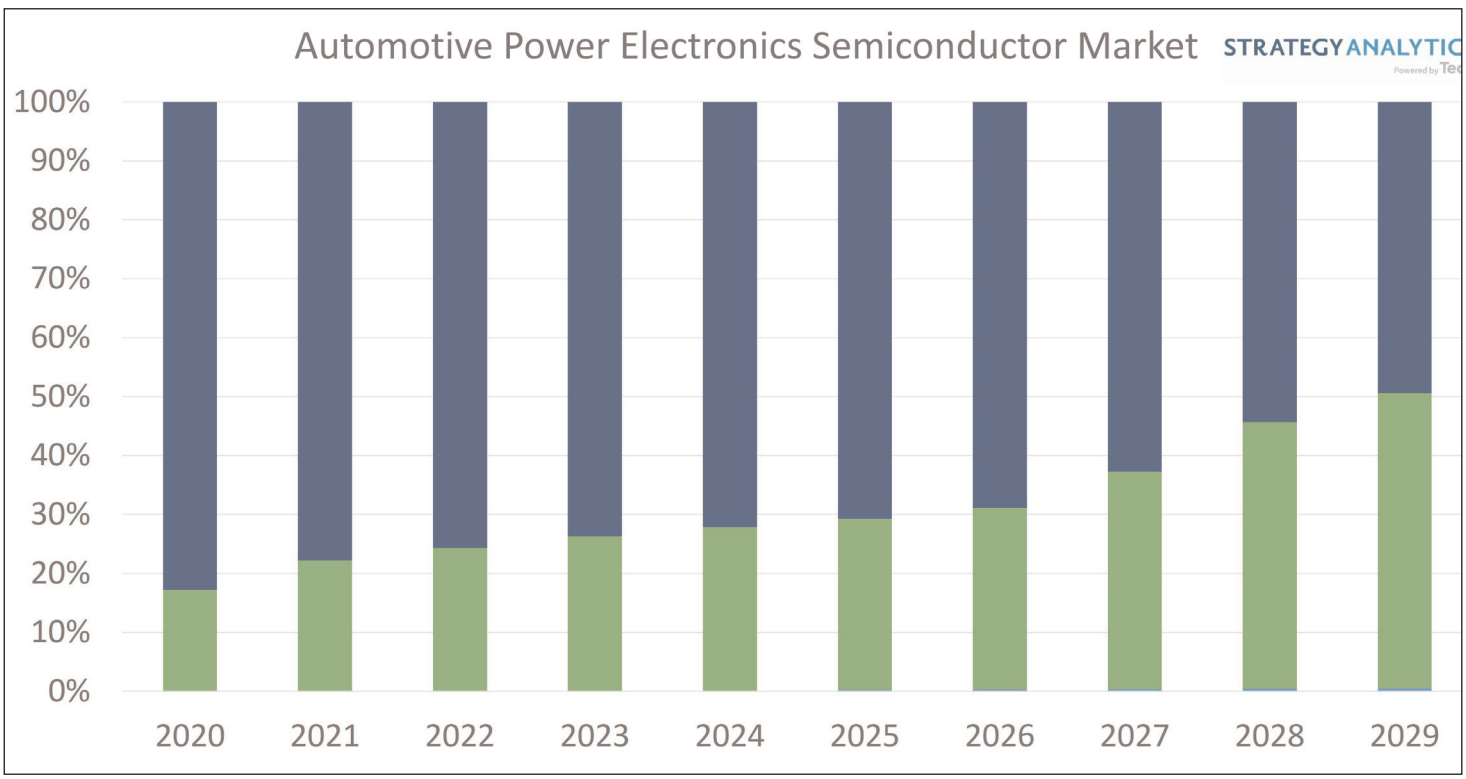
Semiconductor demand covered in the analysis include key systems necessary for the operation of mild hybrid, full hybrid, plug-in hybrid, and battery electric powertrains. This includes battery management systems, DC/DC converters, main traction inverter, electric motor, and onboard charger.

Battery electric vehicles will comprise the largest demand sector, growing at a CAAGR of 39% and accounting for 82% of the total electric vehicle powertrain semiconductor market opportunity in 2029, it is forecasted.

Semiconductors required for power electronics will comprise the largest market, with growth accelerating in line with the push towards battery electric vehicles

"Semiconductors required for power electronics will comprise the largest market, with growth accelerating in line with the push towards battery electric vehicles and the move towards higher-performing, more efficient wide-bandgap semiconductors," notes Asif Anwar, executive director at Strategy Analytics. "This will translate to the market for SiC (silicon carbide) growing at a CAAGR of 39% over 2021 to 2026 and grow through 2029 to reach $8.3bn, at which point we will have reached a tipping point with SiC semiconductor demand exceeding that of silicon power semiconductors."

www.strategyanalytics.com/access-services/automotive/electric-vehicles-service/



Due to the transition to battery electric vehicles, by 2029 demand for silicon carbide (green) will exceed demand for silicon (blue) in the automotive power electronics semiconductor market.

UK Government deems Nexperia's acquisition of Newport Wafer Fab a "risk to national security"

Nexperia required to sell at least 86% of South Wales fab

Pursuant to section 26 of the National Security and Investment Act 2021, the UK Government's Secretary of State for Business, Energy and Industrial Strategy (BEIS) has made a final order after its review of the acquisition on 5 July 2021 by Netherlands-based Nexperia BV of an additional 86% of the shares of Newport Wafer Fab (NWF, now Nexperia Newport Ltd, or NNL), taking its stake to 100%.

The order determines that the acquisition constitutes a trigger event under section 8(2)(c) of the Act. Specifically, the acquisition by Nexperia (a subsidiary of China-based Wingtech Technology Co Ltd) presents a risk to national security relating to:

- technology and know-how that could result from a potential reintroduction of compound semiconductor activities at the Newport site, and the potential for those activities to undermine UK capabilities; and
- the location of the site could facilitate access to technological expertise and know-how in the South Wales-based compound semiconductor cluster, and the links between the site and the Cluster may prevent the Cluster being engaged in future projects relevant to national security.

As a "necessary and proportionate" measure to mitigate the risk to national security, the UK Government order has the effect of requiring Nexperia to sell at least 86% of NNL within a specified period and by following a specified process.

Nexperia says that, on 25 May, it learned that the UK Government's Secretary of State for Business, Energy and Industrial Strategy was exercising his statutory power to retroactively 'call in' its acquisition of NWF. "The Secretary of State exercised this power under the new National Security and Investment Act (which became effective in January), after previous reviews by BEIS and the UK's National Security Advisor, both of which found no substantive national security concerns that should give cause to block the acquisition," says Nexperia.

Nexperia responds that it is shocked by the UK Government's final order, and does not accept the national security concerns raised. To fully address the Government's concerns, Nexperia had offered to BEIS's Investment Security Unit that it would not conduct the compound semiconductor activities of potential concern and that it would provide the UK Government with direct control and participation in the management of Newport, but that its proposal has been "entirely ignored".

"The UK Government chose not to enter into a meaningful dialogue with Nexperia or even visit the Newport site," says Nexperia. "More than 500 employees in Newport also raised their own significant concerns about such a divestment — the Government has chosen not to listen to them and instead taken this decision which puts the livelihoods of them and their families, as well as more than £100m of taxpayers' money, completely unnecessarily at risk. Nexperia will now challenge the order and will do everything possible to keep the factory and protect its employees in South Wales," it adds.

"We will appeal to overturn this divestment order to protect the over 500 jobs at Newport," says Nexperia UK country manager Toni Versluijs. "This decision sends a clear signal that the UK is closed for business," he adds.

"It is legally wrong – being disproportionate given the remedies Nexperia has proposed. It is wrong for the employees of Nexperia Newport — creating further uncertainty. It is wrong for the UK semiconductor industry — taking out a strong player. It is wrong for the UK economy — undermining its semiconductor industry as we brought new production to Newport. It is wrong for the UK taxpayer — who could now be faced with a bill of over £100m for the fallout from this decision," continues Versluijs.

"We are hugely disappointed by this extraordinary U-turn, and the greater uncertainty that it creates for our employees and their families in Wales whilst also not recognizing the commitment of our 1000 employees in Manchester. As a globally successful European-centred company, with our roots at Royal Dutch Philips and proud 90-year track record in Britain, it is astonishing that our employees face such jeopardy and hundreds of millions of pounds of foreign direct investment are not welcome," he adds.

"We rescued an investment-starved company from collapse. We have repaid taxpayer loans, secured jobs, wages, bonuses and pensions, and agreed to spend more than £80m on equipment upgrades since early 2021. Those who sold the business to us agreed that it was the only viable solution, and the deal was publicly welcomed by the Welsh Government," notes Versluijs. "We made every effort to engage, to explain our business and made bold proposals for our operations in Newport and its management to nullify any potential fears about possible national security risks. We have been especially disappointed that we were denied the opportunity to discuss these with the Secretary of State himself or any of his political or Private Office team."

Nexperia says that it will prioritise looking after the impacted employees at Nexperia Newport and reducing the negative impact on its customers.

www.newportwaferfab.co.uk
www.gov.uk/government/publications/acquisition-of-newport-wafer-fab-by-nexperia-bv-notice-of-final-order

UCSB and UCSD professors receive 2022 University Research Awards from SIA/SRC

Mark Rodwell honoured for development of millimeter- and sub-millimeter-wave InP HBTs and III–V MOSFETs

The Semiconductor Industry Association (SIA) and the Semiconductor Research Corporation (SRC) have announced the recipients of the 2022 University Research Awards: Dr Mark J.W. Rodwell, Doluca Family Endowed Chair and Professor in the Electrical and Computer Engineering Department at the University of California, Santa Barbara (UCSB); and Dr Tajana Simunić Rosing, Fratamico Endowed Chair and Professor in the Computer Science and Engineering Department at the University of California, San Diego (UCSD).

SIA and SRC present the University Research Awards annually to individuals who demonstrate excellence in advancing research in semiconductor technology and design. Rodwell and Rosing received the awards at the SIA Awards Dinner on 17 November in San Jose, CA.

"Research drives game-changing innovations in semiconductors and the countless technologies they enable," comments John Neuffer, president & CEO of SIA, which represents US-based semiconductor manufacturing, design and research. "Through their excellence in semiconductor research, professors Rodwell and Rosing are advancing American innovation and helping make the world smarter, more efficient, and better connected."

Mark Rodwell.

Neuffer also highlighted the importance of recent enactment of the CHIPS and Science Act, which provides critical semiconductor manufacturing incentives and research investments. This federal research funding will complement existing large investments from the semiconductor industry, which plows about one-fifth of revenue into R&D.

Rodwell and Rosing join a "distinguished lineup of past award winners based on their incredible contributions into the semiconductor industry," comments Dr Todd Younkin, president & CEO of SRC.

Rodwell will receive the honor for excellence in semiconductor technology research. His development of millimetre- and sub-millimeter-wave indium phosphide (InP) heterojunction bipolar transistors (HBTs) and III–V metal-oxide-semiconductor field-effect transistors (MOSFETs) have extended the limits of high-frequency radio, high-speed optical communications, and imaging applications. His work has not only enabled ultra-high-speed 5G wireless radios and links but has also closed the 'Terahertz Gap' to make the next generation of 6G communications and high-resolution cameras and imagers possible. Rodwell is an IEEE Fellow and has received numerous awards, including the 1997 IEEE Microwave Prize, the 1998 European Microwave Conference Microwave Prize, and the 2010 IEEE Sarnoff Award.

Rosing will receive the award for excellence in semiconductor design research. Inspired by the human brain, her research work on hyper-dimensional computing systems has been accelerated in hardware such as GPUs, field-programmable gate arrays (FPGAs) and PIM to handle high-dimensional vectors in data-intensive applications, including COVID-19 sequence analysis, drug discovery, personalized healthcare, and the Internet of Things (IoT). Her approaches are delivering impressive accuracy in learning from big data, with excellent performance, extreme energy efficiency, and robustness. Rosing is a both an IEEE and ACM Fellow.

www.src.org
www.semiconductors.org

Guerrilla RF surpasses 150 million RFIC/MMIC deployments

Cumulative shipments accelerate, growing by 50% in 15 months

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — a provider of radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has surpassed the 150 million milestone for RFIC/MMIC deployments – a 50% increase in lifetime shipments since it reached the 100m mark 15 months ago. Since opening its doors in 2013, Guerrilla RF has experienced rapid growth within the wireless infrastructure market. In 2020 and 2021, the firm was recognized by Inc. magazine as being one of the top 500 fastest-growing companies in the USA.

"We continue to gain traction within our strategic markets, especially within the automotive, 5G infrastructure, and cellular repeater segments," says CEO & founder Ryan Pratt. "Our catalog business, with a base of 300+ customers, is similarly fueling the rapid acceleration of component deployments, and we're constantly finding new and exciting applications that can leverage our industry-leading cores," he adds.

"Our growth also serves as a validation of our overall market strategy," Pratt continues. "At Guerrilla RF, we stealthily disrupt the underserved wireless infrastructure market by combining the very best in RF innovation and performance with unparalleled customer support," he claims. "Over the course of the next few weeks, we'll introduce a myriad of new products which will help accelerate our growth in future years."

http://guerrilla-rf.com

Guerrilla RF completes ¼W linear power amplifier family

InGaP HBT PA provides 23.5dBm for cellular applications requiring exceptional native linearity over temperature extremes

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — a provider of radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has introduced the GRF5521, one of ten ¼W linear power amplifiers (PAs) released as part of its continued expansion into the cellular market. The indium gallium phosphide (InGaP) heterojunction bipolar transistor (HBT) amplifiers were designed for 5G/4G wireless infrastructure applications requiring exceptional native linearity over temperature extremes of –40°C to 85°C.

Spanning a frequency range of 2.11–2.17GHz, the GRF5521 is tuned to operate in the n1, n65 and n66 5G new radio (NR) bands. The device delivers 23.5dBm of linear power over the entire –40°C to 85°C temperature range while maintaining ACLR (adjacent-channel leakage ratio) levels of better than –45dBc, IMD3 (third-order intermodulation distortion) levels <–22dBm, EVM (error vector magnitude) levels <1% and PAE efficiencies >20% — all without the aid of supplemental linearization schemes like digital pre-distortion (DPD).

The ability to beat the –45dBc ACLR performance metric without DPD is critical for cellular applications like residential and commercial repeaters/boosters, femtocells, picocells, and cable loss compensators associated with automotive 'shark fin' antennas. In each of these use cases, the sensitivity to cost, power and size constraints prohibits the use of elaborate linearization techniques like DPD. Instead, designers must rely on the PA's native linearity to meet the stringent emissions mask requirements imposed by 5G and 4G standards.

During the development of the GRF55xx series, Guerrilla RF consulted with its base of automotive and cellular repeater/booster customers to ensure that the devices delivered the best blend of power and linearity, thus maximizing the effective range and throughput for their cellular systems. Guerrilla RF also designed the family of devices to be fully footprint compatible, enabling its customer base to rapidly customize their designs for a myriad of cellular frequencies.

"The GRF5521 is the final variant in our series of mid-band ¼W PAs which were tuned specifically for cellular bands residing within the 1.7–2.17GHz spectrum," says CEO & founder Ryan Pratt. "By the end of the year, we'll have production-released products covering every major cellular band between 660MHz and 4200MHz," he adds. "These linear PAs are extremely popular with our cellular booster/repeater and automotive customers, and we continue to see significant design wins queuing up for these devices as our customers pivot to cover additional bands of operation."

The GRF55xx family comes in pin-compatible 3mm x 3mm, 16-pin QFN packages. Samples and evaluation boards are available for the GRF5521.

Prices start at $1.55 (10,000-up, EXW USA).

www.guerrilla-rf.com/products/detail/sku/5521

Qorvo and SK Siltron sign long-term silicon carbide supply agreement

Deal to promote domestic semiconductor supply chain resilience and support rapidly growing demand for SiC

Qorvo has finalized a multi-year agreement for the supply of silicon carbide (SiC) bare and epitaxial wafers from compound semiconductor wafer maker SK Siltron CSS of Auburn, MI, USA (a subsidiary of South Korea-based SK Siltron, a part of the SK Group).

The agreement is targeted at promoting domestic semiconductor supply chain resilience and a greater ability to support the rapidly rising demand for silicon carbide solutions, specifically in the automotive market. It is also aimed at providing end-user customers a level of protection and confidence as they adopt Qorvo's Gen 4 SiC FETs.

SiC devices are more efficient at handling high powers and conducting heat than traditional silicon. When used in electric vehicle (EV) system components, this allows more efficient transfer of electricity from the battery to the motor, increasing the driving range of an EV by 5–10%, it is reckoned.

www.sksiltron.com
www.qorvo.com

Qorvo announces $2bn share repurchase program

Remaining authorized dollar amount under prior program included

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) says that its board of directors has authorized the repurchase of up to $2bn of its outstanding common stock. The new repurchase program includes the remaining authorized dollar amount under the prior program, which was terminated concurrent with the new authorization.

Share repurchases will be made in accordance with applicable securities laws on the open market or in privately negotiated transactions. The extent to which the company repurchases its shares, the number of shares and the timing of any repurchases will depend on general market conditions, regulatory requirements, alternative investment opportunities and other considerations. The program does not require the firm to repurchase a minimum number of shares and does not have a fixed term, and it may be modified, suspended or terminated at any time without prior notice.

Qorvo serves diverse high-growth segments of large global markets, including consumer electronics, smart home/IoT, automotive, EVs, battery-powered appliances, network infrastructure, healthcare and aerospace/defense.

www.qorvo.com

Altum RF announces sales rep agreement with NWN

Expanded coverage supports customers in Northern California, Northern Nevada and Oregon

Altum RF of Eindhoven, The Netherlands (which designs high-performance RF to millimeter-wave solutions for commercial and industrial applications) has announced a sales representative agreement with NWN Inc of San Jose, CA, USA, covering customers in Northern California, Northern Nevada and Oregon.

Founded in 1994, NWN specializes in technical knowledge of RF, mmWave, microwave, frequency control and analog components. NWN also has expertise and solid relationships in the commercial advanced technology, semiconductor tool, networking components, test & measurement, military and aerospace markets.

The sales representative agreement with NWN "advances our ability to provide comprehensive support to customers in Northern California, Northern Nevada and Oregon," says Altum RF's CEO Greg Baker. "With a solid team of sales engineers, we are certain NWN will effectively assist our customers throughout the entire product development cycle," he adds.

"We are excited for our line card to gain this emerging industry leader that focuses on expanding its product portfolio to meet market and customer requirements," comments NWN's president Bob Gibbens. "Using advanced and innovative technologies, Altum RF offers compelling and differentiated products for the growing microwave and millimeter-wave markets."

www.altumrf.com

Vishay Intertechnology acquires power semi design firm MaxPower Semiconductor for $50m

Silicon carbide technologies to enhance Vishay's MOSFET range

Discrete semiconductor and passive electronic component maker Vishay Intertechnology Inc of Malvern, PA, USA has acquired fabless power semiconductor provider MaxPower Semiconductor Inc of San Jose, CA, USA for $50m (net of cash acquired) plus contingent payments of up to $57.5m upon the achievement of certain technology milestones and the occurrence of certain non-operating events. MaxPower will be incorporated into Vishay's MOSFETs reportable segment.

With an IP portfolio of over 100 patents, MaxPower provides silicon and silicon carbide (SiC) MOSFET products using proprietary device structures and process techniques. Its SiC product development includes both trench and planar technologies from 650V to 1700V targeting automotive and industrial applications.

"As Vishay orients the company for growth, innovation will play an important role, and we plan to intensify business development activities focused on acquiring technologies that offer attractive opportunities to expand our product portfolio and strengthen our competitive positioning," says executive chair Marc Zandman. "Importantly, this acquisition will enable Vishay to support customers' advanced development of high-voltage electrification applications, thereby opening the door for us to provide them with our entire portfolio of products," he adds.

This acquisition will enable Vishay to support customers' advanced development of high-voltage electrification applications, thereby opening the door for us to provide them with our entire portfolio of products

"MaxPower's team of world-renowned power semiconductor experts brings extensive experience in R&D, design and application of power devices, and we look forward to working with the team to develop product offerings that will serve fast-growing markets such as electric vehicles and enhance our leadership in MOSFETs," says president & CEO Dr Gerald Paul.

www.vishay.com

ComEd and NCSU receive $200,000 US DOE grant for SiC-based XFC project

XFC to develop and demonstrate extreme fast charger for EVs

Commonwealth Edison Company (ComEd, a unit of Chicago-based energy provider Exelon Corp), in partnership with North Carolina State University's FREEDM Systems Center, has been awarded a $200,000 federal research and development grant from the US Department of Energy (DOE) to help fund a $5m research project focused on improving the efficiency of, and reducing the cost of, extreme fast charging (XFC) for electric vehicles (EVs).

The XFC project aims to allow EV owners to charge their vehicles at a much faster rate than Level 1 or Level 2 EV chargers, which rely on standard 120V and 240V outlets, respectively (taking about 50 hours and 7.5 hours, respectively, to fully charge a standard 70kWh EV battery).

The XFC charger that the project seeks to develop and demonstrate will be an ultra-low cost, all-SiC modular power converter for direct current charging equipment that can connect directly to a medium-voltage distribution system. With power capabilities of 300kWh, these chargers target reducing the time to fully charge a standard 70kWh EV battery to as little as 15 minutes.

"The goal of this new project is to bring extreme fast charging much closer to market realization and support the continued adoption of electric vehicles by reducing consumers' charge anxiety," says Srdjan Lukic Ph.D., NC State professor, deputy director of FREEDM and principal investigator for the project. "We could not achieve that without collaboration from project partners like ComEd."

The project will be divided into two phases focused on cost analysis & system development and system demonstration, respectively. After the charging systems have been developed, ComEd's Grid Integration and Technology (GrIT) Lab in Maywood, IL, will serve as the initial testing location for the new technology — providing an independent validation of the XFC system performance. ComEd will also support phase two of the project by identifying ideal locations on the distribution grid to demonstrate the technology, unlocking the potential for wider deployment.

The full $5m XFC EV development and demonstration project is funded through collaborator cost shares including $200,000 from ComEd. Other collaborators include Danfoss, GoTriangle, New York Power Authority and North Carolina Clean Energy Technology Center.

www.comed.com
www.ece.ncsu.edu

ST to build €730m silicon carbide wafer factory in Catania, Italy

150mm substrate & epi plant alongside SiC device plant to provide vertical integration, targeting automotive and industrial customers in shift to electrification and higher efficiency

STMicroelectronics of Geneva, Switzerland is to build an integrated silicon carbide (SiC) substrate manufacturing facility in Italy to support the increasing demand from customers for SiC devices across automotive and industrial applications as they transition to electrification and seek higher efficiency. Production is expected to start in 2023, enabling a balanced supply of SiC substrate between internal and merchant supply.

The investment of €730m over five years will be supported financially by the State of Italy in the framework of the National Recovery and Resilience Plan and it will create about 700 direct additional jobs at full build-out.

Built at ST's Catania site in Italy alongside its existing SiC device manufacturing facility, the SiC substrate manufacturing facility will be what's reckoned to be the first of a kind in Europe for the volume production of 150mm-diameter SiC epitaxial substrates, integrating all steps in the production flow. ST says that it is committed to developing 200mm wafers.

ST says that the Catania substrate project is a key step in advancing the vertical integration strategy for its SiC business. The firm's high-volume STPOWER SiC products are currently manufactured in its fabs in Catania and Ang Mo Kio in Singapore. Assembly & test are done at back-end sites in China (Shenzhen) and Morocco (Bouskoura). The investment in the SiC substrate manufacturing facility builds on this and is reckoned to be a significant milestone on ST's path towards reaching 40% internal substrate sourcing by 2024.

"ST is transforming its global manufacturing operations, with additional capacity in 300mm manufacturing and a strong focus on wide-bandgap semiconductors to support its $20bn+ revenue ambition," says president & CEO Jean-Marc Chery. "We are expanding our operations in Catania, the center of our power semiconductor expertise and where we already have integrated research, development and manufacturing of SiC with strong collaboration with Italian research entities, universities and suppliers," Chery adds. "This new facility will be key to our vertical integration in SiC, reinforcing our SiC substrate supply as we further ramp up volumes to support our automotive and industrial customers in their shift to electrification and higher efficiency."

Catania has long been an important site for innovation for ST as the home of its largest SiC R&D and manufacturing operations, contributing to the development of new solutions for producing more and better SiC devices. With an established eco-system focused on power electronics, including a long-term collaboration between ST and various stakeholders (the University, the CNR — Italian National Research Council, companies involved in equipment and product manufacturing) as well as a large network of suppliers, the investment is intended to strengthen Catania's role as a global competence center for silicon carbide technology and for further growth opportunities.

www.st.com

ST exhibits and presents at electronica

Technology showcased for smarter mobility, energy efficiency and industrial applications

At the electronica 2022 event (15–18 November) in Munich, Germany, STMicroelectronics of Geneva, Switzerland exhibited and presented its technology, focusing on four broad areas: smarter mobility; industrial IoT and factory automation; energy management and power efficiency; and developing and securing AI-based connected systems. Over 35 demos showcased technology already deployed in the field with existing customer and partner systems and devices as well as next-generation, innovative solutions.

In particular, as part of the electronica conferences and Forums, ST delivered presentations on silicon carbide (SiC) and gallium nitride (GaN) for automotive power applications, as well as on the challenges of securing software-defined vehicles.

Hunan Sanan secures $524m silicon carbide chip order for new electric vehicle power systems

SiC MOSFETs to enter production in 2024; joint venture Sike Semiconductor to make half-bridge SiC power modules

China's Sanan Optoelectronics Co Ltd says that its subsidiary Hunan Sanan has signed a procurement letter of intent (LOI) agreement to supply silicon carbide (SiC) chips worth US$524m over the next few years for the new electric vehicle (NEV) product line of a strategic automotive partner. Hunan Sanan's SiC technology will provide energy for the NEV power system for medium- and high-voltage platforms.

"Our agreement with this strategic partner further demonstrates the automotive industry's commitment to providing innovative electrification experience to the market and leveraging the advantages of wide-bandgap semiconductors to improve overall vehicle performance," says Hunan Sanan's general manager Tony Chiang. "The agreement ensures a long-term supply of SiC to our customer to help them realize their promise of low-carbon, smart mobility."

Hunan Sanan's fab in Changsha.

The SiC chips will be manufactured in Hunan Sanan's mega fab in Changsha, the first vertically integrated SiC wafer manufacturing service platform in China, which provides an in-house supply chain from SiC crystal, substrate, epitaxy, chip manufacturing, packaging and testing, with a committed annual production capacity of 500,000 SiC 6-inch wafers. Hunan Sanan recently obtained IATF 16949 system certification, while the automotive-grade SiC MOSFETs have been verified with the cooperation of strategic partners, and are expected to be released in production in 2024. Sike Semiconductor, a company jointly established by Hunan Sanan and Li Auto, also officially started construction in August and is expected to begin production in 2024 with a planned annual production capacity of 2.4 million half-bridge SiC power modules.

www.sanan-ic.com

Infineon and Stellantis sign MoU for SiC chip supply deal

CoolSiC bare die chip manufacturing capacity to be reserved in second half of decade for direct tier-1 suppliers of Stellantis

Infineon Technologies AG of Munich, Germany and global automaker Stellantis have signed a non-binding memorandum of understanding (MoU) as a first step towards a potential multi-year supply cooperation for silicon carbide (SiC) semiconductors. Infineon would reserve manufacturing capacity and supply CoolSiC bare die chips in the second half of the decade to the direct tier-1 suppliers of Stellantis. The potential sourcing volume and capacity reservation have a value of significantly more than €1bn.

"We firmly believe in electro-mobility and are excited to develop partnerships with leading automotive companies like Stellantis that make it a part of people's everyday life," says Peter Schiefer, division president Automotive at Infineon. "Compared to traditional power technologies, silicon carbide increases the range, efficiency and performance of electric vehicles. With our leading CoolSiC technology and continuous investments in our manufacturing capacities, we are well positioned to meet the growing demand for power electronics in electro-mobility," he adds.

Infineon and Stellantis are in talks about delivering the CoolSiC Gen2p 1200V and CoolSiC Gen2p 750V chips for electric vehicles under Stellantis brands. The performance, reliability and quality of CoolSiC technology would allow Stellantis to build vehicles with longer ranges and lower consumption — and support the company in its efforts to standardize, simplify and modernize platforms, says Infineon.

As a high-volume supplier to the automotive industry, Infineon is preparing for the accelerated demand of the industry with significant investments. In 2024, for example, its new fab for SiC technologies will start manufacturing in Kulim, Malaysia, complementing existing manufacturing capacities in Villach, Austria, in accord with Infineon's multi-site strategy.

www.infineon.com/coolsic

Wolfspeed raising $1.525bn in private offering

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — has priced a private offering of convertible senior notes due 2029 (announced on 16 November) to raise $1525m.

The notes are unsecured, senior obligations of Wolfspeed, bearing interest at a rate of 1.875% per year, payable semi-annually in arrears on 1 June and 1 December of each year (beginning on 1 June 2023). The notes will mature on 1 December 2029, unless earlier repurchased, redeemed or converted.

The initial conversion rate is 8.4118 shares of Wolfspeed's common stock per $1000 of notes (equivalent to an initial conversion price of about $118.88 per share). Conversions will be settled in cash, shares of Wolfspeed's common stock or a combination thereof, at Wolfspeed's election. The initial conversion price represents a conversion premium of about 35% over the last reported sale price of $88.06 per share on the New York Stock Exchange on 16 November.

The size of the private offering was increased from the initial $1300m. In addition, Wolfspeed has granted the initial purchasers an option to purchase (for settlement within a 13-day period from, and including, the date on which the notes are first issued) up to an additional $225m of the notes.

Net proceeds were expected to be about $1497.5m (or $1718.6m, if the initial purchasers exercise their option to purchase additional notes in full) after deducting the initial purchasers' discount and estimated offering expenses payable by Wolfspeed.

Wolfspeed intends to use about $238.7m of the net proceeds to fund the cost of entering into privately negotiated capped call transactions. The remainder will be used for general corporate purposes. If the initial purchasers exercise their option to purchase additional notes, then Wolfspeed intends to use part of the additional net proceeds to fund the cost of entering into additional capped call transactions.

The cap price of the capped call transactions will initially be $202.5380 per share (a premium of 130% over the last reported sale price of $88.06 per share) and is subject to certain adjustments under the terms of the capped call transactions.

www.wolfspeed.com

BorgWarner investing $500m in Wolfspeed

Access secured for up to $650m in annual SiC device capacity for BorgWarner's EV inverters

In a multi-year strategic partnership, BorgWarner Inc of Auburn Hills, MI, USA (which provides sustainable mobility solutions for the vehicle market) is to invest $500m in Wolfspeed's financing transaction, in exchange for being entitled to purchase up to $650m of silicon carbide devices annually as BorgWarner's requirements increase.

"Silicon carbide-based power electronics play an increasingly important role for our customers as our electric vehicle business continues to accelerate," notes BorgWarner's president & CEO Frédéric Lissalde. "This agreement helps ensure that BorgWarner will have a reliable supply of high-quality silicon carbide devices, which are significant to the company's inverter growth plans. Building upon BorgWarner's world-class Viper power switches and inverter technology, we are excited about the opportunity to work jointly with Wolfspeed, the leader in silicon carbide, on the potential development of the next generation of silicon carbide products," he adds. "Our relationship with Wolfspeed will drive innovation, accelerate the global transition to electric vehicles, and further BorgWarner's vision for a clean, energy-efficient world."

BorgWarner's Charging Forward strategy targets $4.5bn of electric vehicle revenue for 2025, up from less than $350m in 2021. Based on new business awards and acquisitions announced as of the firm's Q3/2022 earnings release, BorgWarner believes it is already on track to achieve about $4bn of electric vehicle revenue by 2025.

"BorgWarner has been a strong partner with Wolfspeed for many years, and we are pleased to secure the investment from them which will be used to support our capacity expansion efforts and ensure we have a steady supply of product for their customers," says Wolfspeed's president & CEO Gregg Lowe. "This agreement, combined with our most recent announcement of a multi-billion-dollar materials expansion in North Carolina, confirms the industry transition from silicon to silicon carbide is well underway."

At its Investor Day in October, Wolfspeed outlined a multi-year $6.5bn capacity expansion effort that included the installation of additional tools at its 200mm Mohawk Valley fab and the construction of a 445-acre silicon carbide materials facility in North Carolina, which will expand the firm's existing materials capacity by more than 10x. The first phase of construction is due to be complete by the end of fiscal-year 2024.

JLR's next-gen EVs to use Wolfspeed's SiC devices

Wolfspeed Inc of Durham, NC, USA has announced a strategic partnership to supply silicon carbide (SiC) to UK-based Jaguar Land Rover for its next-generation electric vehicles, delivering increased powertrain efficiency and driving range.

Under its Reimagine strategy, Jaguar Land Rover is transforming to an electric-first business, aiming to become carbon net-zero across its supply chain, products, services and operations by 2039.

Wolfspeed's SiC technology will be used specifically in the vehicles' inverter, managing the transfer of power from the battery to the electric motors. The first Range Rover vehicles with this technology will be available from 2024, and the new all-electric Jaguar brand the following year.

The partnership builds on Wolfspeed's existing relationship with the race-winning Jaguar TCS Racing team competing in the ABB FIA Formula E World Championship, where its SiC technology has been used to accelerate on-track efficiency and performance.

The agreement is the latest in Jaguar Land Rover's program of establishing strategic partnerships with industry leaders for its future modern luxury vehicles: in February, it announced a partnership with NVIDIA focused on software-defined automated driving systems for next-generation vehicles, starting in 2025.

"We are not strangers, having collaborated together with the Jaguar TCS Racing team for the last five seasons," notes JLR's CEO Thierry Bolloré. "By developing that into a strategic partnership as part of our Reimagine strategy, we can integrate Wolfspeed's advanced silicon carbide technology into our next-generation electric vehicles, delivering extended range and performance capabilities for our clients," he adds.

"Wolfspeed is proud to partner with Jaguar Land Rover, supporting its bold commitment to electrify its iconic brands by using silicon carbide's superior performance, efficiency and range," says Wolfspeed's president & CEO Gregg Lowe. "The energy efficiency of silicon carbide will play an essential role as Jaguar Land Rover pursues its own zero-carbon goals, and as the world transitions to an all-electric transportation future."

The partnership agreement sees Jaguar Land Rover participate in the Wolfspeed Assurance of Supply Program, to secure the supply of the technology for future EV production needs. Jaguar Land Rover says this will enable greater visibility and control over its future supply chain and is key to the new value chain approach of its operations and supply chain under the leadership of Barbara Bergmeier, executive director of Industrial Operations.

Wolfspeed's technology is powering electric propulsion systems across the entire voltage spectrum — from 400V to 800V. The SiC power devices will be produced at Wolfspeed's Mohawk Valley Fab in Marcy, New York, which opened in April as the world's largest 200mm silicon carbide fabrication plant. The fully automated facility greatly expands capacity for Wolfspeed's SiC technologies, which will supply the increasing demand for EV production and other advanced technology sectors around the world.

www.jaguarlandrover.com

AMP's e-mobility Energy Management Unit using Wolfspeed's E-Series SiC MOSFETs

AMP of Los Angeles, CA, USA (which specializes in connected battery management and charging technologies for electric mobility) has integrated Wolfspeed's E-Series SiC MOSFETs into its e-mobility Energy Management Unit, enabling it to optimize battery performance, charging and costs.

Wolfspeed's E-Series MOSFETs are optimized for use in automotive applications, such as traction inverters, electric vehicle (EV) on-board battery charging, and high-voltage DC–DC converters.

"At AMP, we understand the power that silicon carbide brings to vehicle electrification. We are proud to collaborate with another US-based company on technologies that make a greener and smarter tomorrow," says Jiaqi Liang, VP of hardware engineering at AMP. "The use of Wolfspeed's silicon carbide in AMP's Energy Management Unit (EMU) unlocks higher power density and efficiency, better platform scalability, and precise charging control. All are acutely observed by consumers through improvements in cabin space, charging time, and lower cost."

AMP's market-ready energy management solution integrates ultra-fast DC charging, DC–DC, and bi-directional on-board AC charging into a single platform, providing optimal charging experience, monitoring, care and performance of batteries.

"AMP's integration of our technology signals continued growth for silicon carbide in the automotive industry," says Jay Cameron, senior VP & general manager, Power, at Wolfspeed. "The expansion of our automotive-qualified 650V and 1200V E-Series silicon carbide MOSFET portfolio allows AMP to easily deploy their products for either 400V or 800V systems," he adds.

www.amp.tech
www.wolfspeed.com/e-series-

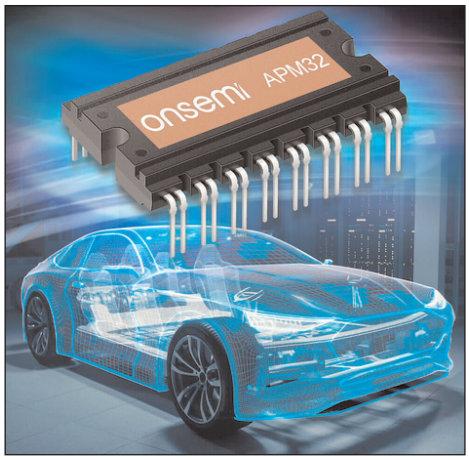
onsemi launches automotive SiC-based power modules for on-board chargers

APM32 series enables faster charging and increased range for xEVs

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA has announced a trio of silicon carbide (SiC)-based power modules in transfer-molded technology for use in on-board charging and high-voltage (HV) DC–DC conversion in all types of electric vehicles (xEV). The APM32 series is reckoned to be the first-of-its-kind that adopts SiC technology into a transfer-molded package to enhance efficiency and shorten charge time of xEVs and is specifically designed for high-power 11–22kW on-board chargers (OBC).

Each of the three modules exhibits low conduction and switching losses, combining with best-in-class thermal resistance and high voltage isolation to deal with 800V bus voltage. The enhanced efficiency and lower heat generation ultimately allow for a more powerful OBC that can charge the xEV faster and increase its operating range (two critical factors for consumers).

"Our new modules employ the latest SiC technology to minimize losses and overall system volume, allowing designers to meet charging efficiency and space goals," says Fabio Necco, VP & general manager Automotive Power Solutions at onsemi. "By adopting the pre-configured modular format, designers are able to configure their designs faster, with significantly lower time-to-market and design risk."



Taking advantage of onsemi's end-to-end SiC supply chain capability and proven SiC MOSFETs and diodes, the APM32 modules offer high levels of reliability, and each module is serialized for full traceability. The modules can operate with junction temperatures (T_j) as high as 175°C, ensuring reliability even in challenging, space-constrained automotive applications.

"APM32 provides a differentiated solution for our customers by leveraging onsemi's best-in-class packaging to unleash the full capability of the leading-edge silicon carbide technology," says Simon Keeton, executive VP & general manager, Power Solutions Group. "In addition, we know our customers value supply assurance, which our end-to-end SiC supply chain capabilities provide."

Two modules of the APM32 series, NVXK2TR40WXT and NVXK2TR80WDT, are configured in H-bridge topology with a breakdown ($V_{(BR)DSS}$) capability of 1200V (ensuring suitability for high-voltage battery stacks) for use in the OBC and HV DC–DC conversion stages. The third module, NVXK2KR80WDT, is configured in Vienna rectifier topology for use in the power factor correction (PFC) stage of the OBC. There will be six-pack and full-bridge modules in the near future to complete the SiC OBC portfolio.

All three modules are housed in a compact and robust dual inline package (DIP), ensuring low module resistance. The top cool and isolated features meet the most stringent automotive industry standards. The creepage and clearance distances meet IEC 60664-1 and IEC 60950-1. Additionally, the modules are qualified to AEC-Q101 and AQG 324 for automotive use.

www.onsemi.com

onsemi demos SiC-based technologies at electronica

Top-side-cooled MOSFETs simplify thermal design

At electronica 2022 in Munich, Germany, onsemi presented and demonstrated its latest innovations spanning the automotive, industrial and Cloud power markets, including applications in electric vehicles (EVs), advanced safety, factory automation, energy infrastructure and EV charging — with many of them based on silicon carbide. With an end-to-end SiC supply chain — from volume boule growth to integrated modules and discrete package solutions, onsemi says it can provide customers with the supply assurance.

A key demo featured top-side-cooled MOSFETs that were developed to simplify thermal design in challenging applications such as motor control and DC/DC conversion. Housed in a LFPAK package measuring just 5mm x 7mm, the seven new devices feature a 15mm^2 thermal pad that allows heat to be dissipated directly into a heat-sink rather than via the printed circuit board (PCB). This results in lower PCB temperatures, increasing overall system reliability and lifetime. The new concept enables a simplified thermal design and system-level cost savings.

The highlight of the booth was the Mercedes-Benz VISION EQXX electric vehicle, which drove 1202km (747 miles) from Germany to the UK on a single charge, enabled by onsemi's SiC technology.

www.electronica.de/en

ROHM, Mazda and Imasen to co-develop inverters for e-Axle using SiC power modules

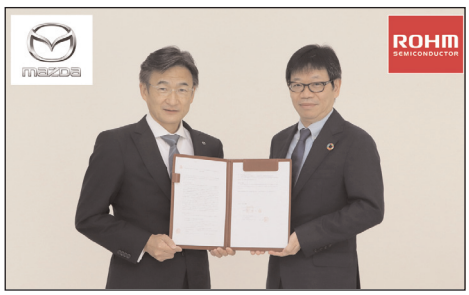
ROHM's SiC MOSFETs to be used in drive units of electric vehicles

Japan's ROHM has signed a joint development agreement with Mazda Motor Corp and Imasen Electric Industrial Co Ltd for inverters and silicon carbide (SiC) power modules to be used in the electric drive units of electric vehicles, including e-Axle.

As the 'heart of the EV', e-Axle integrates a motor, reduction gearbox and inverter into a single unit that plays a large part in determining the driving performance and power conversion efficiency of electric vehicles. SiC MOSFETs in particular are expected to improve efficiency even further.

ROHM will carry out joint inverter development for e-Axle by participating in a 'cooperative framework for the electric drive units development and production' with companies such as Imasen and led by Mazda. At the same time, ROHM will contribute to creating compact, high-efficiency electrical units by developing and supplying SiC power modules that provide improved performance.

Through this collaboration, ROHM aims to develop even more competitive SiC MOSFETs and modules by working backwards from the finished vehicle to understand the performance and optimal drive method required for power semiconductors.

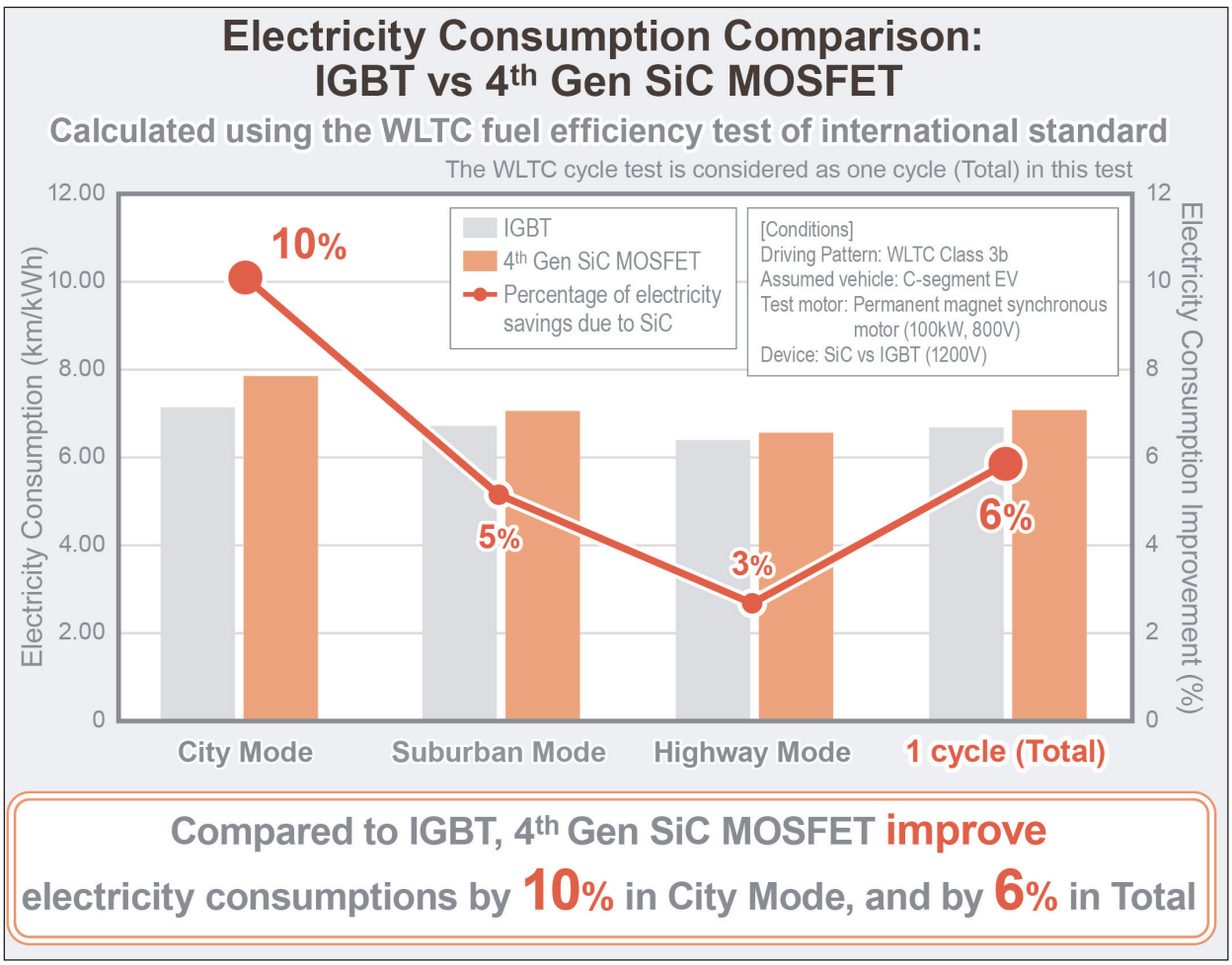


Ichiro Hirose, director & senior managing executive officer Oversight of R&D, Cost Innovation & Innovation, Mazda Motor Corp (left), and Katsumi Azuma, director, senior managing executive officer & COO at ROHM (right).

Besides creating new value through mutual understanding between car and device makers, the three companies also aim to support technical innovation in the automotive field and contribute to a sustainable society by leveraging extensive knowledge, technologies and products garnered on a global basis.

In 2020 ROHM completed development of its latest (4th Gen) SiC MOSFETs that deliver improved short-circuit withstand time along with what is claimed to be the industry's lowest ON-resistance, making it possible to extend the cruising range of electric vehicles by reducing power consumption by 6% compared with silicon-based IGBTs (as calculated by the international standard WLTC fuel efficiency test) when installed in the main inverter. As well as bare chips, ROHM is developing products with discrete packages, and the new collaboration should allow it to develop and offer power modules equipped with the latest (4th Gen) SiC MOSFETs.

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



GlobalFoundries awarded $30m in US funding for development and production of GaN-on-Si

GF to buy tools and extend 200mm GaN wafer manufacturing at Vermont fab

GlobalFoundries (GF) of Malta, NY, USA (which has operations in Singapore, Germany and the USA) has been awarded $30m in federal funding to advance the development and production of gallium nitride (GaN) on silicon at GF's fabrication plant in Essex Junction, near Burlington, Vermont.

GF says that, with its unique ability to handle significant heat and power levels, GaN is positioned to enable what is describes as game-changing performance and efficiency in applications including 5G and 6G smartphones, RF wireless infrastructure, electric vehicles (EVs), power grids, solar energy and other technologies.

The announcement was made at an event at GF's fab attended by US Senator Patrick Leahy, GF president & CEO Dr Thomas Caulfield, GF Vermont Fab VP & general manager Ken McAvey, Greater Burlington Industrial Corp president Frank Cioffi, GF Fab team members, and other guests. Secured by Leahy as an appropriation in the Consolidated Appropriations Act for Fiscal Year 2022, the $30m federal funding will enable GF to purchase tools and extend development and implementation of 200mm GaN wafer manufacturing. The incorporation of scaled GaN manufacturing into the fab's capabilities extends the facility's RF semiconductor technology, and positions GF for making chips for high-power applications including electric vehicles, industrial motors, and energy applications.

"Senator Leahy's leadership and dedication have been instrumental to the growth and success of semiconductor manufacturing in Vermont," commented Caulfield. "I thank Senator Leahy for his steadfast support of GF throughout his many years in office… He has been a champion of putting this facility on the global forefront of semiconductor manufacturing. With this new federal funding, and the potential for further support in the 2023 federal budget, GF is well-positioned to become a global leader in GaN chip manufacturing," he reckons.

"This funding is an investment in US leadership in improved technology for chips that connect everything around us and power our handheld devices," said Leahy.

This Other Transaction Agreement (OTA) was entered into by the Defense Microelectronics Activity via the Trusted Access Program Office (TAPO) of the US Department of Defense. TAPO's primary mission is to procure advanced semiconductors for the Department's most critical and sensitive weapons systems platforms. TAPO has been supporting dual-use (both civilian and military applications) GaN-on-silicon development efforts since 2019 as GaN provides a stable semiconductor suitable in high-power, high-frequency devices that the DoD needs to maintain technology advantage for the USA. This current development phase plans to leverage previous TAPO successes and continue maturing this dual-use technology.

"GlobalFoundries has been a critical partner to the Trusted Access Program Office, enabling semiconductor assurance (Trust) to advanced semiconductor technologies for the Department's most advanced weapon systems platforms," says DMEA director Dr Nicholas Martin. "This engagement is just one step the DoD is taking to ensure the US has continued access to advanced microelectronics technologies such as gallium nitride," he adds.

This $30m agreement is the latest federal investment to support GaN at GF's Vermont Fab. In fiscal years 2020 and 2021, Leahy secured a total of $10m for R&D related to advancing GaN technology at the facility, paving the way for the new award.

GF's facility in Essex Junction was among the first major semiconductor manufacturing sites in the USA. Nearly 2000 GF employees work at the site, with a manufacturing capacity of more than 600,000 wafers per year. Built on GF's differentiated technologies, the GF-made chips are used in smartphones, automobiles and communications infrastructure applications worldwide. The fab is a Trusted Foundry and manufactures secure chips in partnership with the US Department of Defense, for use in some of the nation's most sensitive aerospace & defense systems.

www.globalfoundries.com

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KYOCERA AVX Salzburg and VisIC expand collaboration for GaN-based e-mobility

Combining discrete and module packaging with GaN power devices for electric vehicle OEM and tier-1 traction inverters

VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors for high-voltage automotive applications — and Austria-headquartered automotive electronic component maker KYOCERA AVX Salzburg (which has production sites in North America, China and Europe) are expanding their collaboration.

The partners are combining their strengths in packaging, assembly and GaN wafer technologies with the aim of providing high-current components for high-voltage applications such as charging and e-drivetrains.

The expansion aims to fulfill the automotive industry's demands for reliable and highly efficient power solutions that will save on electric vehicle (EV) costs. With the best thermal resistance it is reckoned, discrete GaN devices and half-bridge modules will be essential for future on-board chargers (OBC) and traction inverters, optimizing weight, size, costs and driving range.

Based on VisIC's second-generation, lowest $R_{DS(on)}$ D^3GaN (Direct Drive D-Mode) switches, the power module, which will provide what is reckoned to be groundbreaking power density and performance, has already been adopted for the next-generation inverter sample of a major tier-1 automotive manufacturer.

In addition to these collaboration developments, the companies have also achieved an approach to

high-voltage battery disconnection, based on GaN power switches, through effective cooperation in a very short timeframe. With the fastest switching time, the current and, therefore thermal stress of the battery and board net, can be limited. This design will be available for lead projects this year.

"The electrification of the automotive industry has generated significant demand for power components, which we foresee continuing its strong growth for the next decade," says Ran Klier, VisIC's senior VP of sales & marketing. "Together with KYOCERA AVX Salzburg, we will provide packaged discrete GaN devices and die-based power modules for major EV OEM and tier-1 designs."

VisIC says that its D^3GaN technology was developed for the high-reliability standards of the automotive industry and for the lowest losses. It also simplifies the system solution and enables highly efficient and affordable powertrain platform solutions. These benefits have been well received by the premium automotive clients that VisIC has been working with over the past several years.

"Gallium nitride semiconductors are the key to efficiency improvements and increasing the driving range of electrified vehicles," says Martin Knosp, product line director at KYOCERA AVX Salzburg. "This technology offers significantly better switching speed and smaller and lighter package sizes, thereby reducing total system costs," he adds. "We are happy to expand our cooperation with VisIC Technologies, leveraging our advanced design and manufacturing abilities to create more GaN products and devices to better serve the booming EV market demands."

www.visic-tech.com

VisIC recruits senior VP of product

Liesabeths to expand footprint in automotive sector, and lead transition from silicon to GaN for electrical drive train and on-board chargers

VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors for automotive applications — says that Dieter Liesabeths is joining it as a senior VP of product.

With over 30 years of experience in the semiconductor industry, Liesabeths will drive the adaptation of GaN power devices in the automotive and industrial fields. In the last 12 years, he was a leader in Europe driving the conversion from silicon to wide-bandgap (WBG) semiconductors. In his new role he will lead the next-generation transition with VisIC's D^{3}GaN (Direct-Drive D-Mode) technology.

"With his long-term experience in wide-bandgap power semiconductors combined with his excellent knowledge of the automotive market, Dieter is the ideal candidate to extend our management team, expand our footprint in the automotive industry, and lead the transition from silicon to GaN for the next generation of the electrical drive train and on-board chargers," says CEO Tamara Baksht.

Dieter Liesabeths.

"VisIC's D^{3}GaN will leverage the development of the next generation of power devices, which will make electrical drive trains more affordable while providing longer range and lower power consumption compared with other wide-bandgap materials like silicon carbide (SiC)," comments Liesabeths.

In the newly formed role of senior VP of product, Liesabeths will focus on developing and releasing reliable, affordable and tailored die, discrete and module products to accommodate the market needs of the electrical drive train, on-board chargers, and other industrial applications.

Before VisIC, Liesabeths held management positions in the semiconductor industry in sales, marketing, business development, new technology and product definition. During the last 10 years, he worked for Wolfspeed GmbH as a senior director and built the Automotive department. Liesabeths created an eco-system to support the fast-switching wide-bandgap devices and partnered with industry leaders. Thus, the market could accelerate the adaptation of WBG devices.

Liesabeths holds a Dipl.-Ing. (TH) engineering degree from the University of Aachen, Germany.

www.visic-tech.com

Sumitomo Electric develops N-polar GaN HEMT using Hf-based gate dielectric

Highly heat-resistant, high-dielectric material targets post-5G telecoms

On 17 October at the 2022 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS) in Phoenix, AZ, USA, Japan's Sumitomo Electric Industries Ltd (SEI) reported that it had developed a gallium nitride high-electron-mobility transistor (GaN HEMT) that uses N-polar GaN and, for the gate insulating layer, what is reckoned to be the world's first hafnium (Hf)-based, highly heat-resistant, high-dielectric material, targeting the post-5G era, which will realize even greater capacity and high-speed communications.

In the future post-5G era, the transistors used in communication devices will need to support higher power and higher frequencies for greater data transmission volume.

Conventionally, Ga-polar (0001 orientation) GaN has been widely used. Along with the demand for further higher power and higher frequencies, however, attention is being focused on the improvement of characteristics with N-polarity ($000\bar{1}$ orientation), which enables an inverted HEMT structure that increases the degree of freedom in device design and can reduce leakage current. Meanwhile, N-polar crystals have the problem of being prone to irregularities caused by abnormal growth called hillocks. In addition, in terms of device design, the realization of an inverted HEMT structure required the development of a high-quality gate insulating layer to serve as a barrier against the gate electrode in place of the conventional semiconductor barrier layer.

Sumitomo Electric says that it has hence used its years of experience in crystal growth technology to realize high-quality N-polar crystal without hillocks. Also, by applying a type of hafnium-based highly heat-resistant and high-dielectric material (used in state-of-the-art silicon transistors) to the challenging gate insulating layer for the first time, the firm has created an N-polar crystal transistor with high-dielectric material and excellent high-frequency characteristics.

The work is a result of the 'Research and Development Project for Strengthening Post-5G Telecommunication System Infrastructure', commissioned by Japan's New Energy and Industrial Technology Development Organization (NEDO).

www.bcicts.org

www.sedi.co.jp

Navitas and VREMT open joint R&D lab for electric vehicle power systems and semiconductors

EV high-voltage applications to use GaNFast & GeneSiC power semis

Navitas Semiconductor of Torrance, CA, USA says that on 1 November Charles (Yingjie) Zha, VP & general manager of Navitas China, and Shuibao Guo, vice general manager of VREMT of Ningbo, Zhejiang, China (a subsidiary of Geely Group that supplies electric powertrains to ZEEKR, Volvo, Polestar and Lotus), opened a joint R&D power semiconductor laboratory in Ningbo.

Working with power system design tools and in close partnership with the system design teams of VREMT (Viridi E-Mobility Technology (Ningbo) Co Ltd), the lab will host Navitas engineers, with the aim of accelerating electric vehicle (EV) power system developments using Navitas' GaNFast power ICs and GeneSiC power MOSFETs and diodes.

As wide-bandgap power semiconductors, GaN and SiC deliver higher efficiency at faster switching speeds, with smaller system size and lower costs than silicon chips. EV power conversion systems can hence deliver faster-charging, faster-acceleration, longer-range and lower-cost EVs, accelerating the transition from fossil-fuel to clean-air vehicles.

The joint R&D lab will be further supported by Navitas' own EV System Design Center in Shanghai, which helps customers to maximize GaN and SiC performance advantages, including high-frequency magnetics design plus advanced packaging and modules to create higher-power-density, higher-efficiency and lower-system-cost power electronics systems for EVs.

"Navitas' next-generation power semiconductors bring enormous value to VREMT's design teams," comments Guo. "We expect that Navitas' high-frequency power system expertise will greatly reduce time-to-prototype and time-to-market for VREMT systems," he adds.

"This new partnership is aligned on both technical goals and also for sustainability, as both companies focus on carbon neutrality," comments Zha.

www.vremtglobal.com

Avnet Silica to expand EMEA market for Navitas' GaNFast power ICs with GaNSense

Avnet Silica of Brussels, Belgium (the European semiconductor specialist division of global technology distributor Avnet) is collaborating with gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA to grow the market in Europe for GaNFast power ICs with GaNSense technology.

The two firms say that they will work closely together to deliver their combined complementary knowhow to bring a high level of support and expertise to customers across the Europe, Middle East and Africa (EMEA) region.

Navitas' GaNFast power ICs with GaNSense technology integrate GaN power and drive circuitry with control capability, as well as autonomous protection and loss-less current sensing, to deliver what is claimed to be the industry's highest energy efficiency, smallest footprints, and the fastest power-conversion performance. The latest family of GaNSense half-bridge ICs offers a fully integrated, single component solution that enables AC–DC power supplies to achieve MHz switching frequencies in a broad range of soft-switching applications.

"We chose to work with Avnet Silica as one of the premier experts in semiconductor distribution in Europe," says David Carroll, senior VP of worldwide sales at Navitas. "The combination of our highly differentiated solutions together with Avnet Silica's expertise in technology markets will further support designers and engineers to meet ever more stringent efficiency and size requirements and regulations. With our highly experienced technical team and our European applications lab, together, we can support customers with the best possible solutions and fastest time-to-market," he adds.

"Navitas' unique GaN technology and its world-renowned monolithically integrated gate driver and feature set will significantly expand our 'SILICA' wide-bandgap semiconductor portfolio," comments Avnet Silica's president Gilles Beltran. "Navitas has a depth of expertise in power semiconductors that is unrivalled across the industry for this kind of advanced technology. We envisage this cooperation will bring huge benefits for customers operating at the cutting edge of power system architectures in a wide selection of applications."

www.avnet-silica.com
www.navitassemi.com

Growth in data-center, EV, energy storage, solar, home appliance & industrial outweighs drop in mobile

New long-term SiC supplier deals enable 5x capacity increase in 2023

For third-quarter 2022, gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA has reported revenue of $10.2m, up 19% on $8.6m last quarter and 82% on $5.6m a year ago. However, this includes a partial quarter of revenue from GeneSiC (acquired in mid-August).

Gross margin (on a non-GAAP basis) has fallen further, from 46.2% a year ago and 41.6% last quarter to 38.4% (below the expected 40%), while operating expenses have risen further, from $9.1m a year ago and $12.5m last quarter to $14.2m (including the partial quarter of expenses from GeneSiC).

Net loss has hence risen from $6.6m a year ago and $9.1m last quarter to $9.5m.

"Despite continued softness in the mobile market, demand in the higher-power GaN markets and for SiC remained strong, including 50 new SiC opportunities, for which we have recently signed long-term supply agreements to enable 5x SiC capacity expansion in 2023," says CEO & co-founder Gene Sheridan. "We are seeing strong demand across electric vehicles (EVs), energy storage, solar, data-center, home appliance and industrial markets, all fueled by the world's pursuit to replace silicon with more efficient GaN and SiC technologies and the commitment to address sustainability, climate change and electrification," he adds.

Navitas highlights its diversified markets and customer geographies:

- **Mobile**: 17 new fast chargers, including record-setting Xiaomi Redmi Note 10 210W ultra-fast charging from 1–100% in only 9 minutes, plus Lenovo, iQOO, Anker, Moto and Best Buy models;
- **Motor drive**: over 15 new home appliance & industrial opportunities, deploying recently announced GaNSense half-bridge ICs;
- **Data center**: now nine customer projects, including a $5m purchase order for mid-2023 initial shipments;
- **Solar**: commercial & residential customers such as APS, Chint, Enphase, Goodwe and Sungrow in production with SiC now, or on schedule for GaN starting in 2024;
- **Electric vehicle**:

— 22 new SiC customer projects add to strong growth from BYD, Geely, General Motors, Saab, Land Rover Jaguar, Shinry and many others;
— new joint design center with leading EV systems provider VREMT (Geely group, a supplier to brands including ZEEKR, Volvo, Polestar and Lotus);
— Navitas' EV design center team now has four onboard charger (OBC) platforms in development, for eight customer projects with expected revenue ramps by 2025.

Navitas also highlights its research and operational execution, including:

- shipping over 65 million GaN units with zero reported GaN field failures;
- rapid adoption of Gen 4 GaN in mobile, data center and motor drive applications.

Major macro-economic growth drivers are cited as:

- secular global trends driving the transition of the silicon power semiconductor industry to GaN and SiC for sustainability, energy savings and electrification;
- the United States' CHIPS Act and $300bn+ Inflation Reduction Act investments focused on sustainability and climate change.

For fourth-quarter 2022, Navitas expects revenue of $11–13m, gross margin of 40% and operating expenses of about $17.5m.

www.navitassemi.com

GeneSiC founder enters NCSU ECE Alumni Hall of Fame

Navitas Semiconductor says that Dr Ranbir Singh, executive VP of its GeneSiC business unit, has been inducted into the North Carolina State University's Department of Electrical and Computer Engineering (ECE) Alumni Hall of Fame, which celebrates the accomplishments of outstanding graduates who have used their education to excel in a profession, career or service. Singh's induction was based on his pioneering career in high-performance, high-reliability silicon carbide semiconductors for high-power, high-voltage applications. This includes several innovation and R&D awards, plus the founding in 2004 of GeneSiC Semiconductor (acquired by Navitas in August).

Singh holds a Bachelor of Technology, Electrical Engineering from the Indian Institute of Technology, Delhi, and both a master's and PhD in Electrical Engineering – Power Semiconductors, from NCSU. He also holds over 40 US patents and has presented and published over 200 journal and conference papers.

"Since he graduated, we have followed his career and groundbreaking work with SiC technologies closely," says Jay Baliga, Progress Energy Distinguished University Professor of the ECE Department at NCSU (Singh's doctoral thesis advisor). "A very small number of experts are chosen for the Hall of Fame, from more than 15,000 ECE alumni," he adds.

The ECE Department formed a "solid foundation for my work in power electronics and the development of the advanced technologies on which the success of GeneSiC was built," commented Singh.

www.ece.ncsu.edu

Transphorm appoints six company leaders

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has appointed six company leaders. The roles are being filled by company veterans as well as newly hired experts. Their collective sales, operations, engineering and product marketing skillsets will contribute to business growth and customer support strategies as Transphorm responds to rapidly rising demand for high-voltage GaN power semiconductors across industries.

"The GaN power semiconductor field is an exciting one, enabling significant efficiency savings with compact, cost-effective power converters and inverters. This challenges engineers and operational leaders alike to think beyond the status quo," says president & COO Primit Parikh. "The team we have assembled to date is comprised of passionate individuals who understand our role in the power electronics industry and deeply value what Transphorm offers customers and ecosystem partners," he adds. "We are proud to have this strong team in place to lead the next phase of growth and innovation."

www.transphormusa.com

● Philip Zuk, appointed to senior VP, business development & marketing, has spent nearly seven years supporting Transphorm in various capacities. He has been instrumental in developing relationships with marquee customers and technical partners; defining products and solutions; and establishing the company's brand image while evangelizing its technology. That knowledge and experience led to him play a key supporting role in taking Transphorm public. He draws on nearly three decades of engineering experience anchored primarily in power semiconductors, having previously held engineering and marketing roles at Vishay (Siliconix), Microsemi PPG, Fairchild Semiconductor, and other major power technology firms.

● Sal Barlett recently joined Transphorm as senior VP, operations. For nearly three decades, he worked for onsemi ,where he most recently led the global capacity, capital planning, and strategy teams. His leadership there enabled the firm to more than double its multi-billion-dollar annual revenue. Among other achievements, he acted as operations leader for various factory acquisitions and divestitures transacted during his tenure. His responsibilities called for consistent exploration and deep analysis of operational needs followed by the development and implementation of processes and supply solutions fundamental to corporate growth.

● Likun Shen, a 15-year Transphorm veteran, has been appointed to VP of engineering. He has previously served in a device and product engineering leadership capacity as well as a senior member of technical staff. His work has contributed to the design, fabrication, characterization and qualification of Transphorm's GaN platform and derivative products. Notably, he led an initiative responsible for improving manufacturing yields while supporting reliability improvement efforts among others. Early in his career, he earned his Ph.D. on GaN devices and held the role of assistant project scientist in the Department of Electrical and Computer Engineering at the University of California, Santa Barbara (UCSB), working directly with Transphorm's co-founder & chief technology officer Umesh Mishra.

● Tushar Dhayagude assumes an expanded role as VP of worldwide sales, having joined in 2021 as VP of field applications & technical sales. He has become an integral member of the company's leadership team, helping to strengthen Transphorm's foothold in the adapter and select high-power markets while aiding solutions partnership development. He brings to this role more than 25 years' experience in sales, marketing and engineering roles (including more than 18 years specific to power and semiconductor technologies). Prior to Transphorm, he was founder & CEO of GV Semiconductor Inc, which produced GaN-on-silicon power HEMTs, controllers and power systems.

● Vipin Bothra joins Transphorm as VP of sales, North America & Europe. With 25 years of global sales and technical experience in semiconductors, he was most recently director, sales for industrial markets at global semiconductor manufacturer STMicroelectronics, where he led the definition and execution of go-to-market strategies for the Aerospace, Automation, Energy, Healthcare and Motion sectors. These strategies drew on a diversified set of disciplines from partnership ideation and channel programs to global market development campaigns which resulted in a multi-fold revenue growth.

● Peter Cheng joins Transphorm as VP of product marketing & applications. His experience spans managerial roles in design engineering and product marketing, most recently as senior director, Power IC Product Line at Alpha and Omega Semiconductor Inc. Overseeing five product groups, he was instrumental in defining new product requirements and application criteria along with developing viable product roadmaps. He has a multi-disciplined background — design engineering, application engineering, product engineering, marketing, and business development — in the power semiconductor industry.

www.transphormusa.com

Transphorm's quarterly growth dips, but product revenue still up 38% year-on-year

Sequential growth of 20–25% to resume next quarter, while epi capacity added

For fiscal second-quarter 2023 (to end-September 2022), Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has reported revenue of $3.67m, down from $5.16m last quarter but up 11% on $3.3m a year ago (excluding the latter's one-time licensing revenue of $8m, making $11.3m in total). Specifically, product revenue was up 38% year-on-year, reflecting another strong quarter from ramping shipments of GaN products for a variety of power conversion applications.

"We continue to maintain our leadership position in high-power GaN, which comprised over 65% of our fiscal Q2 revenue, while winning marquee new designs in fast chargers and adapters, enabled by superior and easy-to-interface SuperGaN FETs," says president, COO & co-founder Primit Parikh.

Highlights of the quarter are:

- improving supply from Japan Epi reactors and completing the acquisition of additional metal-organic chemical vapor deposition (MOCVD) reactors;
- increasing shipments on a previously announced Fortune 100 laptop adapter win, a top-three worldwide laptop manufacturer, and securing a new Fortune 100 laptop adapter design-win;
- strengthening senior operations, sales and marketing teams with the addition of industry leaders;
- securing an ARPA-E program to innovate on Transphorm's unique bi-directional GaN technology (which replaces 2–4 silicon devices with a single FQS GaN in applications like micro-inverters and motor drives);
- securing approval for a Shenzhen, China WFOE (wholly foreign-owned enterprise) to enhance local customer support, sales, field applications and marketing;
- expanding package offerings by adding industry-standard PQFN products (which enable pin-to-pin compatibility with multiple sources), complementing Transphorm's existing high-performance PQFN products — both validated to deliver superior results versus competing GaN.

Non-GAAP operating expenses were $5.1m, up on $4.5m a year ago but cut from $5.4m last quarter.

Net loss was $5.12m ($0.09 per share), compared with $4.55m ($0.08 per share) last quarter and a net profit of $3.62m ($0.09 per share) a year ago. Cash, cash equivalents and restricted cash as of end-September were $34m.

"This quarter saw solid execution and lower operational burn despite reduced revenue," says chief financial officer Cameron McAulay. "The company remains well-positioned with a solid balance sheet to continue to invest in staffing and capital equipment to realize its short- and long-term objectives," he adds.

"We are also executing on our stated plan of increasing capacity, with notable improvements from our Japan Epi reactors, giving us confidence we can better address demand," Parikh says.

"We exceeded our fiscal Q2 revenue target and remain well-positioned to resume revenue growth of 20% sequentially in fiscal Q3, with the opportunity to achieve 25%, despite persistent macroeconomic headwinds," says Parikh. "We continue to aggressively pursue new customer wins and are fulfilling our existing backlog, while managing both internal and external supply chain constraints. With our wide range of product offerings, and notably high-power GaN, we continue to be well-positioned for growth across multiple market segments – including consumer, data centers, blockchain, and industrial. We also continue to pursue near-term opportunities in two-wheel and three-wheel EVs and longer-term opportunities in the automotive EV market," he adds.

www.transphormusa.com

HG begins production of GaN power electronics epiwafers

Hong Kong-based HG Semiconductor Ltd recently began manufacturing its own 6-inch gallium nitride (GaN) power electronics epitaxial wafers, which have hence now officially entered full-scale production. This was far earlier than the expected timetable, as the firm's technical team has capitalized on its experience to debug production facilities and technology in just three months, paving the way to the rapid industrialization and mass production of GaN 'third-generation' semiconductors.

The GaN epiwafer market reached US$420m in 2021, and is projected to rise at a compound annual growth rate (CAGR) of 21.2% from 2022 to US$1.5bn in 2028.

HG reckons that epiwafer making represents a "giant leap" in reaching its goal of mass producing chips. The firm now expects to begin pilot production of chips in second-quarter 2023, followed by mass production by early 2024. Also, in second-half 2022, the firm has launched GaN-related fast-charging products.

www.hg-semiconductor.com

Innoscience completes 650V GaN HEMT range

New 190mΩ, 350mΩ and 600mΩ $R_{DS(on)}$ parts complement 140mΩ, 240mΩ and 500mΩ devices

Innoscience Technology of Suzhou, China has filled out its portfolio of 650V enhancement-mode (E-mode) gallium nitride high-electron-mobility transistors (GaN HEMTs) by adding devices with on-resistances ($R_{DS(on)}$) of 190mΩ, 350mΩ and 600mΩ. Available in industry-standard 8x8 and 5x6 DFN packages, they join the previously announced 140mΩ, 240mΩ and 500mΩ $R_{DS(on)}$ parts.

The 650V HEMTs are all qualified to JEDEC standards for chip and package, and have passed dynamic high-temperature operating life-test (DHTOL) reliability testing according to JEP180 (JEDEC's newly released guidelines dedicated to GaN technology). In addition, Innoscience's 650V HEMTs (InnoGaN) have undergone accelerated life-tests beyond 1000V that give lifetime calculations of 36 years at 80% of the rated voltage (520V; 150°C; 0.01% failure rate).

The new devices also feature very good drain–source voltage transient ($V_{DS,\ transient}$) of 800V for non-repetitive events with an extended pulse time up to 200µs and pulsed ($V_{DS,\ pulsed}$) characteristics for a repetitive pulse up to 100ns of 750V for the 190mΩ $R_{DS(on)}$ parts (claimed to be best-in-class characteristics). Moreover, similarly to the existing 650V products, the new 190mΩ, 350mΩ and 600mΩ $R_{DS(on)}$ devices all feature a strong ESD protection circuit embedded in the die to ease mass-production assembly of these device in package and easy handling.

Possible applications of the new devices include power factor correction (PFC) converters, DC–DC converters, LED drivers, fast battery chargers, notebook and all-in-one (AiO) adaptors and power supplies for desktop PC, TV, power tools etc.

"These new devices complete our 100–600mΩ device portfolio at 650V," notes Yi Sun, senior VP of product development. "I am especially happy to add the 650V/190mΩ, as it is becoming a standard in the GaN industry that offers greater flexibility to customers upon selecting suppliers for their applications."

Because GaN devices do not have a body diode, reverse recovery losses are much less than silicon MOSFETs and the figure of merit (FOM) is much better, notes Innoscience. So, GaN HEMTs (such as Innoscience's new 650V parts) can be used in simple totem-pole configurations for PFC applications, and benefit from the reduced bill-of-materials (BOM) count without incurring the high losses of conventional silicon devices, the firm says. This benefit, combined with the high-frequency capabilities of InnoGaN, helps to reduce the size of passives and results in more compact systems, it adds.

www.innoscience.com

EPC extends packaged GaN FET family to 150V

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits for power management applications — has expanded its range of off-the-shelf GaN FETs in thermally enhanced QFN packages by introducing the 150V EPC2308 designed for motor drives in power tools and robots, high-density DC–DC from/to 80V–100V for industrial applications, synchronous rectification to 28V–54V for chargers, adaptors and power supplies, smartphone USB fast chargers, and in solar optimizers and micro-inverters.

The EPC2308 GaN FET offers a small on-resistance ($R_{DS(on)}$) of just 4.9mΩ typical, together with very small Q_G, Q_{GD} and Q_{OSS} parameters for low conduction and switching losses. The device features a thermally enhanced QFN package with footprint of just 3mm x 5mm, offering an extremely small solution size for the highest-power-density applications.

The package offers wettable flanks to simplify assembly and inspection and exposed top and ultra-low thermal resistances to optimize thermal dissipation through heat-sink for cooler operation.

The EPC2308 is footprint compatible with the previously released 100V, 1.8mΩ EPC2302 and the 100V, 3.8mΩ EPC2306.

"The EPC2308 combines the advantages of 150V GaN with an easy-to-assemble and thermally enhanced QFN package," says CEO & co-founder Alex Lidow. "Designers can use our family of packaged GaN FETs to make smaller and lighter-weight battery-operated BLDC [brushless DC] motor drives for robotics and power tools, higher-efficiency 80V input DC–DC converters, and higher-efficiency USB chargers and power supply."

The EPC90148 development board is a half bridge featuring the EPC2308 GaN FET. It is designed for 150V maximum device voltage and 12A maximum output current. The purpose of this board is to simplify the evaluation process to speed time to market. This 2" x 2" (50.8mm x 50.8mm) board is designed for optimal switching performance and contains all critical components for easy evaluation.

The EPC2308 is priced at $3.75 each in 1000-unit volumes. The EPC90148 development board is $200.

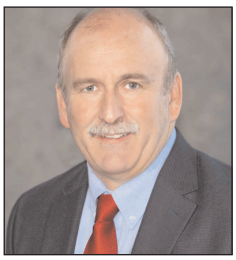
www.epc-co.com

Gallium Semiconductor appoints Rohan Houlden as CEO

Former Akoustis and Qorvo veteran to drive new product development and revenue growth

Singapore-based RF gallium nitride supplier Gallium Semiconductor has appointed Rohan Houlden as chief executive officer, focused on expanding its product offering and driving revenue growth. He succeeds Kin Tan, who will continue to serve as an advisor to the company.

Houlden has over 30 years of industry experience, having served in leadership positions across various semiconductor companies, most recently as chief product officer at Akoustis Technologies, where he led product strategy and product development and played a pivotal role in establishing Akoustis as a high-volume supplier of RF BAW filters for WiFi Access Points, 5G infrastructure, 5G mobile, and other applications.



NGallium Semiconductor's new CEO Rohan Houlden.

Prior to Akoustis, Houlden served as general manager of the Connectivity business unit at Qorvo Inc.

"I am excited for this opportunity to lead Gallium Semi and build upon the foundation that Kin and the team have established," says Houlden. "Together we will forge ahead to deliver industry-leading RF GaN devices and amplifiers that enable our customers in the 5G infrastructure, aerospace & defense, and industrial, scientific & medical (ISM) markets to design high-performance systems," Houlden adds.

"We welcome Rohan to Gallium Semiconductor as a proven builder of successful products and businesses," comments Kin Tan. "We have high confidence that the company will continue to accelerate its position in the growing market for RF GaN semiconductors under his leadership."

www.galliumsemi.com

Gallium Semiconductor unveils new GaN transistor product portfolio

RF power transistors and evaluation boards available for sampling

At European Microwave Week (EuMW 2022) in Milan, Italy (25–30 September), Gallium Semiconductor unveiled its broad portfolio of RF power transistor products.

Specifically, the company showcased a wide variety of GaN solutions for 5G infrastructure, aerospace & defense, public safety, and industrial, scientific & medical (ISM) applications. Product highlights include:

- known good die of GaN devices optimally designed for low thermal resistance and ranging from 10W to 400W of saturated output power;
- unmatched GaN transistors in low-cost plastic DFN packages with high reliability and heat dissipation;
- easy-to-use broadband and pre-matched GaN transistors in air-cavity packages;
- innovative dual-path transistor solutions for 5G networks with excellent digital pre-distortion capability.

The products deliver what is claimed to be optimal performance for output power, gain, efficiency and bandwidth. "Customers continue to demand RF power amplifiers that deliver high performance with high efficiency," says Michael Guyonnet, VP of networks. "Our innovative GaN solutions provide breakthrough performance that customers require for their critical communication, radar and ISM applications."

The new RF power transistors and evaluation boards are currently available for sampling to qualified customers.

www.eumweek.com
www.galliumsemi.com

Cambridge GaN Devices secures $19m in Series B funding round

CGD to begin mass production of ICeGaN transistor family

Fabless semiconductor company Cambridge GaN Devices Ltd (CGD) has raised $19m in a Series B funding round led by Parkwalk Advisors and BGF, with participation from IQ Capital, CIC, Foresight Williams Technology and Martlet Capital. The investment will enable CGD to begin mass production of its range of GaN transistors for power applications.

Spun out of the University of Cambridge Department of Engineering's Electrical Power and Energy Conversion group in 2016 by Dr Giorgia Longobardi and professor Florin Udrea, CGD designs, develops and commercializes power semiconductors products that use gallium nitride (GaN)-on-silicon substrates.

"As we move to a net-zero carbon society with rapidly increasing levels of electrification, we need clean, renewable sources of electricity and more efficient conversion methods. GaN provides the optimum conversion solution, reducing power losses by more than 50% and increasing energy conversion efficiency to above 99%," notes co-founder & CEO Longobardi. "If all data centers were to adopt GaN, this would save 12.4TWh of electricity per year, or 9 million tons of CO_2 — the equivalent of taking 1.9 million internal combustion engines vehicles off the road for a year [according to Eaton, Statkraft 'Data Centers and Decarbonization', October 2021]," she adds. "Our ICeGaN GaN transistors — which are now in the hands of customers at scale — are amongst the most efficient devices of their type on the market. Our devices are also the easiest for designers to use."

CGD has already developed new intellectual property and brought to market its new ICeGaN GaN transistor family, which addresses a $50bn global power semiconductor market. The firm is targeting multiple industries such as consumer and industrial power supplies, lighting, data centers and automotive hybrid electric vehicles (HEV/EV). CGD claims that its technology provides efficient, sustainable and more cost-effective power solutions for electronic equipment.

CGD is leading a $10m European-funded GaNext project developing GaN-based modules for low- and high-power applications; is participating in the P3EP UK supply chain initiative for PCB-embedded power systems with GaN devices. The firm recently launched the ICeData project to develop highly reliable GaN power transistors and ICs to cut data-center emissions. CGD is also focused on key partnerships with their customers focused at datacom and automotive solutions. The firm has completed its brand development, moved to new offices, and now employs over 40 staff worldwide, with more planned to support the up-scaling.

"This latest round of investment is a great recognition of our success to date, with new and existing investors confirming the strength of our technology," says Longobardi. "We are thrilled to be in a position to move to mass production and global supply, delivering devices where our unique technology can have the biggest impact," she adds.

"CGD's technology can play a significant role in the global shift to net zero and it is already making an impact in real-world applications," comments John Pearson, investor at Parkwalk Advisors. "Parkwalk is delighted to be able to continue supporting the company and its impressive and growing team," he adds.

"The commercialization of CGD's technology comes at an important point in time, as we look for technology-enabled solutions to lower power consumption across applications as diverse as phone chargers and data centers," says Ian Lane, investor at CIC. "Cambridge is a globally important hub for semiconductor design and CGD is a great example of the innovation in the cluster," he adds.

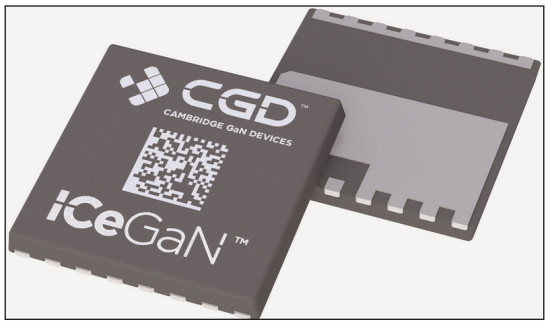
"Imec.IC-link helps companies, academia and emerging start-ups to bring their chip-based innovations to production by providing complete ASIC solutions, including design, access to advanced ASIC foundry technologies, assembly and test & qualification services," says Arnaud Garnier, business development manager at Imec.IC-link. "As a Value Chain Aggregator of TSMC, we supported Cambridge GaN Devices as the first GaN customer in Europe."

www.ganext-project.com

CGD and Neways co-developing GaN-based solar inverters

Fabless semiconductor company Cambridge GaN Devices Ltd (CGD) and Neways Electronics of Eindhoven, The Netherlands (which develops and produces electronics for smart mobility, semiconductor and connectivity solutions) signed an agreement to develop high-efficiency photovoltaic solar inverter products based on gallium nitride technology.

"Neways and CGD are perfectly aligned in our commitment to a sustainable future based on clean tech energy," says CGD co-founder & CEO Longobardi. "This program to jointly develop photovoltaic products that lead the world in terms of efficiency and performance will move the market forward," she believes.



"Neways is committed to working with like-minded innovative companies to bring state-of-the-art, sustainable energy solutions to the market," says Neways Electronics' chief technology officer Hans Ketelaars. "The combination of Neways' extensive systems experience and CGD's high-efficiency, rugged and simple-to-use GaN devices is a perfect fit for this application."

Forged after the two companies met while collaborating on the European-funded GaNext project, the partnership has already borne fruit. At Electronica 2022 in Munich, Germany (15–18 November), both firm's booths demoed a 3kW photovoltaic inverter jointly developed by the two companies. Using eight CGD65A055S2 GaN transistors, the transformer-less, ultra-compact design achieves a power density of 1kW/L. With a V_{in} of 150–350V_{DC}, a V_{out} of 230V_{AC} and a switching frequency 350kHz, the design has a maximum efficiency of 99.22%.

www.neweyselectronics.com

CGD's ICeGaN HEMTs available in high volume

Monolithic GaN HEMTs drive like silicon, reduce BOM count, and deliver class-leading reliability

Fabless semiconductor company Cambridge GaN Devices Ltd (CGD) says that its IceGaN smart high-electron-mobility transistor (HEMT) monolithically integrated power solutions are now available for volume shipment. What is said to be the industry's first easy-to-use and scalable 650V GaN HEMT family is also expected to be verified as the industry's most rugged GaN platform.

"The principal values of GaN have been understood for a long time," notes co-founder & CEO Longobardi. "Cambridge GaN Devices' contribution has been to innovate the easiest-to-use, most reliable devices so that design engineers can take advantage of the efficiency benefits offered by GaN, and deliver products and systems that contribute to a sustainable world."

Unlike other discrete or hybrid solutions, CGD's IceGaN HEMTs are fully integrated GaN-only devices, leading to several key advantages, First, devices are stable, reliable and simple to drive, using an internal GaN interface attached to the gate. Devices also exhibit high V_{th} performance of about 3V, eliminating the risk of damage at turn-on, and are available in an extended voltage range of up to 20V. Also, current sensing, a Miller clamp for safe turn-off and gate protection, and integrated ESD protection are included on-chip. Finally, there is no negative voltage requirement, which avoids potential problems of dynamic $R_{DS(on)}$ degradation over time.

Compared with other GaN devices, designers of low-side and half-bridge topologies can use standard silicon gate drivers and reduce the bill-of-materials (BOM) count.

Available now in production-order quantities and through distribution, ICeGaN HEMTs have a unique set of intrinsic capabilities that elevate device reliability well above current state-of-the-art GaN competition, CGD claims. This is due to the higher voltage threshold and higher voltage range, stronger gate voltage clamping action at lower temperatures, high gate over-voltage margin and higher dV/dt and dI/dt immunity. Less exposure to dynamic Ron stress, DC voltage flexibility (9–20V) and a high-efficiency current sense also contribute to what is claimed to be industry-leading device ruggedness.

"Our mission is to make deciding to use and implement high-efficiency, sustainable solutions the obvious choice," says Longobardi. "We aim to deliver on four key values: sustainability, knowledge, innovation and collaboration. The IceGaN smart HEMT family of monolithically integrated power solutions is the realization of our goals to date, and customers have told us how easy they are to employ, one user explaining that 'CGD's GaN can work on our 65W system and support high gate drive voltage — just like silicon'," she adds.

www.camgandevices.com

SweGaN's €12m Series A to fund capacity expansion

SweGaN AB of Linköping, Sweden, which makes custom gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers (based on a unique growth technology) for telecom, satellite, defense and power electronics applications, has completed a Series A financing round totaling SEK125m (€12m). The financing was co-led by Intertech Ventures, Mount Wilson Ventures and European investor Atlantic Bridge, with participation by STOAF of Sweden and global fabless semiconductor firm MediaTek, forming a global network spanning the USA, Taiwan and Europe. Fred Chang of InterTech Ventures, David Lam of Atlantic Bridge and semiconductor manufacturing executive Walter Wohlmuth have joined the board.

SweGaN reckons that performance of its GaN epitaxy process opens up new applications in the multi-billion-dollar GaN-based radio frequency (RF) and power markets. Powered by its patented QuanFINE buffer-free GaN-on-SiC epiwafers, customers can reach levels of device performance and reliability previously unachievable with conventional materials available on the market, it is claimed. The firm has over 30 paying clients and is in qualification for applications in Europe, the USA and Asia.

The investment allows SweGaN to significantly increase production capacity to meet demand from major suppliers of 5G base-stations, defense radars, low-orbit satellite communications and on-board chargers in electric vehicles (EVs). Also, the financing empowers the firm's plans to expand its executive team and to boost engineering, sales and production staff.

In conjunction, from 1 September, chief technology officer Jr-Tai 'Ted' Chen (who co-founded SweGaN in 2014 and invented its proprietary QuanFINE technology) has been appointed CEO, replacing chairman Jonas Nilsson (interim CEO since fall 2020).

"I look forward to our continued work together to fulfill SweGaN's strategy, vision and future-oriented goals for serving the industry with the best GaN-on-SiC technology available on the market," says Nilsson. "Since starting SweGaN, Ted has displayed remarkable determination, passion and professional growth, and he is well equipped to lead SweGaN's in this next chapter of its journey to become a dominant player in the GaN-on-SiC market," he adds.

"As we move from silicon to the third wave of semiconductor materials, GaN and SiC are poised to dominate," believes David Lam, general partner at Atlantic Bridge. "SweGaN's revolutionary GaN-on-SiC technology brings together these two key materials to enable RF and power performance characteristics that are simply impossible to achieve today," he adds.

"This strategic financing round enables us to lift SweGaN to the next level and beyond in our growth journey and positions us to execute on the SweGaN vision and strategy," says Jr-Tai Chen. "To meet explosive market demand, SweGaN's roadmap targets building of new production facilities and expanding our team to deliver of tens of thousands of epiwafers annually," he adds.

"We are thrilled to welcome seasoned semiconductor investor Atlantic Bridge and global fabless semiconductor leader MediaTek as investors," comments Richard Weil, general partner at Mount Wilson. "We have been delighted to support SweGaN through the early stages of development and commercialization of its industry-leading epitaxial technology. Now, with this financing, SweGaN has access to the financial resources and industry experience required to scale to the next level."

www.swegan.se

SweGaN adds chief operating officer as it scales up

SweGaN has added a new role to its executive team by appointing Henrik Tölander as chief operating officer to support its growth strategy to serve what it describes as explosive global market demand.

"Bringing extensive experience from the manufacturing industry, including nearly a decade at Fortune 500 company Siemens, Henrik will bring valuable competence for cultivating and executing the next phases of SweGaN's manufacturing roadmap and expansion plans," says CEO Jr-Tai 'Ted' Chen. "We have secured the industry and leadership experience needed to scale SweGaN manufacturing to the next level," he adds.

"SweGaN growth plans target new production facilities and team expansion to deliver large quantities of epiwafers annually to supply a demanding and sophisticated semiconductor market," notes Tölander. "I am inspired by what CEO and co-founder Ted Chen and the skilled team at SweGaN have achieved in developing world-class materials and a high-profile international investor portfolio."

As an experienced COO and industrialization executive, Tölander has a background in gas turbine manufacturing, engineering management, control systems design, and has held overall responsibility for CapEx portfolios aimed at developing and expanding advanced additive manufacturing capabilities. Other experience includes developing and maintaining technology and hardware strategies, component and capital investment forecasting, planning and implementing production for additive manufacturing, and building and managing productive, efficient and profitable production facilities. His roles include leading an international cross-business unit.

France's DIAMFAB moves to new dual business model strategy

CNRS spin-off to sell technology directly and through application-oriented strategic partnerships and alliances

DIAMFAB of Grenoble, France — which was spun off from France's National Centre for Scientific Research (CNRS) in March 2019 to synthesize and dope diamond semiconductor epilayers — is moving to a new dual business model strategy under which it will sell its technology directly and through application-oriented strategic partnerships and alliances.

The strategy is designed to achieve a scalable go-to-market model implemented through a mix of in-house capabilities and an extended partner ecosystem based on co-development. "Over the past two years, we have made significant progress working with R&D teams to process high-value-added diamond wafers," says CEO Gauthier Chicot. "Our application-oriented approach based on a dual business model will now allow us to work with a broader set of industrial partners, to develop and sell high-value-added diamond wafers and our patented diamond devices manufacturing processes, while also selling directly to end-users with a fab-light model," he adds.

DIAMFAB has already started to work with partners on the design and fabrication of high-performance devices including diodes, transistors, capacitors, quantum sensors and high-energy detectors. The company's first market is capacitors for electrical vehicles (EVs), where the advantages of diamond semiconductors over actual capacitor technologies show tremendous potential for improving compactness and performance over the lifetime of a vehicle. "We have already filed a patent on an all-diamond capacitor and are collaborating with a leading player in this field," says Chicot. "Among other parameters, we have achieved our targets: a high current density of over 1000A/cm^2 and a breakdown electric field larger than 7.7MV/cm. These are key parameters for the performances of future devices and are already superior to what existing materials like silicon carbide (SiC) can provide for power electronics," he adds. "Moreover, we have a clear roadmap to reach 4-inch wafers by 2025 as a key enabler for mass production."

Diamond has the potential to be the ultimate semiconductor due to its electrical properties (5000 higher current density and 30 times higher voltage than silicon) and its ability to operate in harsh environments (high temperature and radiation). DIAMFAB says its patented approach to growing synthetic diamond ranging from a few nanometers in thickness to tens of microns is unique.

DIAMFAB diamond wafers can be used for insulator, semiconductor, metallic and superconductive conduction applications. In automotive applications, the wafers could allow the fabrication of 80% lighter and more compact power converters, it is reckoned. In power grid applications, they could also more easily handle higher voltage and reduce energy losses ten-fold compared with silicon, the firm adds.

Applications range from EVs with diamond power electronics devices to IoT with 20 years long-life battery, to nuclear and spatial applications with hardened electronics or detectors in healthcare, and even ultra-precise quantum sensors for AVs.

www.diamfab.com

Ampleon showcases new 700W L-band GaN-SiC HEMT

At European Microwave Week (EuMW 2022) in Milan, Italy (27–29 September), Ampleon Netherlands B.V. of Nijmegen, The Netherlands showcased its latest solutions and products in gallium nitride (GaN) and LDMOS technologies, including those targeting wireless infrastructure, avionics/defence, non-cellular communication, cooking/defrosting, and industrial, scientific & medical (ISM)-related applications.

A key highlight is the new CLL3H0914L-700 gallium nitride on silicon carbide (GaN-SiC) high-electron-mobility transistor (HEMT). This rugged GaN transistor is optimized for radar implementations where long pulse width and high duty cycles are required. The transistor was engineered to achieve over 700W of peak output power from a single transistor while operating at a voltage of 50V with industry-leading efficiency of over 70% as well as designed thermally for long-pulse applications, such as pulse widths (~2ms) and 20% duty cycles.

The L-band GaN HEMT's superior performance capabilities are demonstrated in a variety of application reference designs shown at the booth, including ones for defence/aerospace bands (960–1250MHz and 1030–1090MHz) plus an L-band ground base radar (1200–1400MHz).

The CLL3H0914LS-700 high-power-density and low-thermal-resistance HEMT is now in full volume production. Units are available directly from Ampleon or authorized distribution partners RFMW and Digi-Key. Large-signal models in ADS and MWO can be sourced via Ampleon's website.

www.ampleon.com

Aehr enhances FOX-P wafer-level test & burn-in systems for silicon carbide and gallium nitride

Bipolar Voltage Channel Module and Very High Voltage Channel Module options added

Semiconductor test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has released two new enhancements for its FOX-P family of wafer-level test and burn-in systems — the FOX Bipolar Voltage Channel Module (BVCM) and Very High Voltage Channel Module (VHVCM) options — which enable advanced capabilities for silicon carbide (SiC) and gallium nitride (GaN) power semiconductors.

SiC power devices and modules are being widely adopted in the drive train used in electric vehicles (EVs) as well as on-board and off-board electric vehicle chargers. GaN-based semiconductors are at the early stages of their application usage, but are expected to grow significantly in their use in a wide range of power conversion applications including photovoltaic, industrial and other electrification infrastructure applications. The new capabilities allow silicon carbide and gallium nitride semiconductor manufacturers more flexibility to address a wider variety of stress and burn-in conditions to address their engineering qualification and production needs in FOX-P multi-wafer test and burn-in systems. These options are available with new system shipments or for upgrades of previously shipped FOX-P systems, with first shipments planned with typical 12–16 week lead times.

The Bipolar Voltage Channel Module (BVCM) provides a wide range of bipolar voltage programmability from +40V to −30V applied to the gate for positive high-temperature gate bias (HTGB) or negative HTGB testing. The BVCM can supply gate bias voltage to more than 3000 die per wafer while capable of monitoring individual die performance. The BVCM, in combination with Aehr's proprietary WaferPak full-wafer contactors, are said to deliver a unique capability benefitting power silicon carbide diodes and MOSFETs and both E-mode and D-mode gallium nitride power MOSFET manufacturers. Enabling these tests are particularly essential in threshold voltage (V_{th}) and gate oxide stabilization and screening.

The Very High Voltage Channel Module (VHVCM) enables customers to perform high-temperature reverse bias (HTRB) testing on wafers at up to 2000V on MOSFETs and diodes and measure individual device leakage current. Aehr's proprietary WaferPak contactor implements arcing mitigation technology to alleviate high-voltage arcing on the wafer, especially with fine-pitch die-to-die geometries. A full-wafer HTRB stress test on silicon carbide or gallium nitride technology can be applied up to 2000V in a single touchdown.

The modularity of the FOX-P system offers the ability to configure solutions to provide advanced test capabilities for their power electronic device wafers. These advanced capabilities enable manufacturers to ship products with higher reliability and parametric stability necessitated by an electric vehicle's traction inverters and on-board chargers. Test and burn-in at wafer level ensures better control of yield loss and improved product reliability. Ultimately, consumers benefit from higher reliability and lower costs.

"Aehr has engaged with a significant number of silicon carbide and gallium nitride semiconductor suppliers from across the world, multiple power semiconductor experts from academia, as well as direct contact with automotive tier-1 module suppliers and automotive drive train and photovoltaic inverter manufacturers," says president & CEO Gayn Erickson. "Based on input from this wide range of manufacturers, module suppliers and purchasers of these devices, we are extending our FOX-P wafer-level test and burn-in platform to provide additional new engineering and production solutions featuring these options with up to 18 wafers to be tested in parallel at the same time. By testing and burning in the devices in wafer form, this significantly lowers the cost of test as well as allows these companies to weed out early life failures that otherwise would show up in packaged or even more costly in multi-chip module form," he adds.

"In addition to the obvious cost advantage of removing these device failures before they are put into a module with many other devices, companies also want to stabilize the inherent early life drift of the threshold voltages (V_{th}) observed in silicon carbide MOSFETs and then select devices with matching threshold voltages to be put in multi-chip modules," Erickson continues. "Feedback from current and a number of new potential customers has been very positive, and we have already taken orders for both systems and WaferPaks for these new options. This includes a new major silicon carbide customer announced last month, and another brand-new customer who just this week ordered WaferPaks for a planned FOX-P system purchase from us for their silicon carbide products. We expect these new enhancements to drive incremental bookings and revenue for our FOX-NP systems for new product introduction and engineering qualification needs as well as our FOX-XP multi-wafer systems to be used for high-volume production with these new features."

www.aehr.com

Indium Corp promotes Sze Pei Lim to senior global product manager, Semiconductor & Advanced Materials

Regional product manager for Semiconductor promoted

Indium Corp of Clinton, NY, USA has promoted Sze Pei Lim to the role of senior global product manager, Semiconductor and Advanced Materials.

The firm refines, smelts, manufactures and supplies materials to the global electronics, semiconductor, thin-film and thermal management markets. Products include solders and fluxes; brazes; thermal interface materials; sputtering targets; indium, gallium, germanium and tin metals and inorganic compounds; and NanoFoil.

Lim leads all aspects of the global Semiconductor and Advanced Materials product line, including the strategic planning, product line roadmaps, promotional activities, pricing, and channel development. She works closely with R&D, engineering, manufacturing, sales and technical support teams around the world to develop and grow Indium Corp's offerings.

Senior global product manager Sze Pei Lim.

Lim is a task force member of the International Electronics Manufacturing Initiative (iNEMI) Packaging Technology Integration Group and has co-chaired a number of industry projects and roadmapping initiatives over the past five years. She is on the executive committee of the Institute of Electrical and Electronics Engineers (IEEE) Electronics Packaging Society Malaysia Chapter, serving as secretary for the past two years. She is also part of the organizing committee for the International Electronics Manufacturing Technology (IEMT). She has authored a number of technical papers and has presented regularly in various international technical conferences. In addition to English and Malay, she speaks fluent Mandarin and has been instrumental in developing Indium Corp's Chinese semiconductor business and team.

Lim joined Indium Corp in 2007 as an area technical manager, based in Kuala Lumpur, Malaysia, where she developed the Southeast Asia Technical Support team. She was promoted to technical manager (SEA) in 2013 and began her role as a regional product manager for Semiconductor in 2015. She holds a bachelor's degree from the National University of Singapore, where she majored in industrial chemistry with a focus in polymers.

www.indium.com

IQE signs three-year wireless epi supply deal with AWSC

New deal builds on 20 year partnership

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has signed a multi-year agreement with compound semiconductor wafer foundry Advanced Wireless Semiconductor Company (AWSC) for the supply of epiwafers for wireless applications.

AWSC has been a partner of IQE for over 20 years. This three-year supply agreement covers epitaxial wafers spanning a range of AWSC's wireless products, including those that enable 4G and 5G mobile handsets and WiFi products.

IQE says that the agreement provides it with diversification opportunities into mass-market power amplifier products. IQE and AWSC will also partner on the design and development of solutions for next-generation wireless applications.

"This strategic partnership agreement, our first with AWSC, represents IQE's new approach to business," says IQE's CEO Americo Lemos. "AWSC and IQE are building upon our long-standing relationship to accelerate innovation by bringing new solutions to serve the growing markets of smart connected devices and automotive," he adds.

From left to right: Simon Dann (IQE Taiwan general manager), Kevin Huang (IQE APAC sales VP), Kooky Xue (AWSC sales & marketing manager), Americo Lemos (IQE CEO), Eric Huang (AWSC president), Chi Hsieh (IQE Taiwan chairman) and Wesley Huang (IQE Taiwan senior advisor).

"At AWSC, we continuously work on process improvement and new technology development to meet our customers' requirements," says AWSC's president Eric Huang. "Our partnership with IQE enables us to create leading-edge solutions and to transition them seamlessly to volume production," he adds. "We are happy to extend and expand our relationship with IQE."

www.awsc.com.tw

IQE announces multi-year high-volume VCSEL supply deal with global consumer electronics firm

Agreement includes joint R&D on next-generation 3D sensing technologies and applications

Compound semiconductor epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has announced the signing of a multi-year strategic agreement with a global consumer electronics leader based in Asia.

The agreement is focused on the high-volume production of vertical-cavity surface-emitting lasers (VCSELs) for advanced 3D sensing applications. The parties are also engaged in joint research and development for next-generation sensing technologies and use cases.

"This agreement marks the start of a long-term strategic relationship between two industry leaders," says IQE's CEO Americo Lemos. "At IQE we have demonstrated our ability to deliver unparalleled levels of innovation, scale and quality over the history of our VCSEL production," he adds. "To secure this partnership with a consumer electronics company of this calibre reaffirms our position as the leading global vendor of VCSEL products to the semiconductor industry."

www.iqep.com

IQE collaborating with SK siltron on GaN epi for Asia

Focus on GaN-on-SiC for RF wireless & GaN-on-Si for power electronics

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has entered into a strategic collaboration agreement with silicon wafer supplier SK siltron of Gumi, South Korea (an affiliate company of Seoul-based SK Group, South Korea's third-largest conglomerate) for the development and commercialization of compound semiconductor products.

The agreement formalizes a strategic agreement to develop business in the Asia market, leveraging SK siltron's substrate expertise with IQE's epitaxy capabilities.

IQE and SK siltron will focus on developing and delivering epiwafers based upon gallium nitride (GaN) on silicon carbide (SiC) for radio frequency applications in the wireless communications market (e.g. high-performance 5G networks, including massive MiMo base stations) and GaN on silicon (Si) for power electronics applications across a range of markets (e.g. automotive, consumer and industrial). Combined, these markets represent a multi-billion-dollar opportunity for GaN devices and are forecast for strong growth in consumer, telecom and automotive applications.

"There are tremendous synergies between IQE's GaN pedigree and SK siltron's substrate offerings, and we will leverage these to bring innovative solutions to market," says IQE's CEO Americo Lemos. "Expansion in Asia is a key focus for IQE and we are excited to be partnering with a globally recognised leader in advanced materials," he adds.

"Two world leaders in advanced materials are joining forces to jointly develop products for exciting growth markets related to GaN materials," says SK siltron's CEO Yongho Jang. "I am looking forward to building considerable success with IQE and developing the relationship to cover a broad range of semiconductor materials."

www.sksiltron.com
www.iqep.com

HexaTech investment accelerates 100mm AlN substrate program

Program targets commercial opto and power/RF device needs

HexaTech Inc of Morrisville, NC, USA (a subsidiary of Stanley Electric Co Ltd of Tokyo, Japan) says that its 100mm-diameter single-crystal aluminium nitride (AlN) substrate product development program, which has been in the early stages of development over the last year, is being accelerated through a significant investment in human resource and capital expenditures, addressing all areas of the manufacturing process (from crystal growth through polishing). Claiming to be the world's leading commercial supplier of single-crystal physical vapor transport (PVT)-grown AlN substrates, HexaTech aims to continue to drive product performance and production scale.

"The 100mm-diameter AlN product in development is targeted at supporting the rapidly expanding deep UV optoelectronic commercial market, as well as the needs of the nascent AlN-based power and RF device development efforts," notes Gregory Mills, VP of business development. "This capability will deliver not only a dramatic improvement in price per unit area, allowing for lower device costs, but will integrate well with established customer fabrication lines already operating at 100mm," he adds.

"HexaTech's history of developing and delivering AlN material with industry-leading structural and surface quality serves as a reliable foundation for scaling our AlN PVT growth process to larger diameters, while maintaining our established quality standards," says co-founder & chief technology officer Dr Raoul Schlesser. "Based on our proven technology, we fully expect to sustain these capabilities as we move towards a 100mm product," he adds.

"With this strategic program focused on substrate diameter expansion, coupled with the substantial financial investment to support it, HexaTech once again demonstrates its commitment to advance the state-of-the-art in AlN substrate technology," says CEO John Goehrke.

All of HexaTech's 2-inch-diameter products, including its full range of deep UV transparent substrate products, are available now with standard lead times.

www.hexatechinc.com

Veeco's new integrated MBE and ALD system chosen for hybrid GaN deposition research

Veeco Instruments has received an order from Justus Liebig University Giessen in Germany for an integrated GENxplor R&D molecular beam epitaxy (MBE) and Fiji atomic layer deposition (ALD) system.

The GENxplor MBE system enables the epitaxial growth of high-quality materials for III–nitride semiconductors for photonic and electronic applications focusing on material research and the development of cubic gallium nitride (GaN) material. This dual platform allows for in-vacuum wafer transfer from the GENxplor system to the plasma-enhanced Fiji ALD system and back, and will further enable research breakthroughs for applications such as micro-LEDs, optical memory and next-generation materials for photocatalysis and water splitting.

According to professor Sangam Chatterjee, head of the University of Giessen Spectroscopy and Optics Group, the integrated GENxplor and Fiji systems were chosen because of Veeco's process and system design expertise. "The decision to partner with Veeco was based on their knowledge of the epitaxial process and their ability to realize an innovative solution that enables

our research," says Chatterjee. "This gives my team confidence that working with Veeco will make our research go beyond established optoelectronics, developing new materials for photocatalysis towards the pressing goals of realizing regenerative energy production and storage."

The GENxplor system deposits high-quality epitaxial layers on substrates up to 3-inch in diameter. The Fiji ALD system is a thin-film next-generation ALD system capable of performing thermal and plasma-enhanced deposition in a modular, high-vacuum, flexible architecture that accommodates a wide range of deposition modes using multiple configurations of precursors and plasma gases. The system's intuitive interface is said to make it easy to monitor and change recipes and processes as required by customers.

"We have seen great interest in combining our proven MBE and ALD technologies to advance semiconductor device performance and this platform, delivered to professor Chatterjee, exemplifies our ability to create novel solutions that allow our customers to solve difficult material challenges," says Ganesh Sundaram Ph.D., Veeco's VP of research & engineering technology.

The research initiative at the University of Giessen is being supported by the European Union and the European Regional Development Fund. The goal of this development fund is to strengthen economic, social and territorial cohesion in the EU by correcting imbalances between its regions.

www.veeco.com

Veeco appoints general manager of KLA's pattern inspection process control division to board

Epitaxial deposition and process equipment maker Veeco Instruments of Plainview, NY, USA has appointed Lena Nicolaides Ph.D. to its board of directors. The firm says that, as well as her industry experience and leadership qualities, Nicolaides was identified through a search process in connection with the board's desire for increased diversity.

Nicolaides is senior VP & general manager of a pattern inspection process control division at KLA Corp. At KLA, she has served in a range of executive leadership and general management roles, including roles in technology supply chain. Prior to joining KLA, Nicolaides was VP of marketing & applications for Therma Wave Inc (acquired by KLA in 2007). She has 38 issued US patents in semiconductor and related fields. Nicolaides holds a Bachelor of Mechanical Engineering degree from Rutgers University and, from the University of Toronto, a Masters degree and a Ph.D., both in Mechanical Engineering.

"Dr Nicolaides brings exceptional technology and industry experience to Veeco's board that includes more than 20 years of leadership experience in semiconductor capital equipment," comments CEO Bill Miller. "Her appointment is of significant importance as we leverage her industry background and perspective," he adds. "Lena's appointment also reflects the board's continuing interest in increased diversity. I am confident that Lena's appointment will enhance our board and is in the best interests of our shareholders."

Riber's revenue halves in Q3, impacted by difficulties sourcing electronic components

Order book almost doubles to €39.1m

For third-quarter 2022, Riber S.A. of Bezons, France — which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells — has reported revenue of €3m, more than halving from €6.8m in Q2/2022 and €6.6m a year ago.

For the first nine months of 2022 (to end-September), revenue was €12.2m (56% of which came from Asia, 37% from Europe, and 7% from North America). This is down 23% year-on-year from €15.8m for the first nine months of 2021.

Specifically, MBE Systems revenue halved, from €7.5m to €3.7m, due to the postponement of the delivery of two systems to fourth-quarter 2022 in the context of difficulties sourcing electronic components.

However, Services & Accessories revenue grew by 2% from €8.3m to €8.5m, confirming the positive trend for research and production MBE activities.

Order book up 93% year-on-year

Following the positive trend for order intake in first-half 2022, Riber says that it has consolidated its position on the market during Q3/2022, confirming four system orders (including two production systems) while continuing to focus its development on services & accessories.

The order book at end-September was hence €39.1m, up 93% on €20.3m a year previously.

Specifically, the order book for Services & Accessories remains €7.7m (the same as a year ago). However, the Systems order book has grown by 149% from just €12.6m to €31.4m, comprising six production and eight research systems in 2022 (compared with two production systems and five research systems in 2021). Also, this does not include (1) the order announced on 25 October for one research system and (2) the option to buy (announced on 8 June) covering four production systems (for which firm orders will be confirmed in 2023 when the export license is obtained).

Riber says that the current large order book already ensures strong growth in 2023 revenue to over €40m (compared with €31.2m). It adds that, in a dynamic market environment with strong demand for systems, it expects to continue taking orders during fourth-quarter 2022.

www.riber.com

Aixtron shipment pushouts in Q3/2022 to lead to record revenue in Q4

Booming GaN and SiC power electronics drive full-year 2022 order and margin guidance upgrade

For the first nine months of the year, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported revenue growth of 13% year-on-year, from €248.1m in 2021 to €279.9m in 2022 (with 78% coming from equipment sales and 22% from after-sales service & spare parts).

Of the equipment revenue, metal-organic chemical vapor deposition (MOCVD)/chemical vapor deposition (CVD) equipment for making gallium nitride (GaN)-based and silicon carbide (SiC)-based power electronics devices comprised 37% (with SiC growing strongly); MOCVD equipment for making optoelectronics devices (telecoms/datacoms and 3D sensing lasers for consumer electronics, solar, and wireless/RF communications) comprised 36% (with optical data transmission and 5G applications growing strongly); and MOCVD equipment for making LEDs comprised just 25% (mainly traditional red LEDs, but also micro-LED applications).

On a regional basis, 66% of revenue came from the Asia region (roughly the same year-on-year), 17% from the Americas region (up from 10%), and just 16% from Europe (down from 23%).

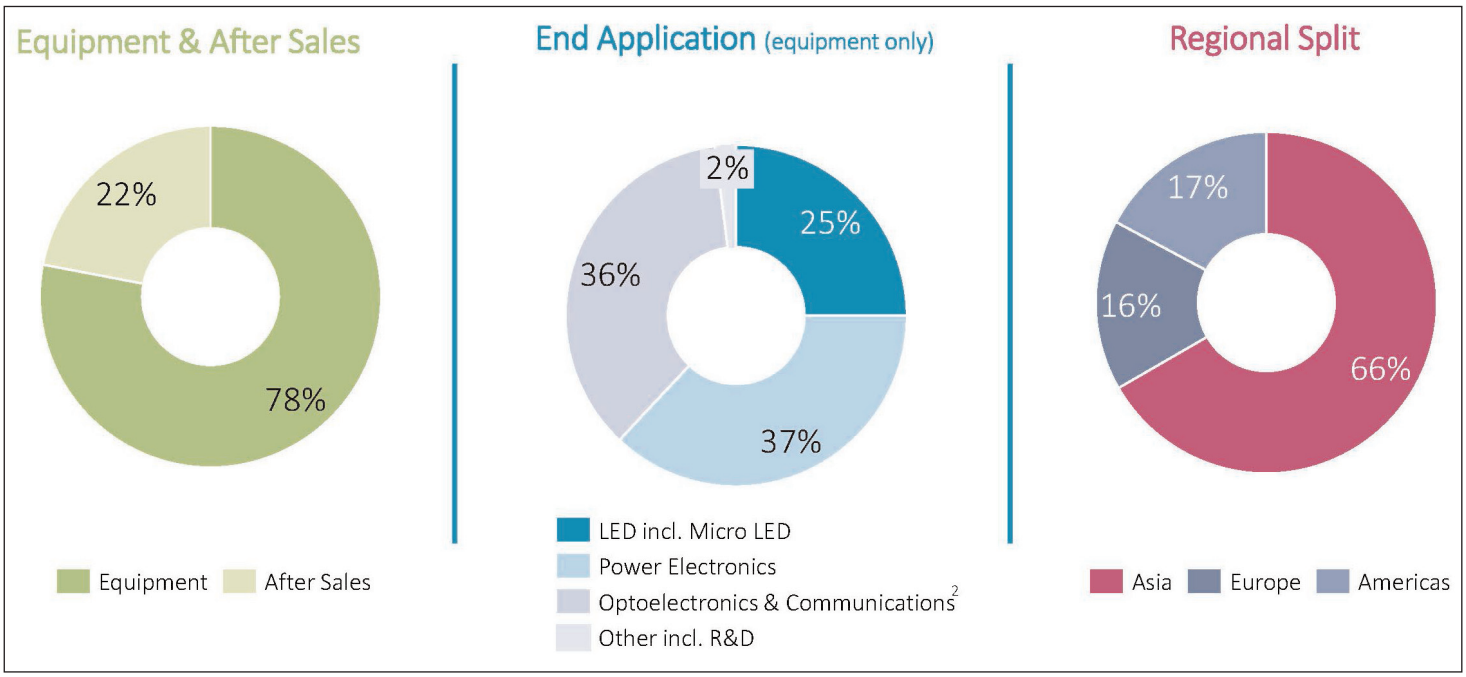
Third-quarter 2022 revenue was just €88.9m, down 13.3% on €102.5m in Q2/2022 and 32% on €130.8m a year ago. However, this was due mainly to a few customer-related delivery delays (shifting some tool deliveries into Q4/2022) and delays to the granting of export licenses. Over half of revenue came from equipment for manufacturing GaN and SiC power electronics. Sales of systems for manufacturing lasers (in particular for optical data transmission and 3D sensor technology) were also described as strong.

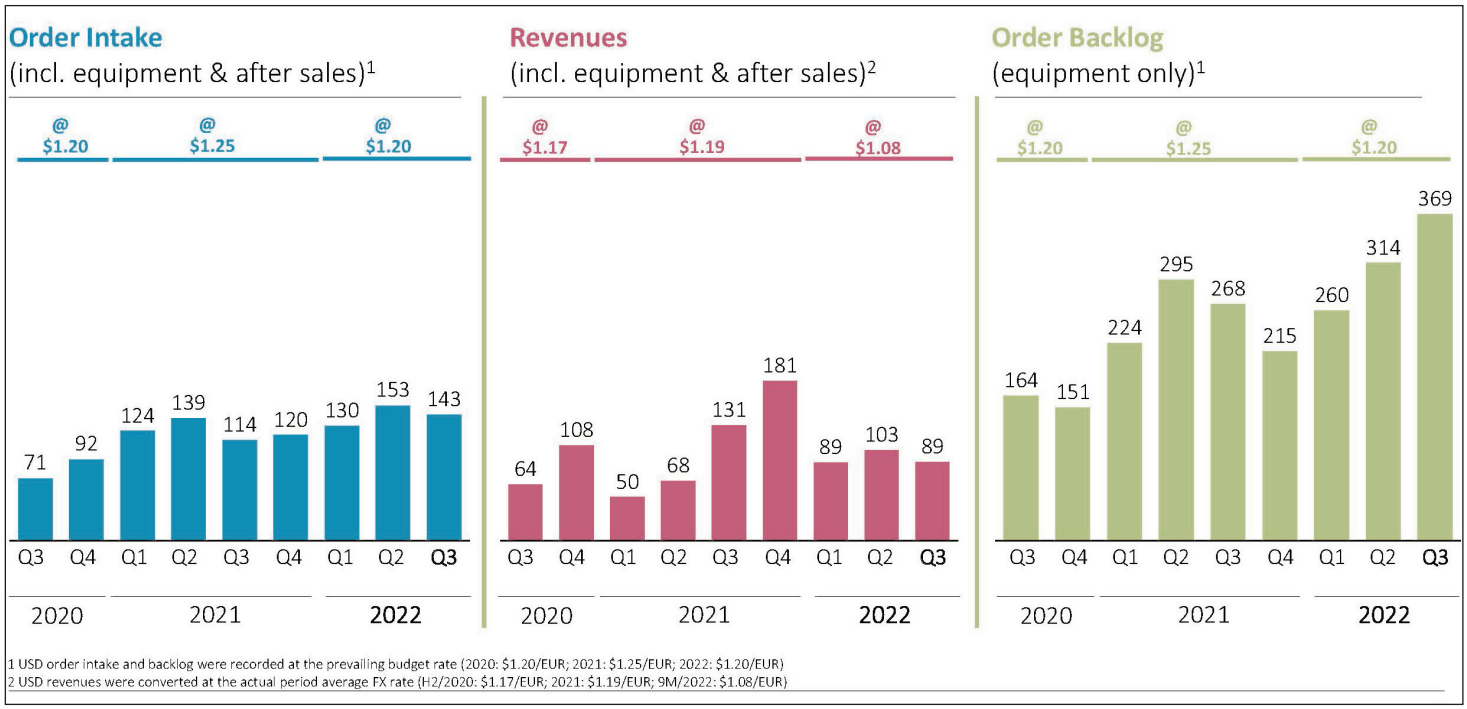
Gross margin for the first nine months of 2022 was 40%, down slightly year-on-year from 41%. However, Q3/2022 gross margin was 44%, up from 37% last quarter and 43% a year ago, due mainly to improved product mix.

Operating expenses have risen further, from €20.1m in Q3/2021 and €20.6m in Q2/2022 to €23.1m in Q3/2022, contributing to €65.4m in the first nine months of 2022 (up year-on-year from €60.3m), due to higher variable compensation components and lower R&D grants.

Operating profit (EBIT, earnings before interest and taxes) improved to €47.6m in the first nine months from €41.1m a year previously, with EBIT margin remaining 17% of revenue. However, Q3/2022 EBIT of €16.2m was down from Q2/2022's €17.2m and Q3/2021's €36.2m (with margin of 18% down from 28% a year ago).

Net profit in Q3/2022 was €19.1m (€0.28 per share, or 21% of revenue), down on €31.4m (€0.39 per share, 24% of revenue) a year ago. However, this is up on €17.3m (€0.16 per share, 17% of revenue) last quarter. Net profit for the first nine months of 2022 was €50.2m (€0.45 per share, 18% of revenue), up from €42.9m (€0.17 per share, 17% of revenue) a year ago.





1 USD order intake and backlog were recorded at the prevailing budget rate (2020: $1.20/EUR; 2021: $1.25/EUR; 2022: $1.20/EUR)
2 USD revenues were converted at the actual period average FX rate (H2/2020: $1.17/EUR; 2021: $1.19/EUR; 9M/2022: $1.08/EUR)

Operating cash flow now positive

Operating cash flow has improved from –€27.6m in Q2/2022 to €0.5m in Q3/2022.

Capital expenditure (CapEx) has almost doubled from €4.2m in Q2/2022 to €8m in Q3/2022 (contributing to CapEx for the first nine months of the year rising from €13.3m for 2021 to €16.9m for 2022), largely investments in new-generation MOCVD tools.

Free cash flow was hence –€7.5m in Q3/2022, but this is a significant improvement on –€19m in Q3/2021 due to higher advance payments from customers. For the first nine months of 2022, free cash flow was €19m, due mainly to the high cash inflow from receivables.

Due to the push-out of shipments from Q3 and in preparation for the exceptionally high shipments expected in Q4/2022, inventories have risen to risen further, from €161.6m at the end of June to €209.2m at the end of September.

However, the increase in inventories was outweighed by a further rise in advance payments received for customer orders, from €103.7m at the end of June to €121.8m at the end of September (almost a third of the order backlog).

Overall, cash and cash equivalents (including financial assets) has fallen further, from €352.5m at the end of December and €346.2m at the end of June to €339.2m at the end of September, but this is due largely to the dividend payment of €33.7m agreed at the annual general meeting (AGM) of shareholders on 25 May (a payout ratio of 35% of the firm's net income).

Aixtron says that its financial strength is underlined by its high equity ratio of 75% at the end of September. Meanwhile, staffing has risen to 842 at the end of September, up 9% from 772 at the end of June and 19% on 710 a year previously, so structural strengthening of the organization for further growth is reckoned to be well on track.

Q3 order intake up 25% year-on-year, driven by GaN- and SiC-based power electronics

Order intake in the first nine months of the year rose by about 13% year-on-year from €377.6m for 2021 to €425.6m in 2022, including €142.8m in Q3, up 25% on €114.2m in Q3/2021. This reflects "consistently high demand" for efficient GaN- and SiC-based power electronics (with the new-generation G10-SiC fully automated multi-wafer (9x6" or 6x8") batch CVD system — launched just in mid-September — already comprising the single largest contribution in Q3, followed by GaN), as well as demand for lasers and LEDs (including micro-LEDs).

The G10-SiC is the first member of the new series family that we are launching. Also for GaN power electronics and for GaAs lasers and micro-LED, we have new family members in the making. We are planning to launch both of them in first-half 2023. These products are in the validation at multiple beta customers

As of end-September, equipment order backlog was €369.4m, up 17.5% on €314.4m at the end of June and up 38% on €267.6m a year previously.

Due to the unabated strong demand and stable supply chains plus the shipment push-outs from Q3/2022, Aixtron expects exceptionally high shipments in Q4/ 2022, resulting in record quarterly revenue.

Full-year guidance upgraded

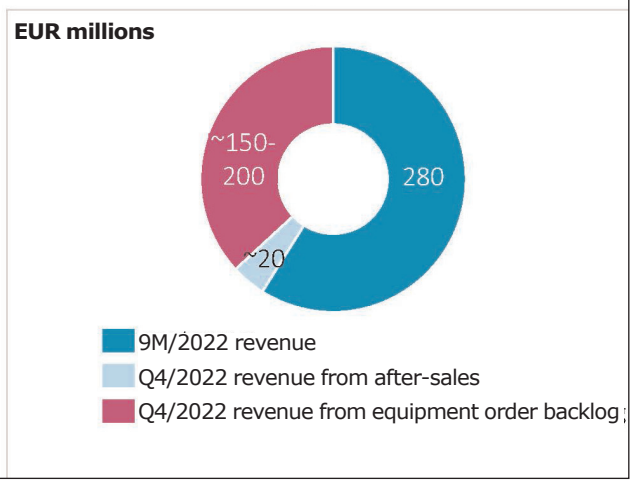
Based on a budget rate of $1.20/€ (versus $1.25/€ in 2021), in view of the continued improvement in demand, Aixtron has raised its guidance for full-year order intake from €520–580m to €540–600m.

2022 Guidance

Upgrade, based on 9-month results, demand situation and current environment:

Total Order Intake	**540 – 600** (from 520 – 580)
Revenues	**450 – 500** (unchanged)
Gross Margin (%)	**42%** (from 41%)
EBIT Margin (%)	**22% – 24%** (from 21% – 23%)

Revenue guidance FY 2022



Based on revenue in the first nine months of 2022 of €279.9m plus a forecasted €20m in after-sales spares & services revenue in Q4/2022, joined by equipment order backlog as of end-September of €150–200m (convertible into revenue during 2022), Aixtron still expects double-digit growth in full-year revenue to €450–500m in 2022.

However, in view of the improvement in product mix (for the remainder of 2022, compared with the first half), Aixtron has raised its guidance for gross margin from 41% to about 42% and for EBIT margin from 21–23% to 22–24%.

"The increase of our 2022 guidance in this challenging environment is the result of rising demand for our pioneering technologies," comments chief financial officer Dr Christian Danninger. "Our strategic initiatives regarding product development and supply chain management are taking effect," he adds.

"We are very pleased with the success of our recently launched G10-SiC and expect similar success for the upcoming launches of our new system generations," says CEO & president Dr Felix Grawert. "The G10 silicon carbide is the first member of the new series family that we are launching. Also for GaN power electronics and for gallium arsenide lasers and micro-LED, we have new family members in the making. We are planning to launch both of them in first-half 2023. These products are in the validation at multiple beta customers," he adds. "The increasing share of fully automated systems also shows the strong demand for new technologies."

"Overall, the current global crisis situations and market developments continue to have only a minor impact on business," notes Aixtron. "Logistics and supply chains are tense, but in our view remain stable overall."

Furukawa selects Aixtron's AIX 2800G4 MOCVD system for optoelectronic device production

Aixtron to support development of GaAs- and InP-based optoelectronics in Japan

Aixtron says that it has received an order from Japan-based compound semiconductor device manufacturer Furukawa Fitel Optical Device Co Ltd (FFOD) for an AIX 2800G4 metal-organic chemical vapor deposition (MOCVD) system, to be used for the development and the production of optoelectronic devices based on gallium arsenide (GaAs) and indium phosphide (InP) materials.

Aixtron claims that the AIX 2800G4 platform is the market-leading tool for the production of various semiconductor devices due to the performance of the Planetary Reactor concept with respect to thickness and wavelength uniformity control of epitaxial layers. The firm also claims that the proven system for high-volume manufacturing provides highest efficiency in the use of chemicals while delivering superior yields for most advanced optical devices due to wafer-level process control.

"We are very pleased to see Furukawa becoming one of our G4 users," says Aixtron's CEO & president Dr Felix Grawert. "With our team of hardware and process experts in Japan, we are looking forward to this new cooperation, supporting Furukawa to swiftly ramp up the platform for their existing and future products."

www.aixtron.com

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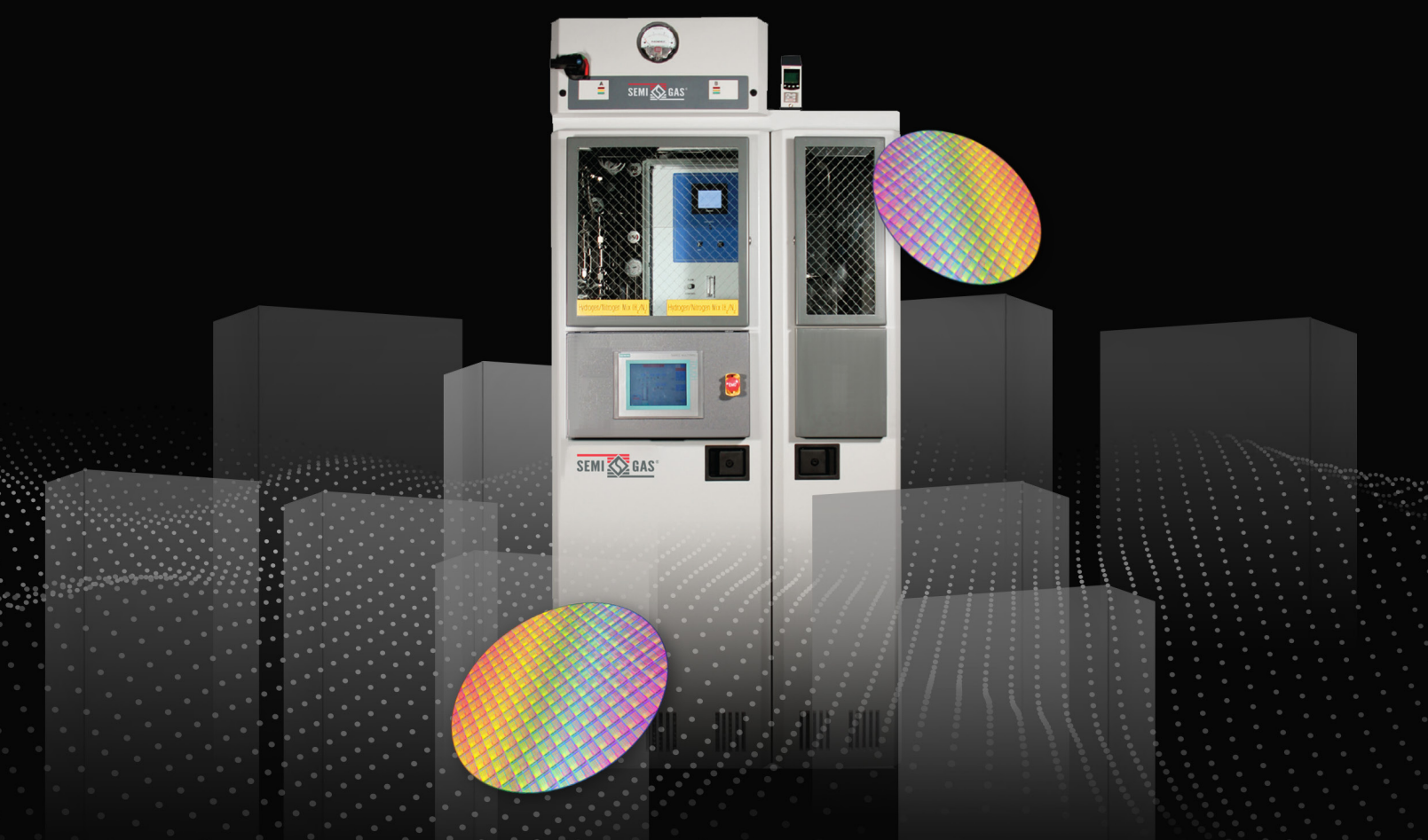

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First European patent for AlixLabs' Atomic Layer Etch Pitch Splitting technique

Validation of patent in key countries in Europe in process

After being granted two US patents by the US Patent Office (US10930515 in February 2021 and US11424130 on 23 August 2022), the European Patent Office (EPO) has issued a notice of intention to grant AlixLabs AB of Lund, Sweden its first European Patent for the firm's Atomic Layer Etch Pitch Splitting (APS) nanofabrication technique, a new method for manufacturing semiconductor components with a high degree of packing (eliminating several steps in the manufacturing process).

The patent covers methods to split nanostructures in half by a single process step using atomic layer etching (ALE). "Our key technology is based on a surprising discovery that sidewalls act as a topographical mask in atomic layer etch processes," notes chief technology officer & co-founder Dr Dmitry Suyatin. "This technology has been proven for such different materials as gallium phosphide (GaP), silicon (Si) and tantalum nitride (TaN) – all being critical materials to the semiconductor and optoelectronic industry. Besides already having secured a granted two US and one Taiwan patent, we are now delighted

to announce that our European patent will also be granted and that we have more patent applications in the pipeline. A process of validating the patent in key countries in Europe is in process," he adds.

AlixLabs says that, since Europe is one of the most important markets for leading-edge semiconductor products (due to the size of the EU inner market for electronic goods like smartphones, PC/laptops, tablets, automotive and Internet servers), it is hence crucial for it to protect its APS process there through IP.

AlixLabs reckons that the method can have a significant impact on the semiconductor industry by enabling sustainable scaling of electronic components and shrink chip designs further in a cost-effective way. "The APS method is complementary for single-exposure immersion and extreme UV (EUV) lithography and corresponding multiple patterning technologies like self-aligned double and quadruple patterning (SADP and SAQP, respectively) as well as multiple exposure lithography-etch and directed self-assembly (DSA)," notes CEO & co-founder Dr Jonas Sundqvist.

"APS can reduce complexity, capital expenditure and the environmental footprint for wafer manufacturing considerably," adds Sundqvist. "Besides that the EU is one of the biggest markets for semiconductor components, the recent announcements of 300mm wafer fab expansions and leading automotive sector means that it is more important than ever to have European IP."

www.alixlabs.com

CVD Equipment to sell & lease back premises for $28.5m

Proceeds to strengthen balance sheet and fund growth opportunities

CVD Equipment Corp (a designer and maker of chemical vapor deposition, gas control and other equipment and process solutions for developing and manufacturing materials and coatings) has entered into an agreement to sell and lease back its Central Islip, New York facility from the prospective purchasers.

On 22 September, the firm entered into an agreement for the sale of the premises (consisting of land and building) for $28.5m (subject to the completion of due diligence by the purchaser within 30 business days, during which time they have the right to cancel the purchase agreement).

Upon the closing of the sale, CVD Equipment will enter into an agreement to lease back the premises from the purchaser. The lease will have an initial term of ten years with two renewal terms of five years each, exercisable at CVD Equipment's option. The annual fixed rent will be $1,548,000 for the first year of the initial ten-year term and increase by 3% each year thereafter. The lease will be 'triple net', and CVD Equipment will continue to be responsible for costs, expenses and obligations relating to the operation of the premises.

The net cash proceeds received by CVD Equipment is expected to exceed $20m after taxes, expenses and fees (subject to the transaction closing and finalization of the firm's tax obligations associated with the sale). The net cash proceeds will be used to strengthen the firm's balance sheet and to fund growth opportunities.

www.cvdequipment.com

Oxford Instruments and ITRI develop recessed-gate GaN MISHEMT

Atomic layer etch used in pilot-production line to boost GaN HEMT performance

Oxford Instruments Plasma Technology (OIPT) of Yatton, near Bristol, UK and its research partner Industrial Technology Research Institute (ITRI) of HsinChu, Taiwan have announced technology developments that, they reckon, can significantly benefit key hyper-growth electric vehicle (EV), data-center and 5G markets.

The developments allow critical transistor components to operate at higher voltages (increasing performance and reliability) while also achieving a safer and more energy efficient operation (normally off E-mode) compared with existing devices. The new gallium nitride (GaN) HEMT device architecture is defined by a recessed and insulated gate junction into the aluminium gallium nitride (AlGaN) layer, i.e. a GaN MISHEMT.

In September 2021, OIPT and ITRI announced a cooperative research program for next-generation compound semiconductors. The latest breakthrough is an example of that collaboration delivering on its goal of accelerating technology to benefit the partners, their regions and wider global markets. Oxford Instruments has since also unveiled an exclusive supply deal with in-situ metrology system maker LayTec AG of Berlin, Germany, whose end-point technology is used to control the GaN MISHEMT recess gate depth. Recess depth accuracy and repeatability is critical to tune the device performance characteristics, and LayTec's technology is designed specifically for this application, achieving target depth accuracy of ±0.5nm. ITRI provides pilot production and value-added services, including process verification and product development. OIPT says that ITRI's integration services, especially this GaN development project, have proved beneficial, quickly proving the higher performance of the GaN MISHEMT and providing a lower risk and faster route to market for the device.

To solve the technology challenges associated with fabrication of next-generation devices, we needed more accurate and controlled technology solutions such as atomic layer epitaxy for gallium nitride high-electron-mobility transistor high-volume manufacturing

"We have excellent strategic partners and customers like Enkris, ITRI, LayTec and ROHM, and our GaN solutions are positioned strongly to serve, grow and gain from big opportunity markets," reckons Oxford Instruments' strategic business development director Klaas Wisniewski. "Our leading atomic layer etch (ALE) and atomic layer deposition (ALD) technology is raising material engineering performance to achieve new levels of surface quality and defect reduction, to meet the growing demand for higher-performing devices. With our technology partner ITRI, high-volume GaN manufacturing customers and our focussed investment into high-value and proprietary process solutions, we expect the GaN device market to be a key driver for our business and technology roadmap," he adds.

"ITRI has well-established expertise and history in providing GaN HEMT manufacturing solutions that enable the global supply chain for GaN power electronics and RF applications," says Robert Lo, deputy general director of ITRI's Electronic and Optoelectronic System Research Laboratories (EOSL). "However, to solve the technology challenges associated with fabrication of next-generation devices, we needed more accurate and controlled technology solutions such as ALE for GaN HEMT high-volume manufacturing. Through our long-standing partnership with Oxford Instruments, we have successfully qualified and integrated their ALE solution for a recessed-gate MISHEMT into our GaN HEMT pilot-production line."

Wisniewski presented a talk 'Enhancing GaN HEMT Performance for Power Electronics Applications with Atomic Scale Processing Production Solutions' at SEMICON Taiwan 2022 in Taipei (14–16 September).

www.plasma.oxinst.com
www.itri.org.tw/eng
www.laytec.de

KLA to build new R&D and manufacturing facility for SPTS in Newport, Wales

Investment of $100m to create 200,000ft² facility for up to 750 staff

Process control and inspection systems provider KLA Corp of Milpitas, CA, USA plans to build a new R&D and manufacturing center for its SPTS division in Newport, Wales, UK (which manufactures etch, PVD and CVD wafer processing solutions for the MEMS, advanced packaging, LED, high-speed RF, and power management device markets).

Designed to meet the Building Research Establishment Environmental Assessment Method (BREEAM) standard of sustainability rating of excellence, the new development is expected to include a capital investment of more than $100m and create a 200,000ft^2 facility. The new innovation center and manufacturing facility will include offices, cleanrooms, storage and support facilities and accommodate up to 750 employees.

"SPTS has experienced significant growth in its business over the past several years and is a highly successful division of KLA," says Oreste Donzella, executive VP of KLA's Electronics, Packaging and Components (EPC) Group. "We are investing in the new site to support SPTS's growth and to establish additional facilities for the wider KLA European organization. Expanding in South Wales allows us to tap into the region's attractive talent pool and benefits from an appealing quality of life with access to many international sporting events, historic parks and outdoor activities. This area is also home to some of UK's leading universities and research institutes with strong semiconductor competencies and industry ties for collaborative research," he adds.

"This investment and expansion in Wales will help us continue to develop wafer processing solutions for the high-growth secular industries and build on the existing expertise in advance packaging and compound semiconductor processing technologies to strengthen our portfolio of solutions for 5G communications, electric vehicles, consumer electronics, data centers, medical devices, and much more," says president & CEO Rick Wallace.

"We have worked closely with KLA behind the scenes to identify the best possible site for their new manufacturing and R&D site and have invested in the energy infrastructure to ensure that the site can offer the company everything they need," states Welsh Government Economy Minister Vaughan Gething. "This is a strong endorsement of the semiconductor cluster in South Wales and the Welsh Government's sustained commitment to it over the past decade," he adds. "We will continue to support and grow Wales' semiconductor cluster and to ensure we are maximizing the regional and global opportunities of this cutting-edge technology."

Adopting the globally recognized science-based sustainable and energy-efficient design standards, the new facility will be designed to achieve a BREEAM Excellent rating, reflecting KLA's commitment to its environmental goals. The new innovation center will provide over 25,000ft^2 of cleanrooms for R&D and more than 35,000ft^2 of bespoke manufacturing assembly halls.

Inside the design of the building façade are three floors of working environments, providing staff with modern workspaces, flexible breakout areas and staff restaurant. With staff wellbeing a priority, the new building includes a gymnasium and a footpath to support employee fitness and health. For those who take part in the company's Cycle Scheme or cycle to work, there is secure cycle storage and shower facilities.

A groundbreaking event to mark the commencement of the new development took place on 5 October. Completion of the building is expected in early 2025.

www.spts.com
www.kla.com

SUSS MicroTec launches 300mm imprint platform

MA12 Gen3 mask aligner combines lithography, micro- to nano-imprint and wafer-level stacking

SÜSS MicroTec SE of Garching, near Munich, Germany (which makes photomask aligners, laser processing systems and wafer bonders) has extended its imprint technology to 300mm wafers and launched its new mask aligner MA12 Gen3 at the SEMICON Europa 2022 show in Munich. The addition to the product portfolio combines photolithography, micro- to nano-imprint, and wafer-level stacking within a compact tool.

As a semi-automated mask aligner, the MA12 Gen3 opens up a large variety of imprint applications to research, pilot and high-volume manufacturing. Its imprint processing capabilities for standard, advanced and high-end processes enable technology trends such as face or fingerprint recognition, light carpets or augmented reality. Other applications include LEDs, micro- and nano-electro-mechanical systems (MEMS/NEMS), micro-optics, and optoelectronic sensors. High-precision parallelism between imprint stamp and substrate is mandatory for these applications. The MA12 Gen3 meets this requirement with the help of the leveling system developed by SUSS MicroTec. This gap measurement technology enables significant improvements in resolution compared with conventional methods.

"It is our aim to offer our customers a full turn-key solution for micro- and nano-imprint that enables outstanding process performance. Our new MA12 imprint equipment is another step towards this goal," says Dr Robert Wanninger, head of the Lithography business unit, underlining the strategic importance of the new imprint lithography platform. "Providing a tool for 300mm wafers and up to 350mm x 350mm substrates is an important part of the imprint ecosystem we are creating."

www.semiconeuropa.org
www.suss.com/en/products-solutions/mask-aligner/ma12-gen3

Plasma-Therm's Grenoble site made EMEA HQ focused on power, wireless, memory, sensor and MEMS devices

Demo facility offers product and applications development, regional field service and technical support for etch, deposition, RTP and plasma dicing

Plasma-Therm LLC of St Petersburg, FL, USA (which makes plasma-process equipment for the semiconductor and compound semiconductor markets) says that its site in Grenoble, France will serve as regional headquarters to support customers in central Europe, Middle East and North Africa (EMEA) markets focused on developing power, wireless, memory, sensor and MEMS, and other advanced microelectronic devices. The firm's European facility, equipped with R&D, manufacturing and demonstration cleanrooms, is poised to support new application and product development with strategic customers and partners in the region.

Plasma-Therm says that its emphasis on process solutions and customer satisfaction has resulted in the recent award of multiple orders for its newly redesigned Heatpulse rapid thermal processing (RTP) platform (launched earlier this year), on target to ship to two major European customers in December. Heatpulse RTP was selected for its new control system software, upgraded robotics and ability to accommodate a variety of substrates up to 200mm, including silicon, gallium arsenide (GaAs), silicon carbide (SiC) and other compound materials. The new system design helps existing Heatpulse customers mitigate any supply chain and obsolescence issues with their existing systems, says Plasma-Therm. Remanufacturing options for legacy systems are also available.

"Increasing our presence in Europe is part of our long-term strategic growth plan to provide a premier client experience and customized technology processing solutions for customers in the region," says Jim Garstka, VP of sales & business development. "We anticipate EMEA will continue to be a high-growth market for us, driven by demand for advanced compound semiconductor and silicon devices used in automotive, wireless, IoT, AR/VR and other end-use applications," he adds.

"Being able to quickly deploy our highly specialized engineering, sales and support teams and offer flexible solutions helps our customers achieve faster time to market for their devices," says Yannick Pilloux, executive sales manager, EMEA. "We expect our new Heatpulse system will continue to see market traction with improved reliability and performance, as well as assurance of readily available spare parts and maximum tool uptime in the fab."

www.plasmatherm.com/Heatpulse-RTP.html

EVG launches next-generation 200mm EVG150 automated resist processing platform

Redesign boosts module capacity for higher throughput and improves architecture for reduced tool footprint

EV Group of St Florian, Austria — a supplier of wafer bonding and lithography equipment for semiconductor, micro-electro-mechanical systems (MEMS) and nanotechnology applications — has strengthened its portfolio of optical lithography solutions by unveiling the next-generation 200mm version of its EVG150 automated resist processing system.

The redesigned EVG150 platform includes features and enhancements that provide greater throughput (by up to 80%) and versatility, as well as smaller tool footprint (by nearly 50%), compared with the previous-generation platform. The EVG150 provides reliable and high-quality coating and developing processes in a universal platform that supports a variety of devices and applications, including advanced packaging, MEMS, RF, 3D sensing, power electronics and photonics. Its high throughput, flexibility and repeatability support the most demanding needs for both high-volume production and industrial development, says the firm.

The first customer to receive the next-generation EVG150 system is Silicon Austria Labs, a research center for electronic-based systems (EBS). "Through our cooperative research with leading manufacturers, we develop key technologies that build the foundation for Industry 4.0, IoT, autonomous driving, cyber-physical systems (CPS), artificial intelligence (AI), smart cities, smart energy and smart health long before they reach the market," says Dr Mohssen Moridi, head of Research Division Microsystems of Silicon Austria Labs. "The high flexibility of EVG's next-generation EVG150 resist processing system helps pave the way for high-volume implementation of new processes and products with our development customers that fuel EBS innovation."

Universal platform provides flexibility

The next-generation EVG150 for 200mm substrates maintains the capabilities of the previous-generation platform, including: fully automated platform with customizable module configurations for spin and spray coating, developing, bake and chill; EVG's proprietary OmniSpray technology for conformal coating of extreme topographies; sophisticated and field-proven robot handling with dual end-effector capability to ensure continuous high throughput; and wafer-edge, bowed, warped and thin-wafer handling.

New features on the next-generation EVG150 200mm platform include:

- up to four wet-processing module spaces and up to 20 bake/chill units, enabling the processing of many more wafers simultaneously;
- singulated coat chambers, providing complete isolation of modules and virtual elimination of cross-contamination between modules;
- further redesign of modules to enable easy access to individual chambers from outside of the tool, minimizing downtime and allowing for continued tool operation when conducting chamber maintenance;
- repositioning of chambers within the platform to enable easy access to robotic handling unit to facilitate maintenance;
- image-based pre-aligner to enable on-the-fly wafer centering for faster processing;
- integration of resist and chemistry lines inside the system, reducing external cabinet space for chemistry storage and reducing tool footprint;
- integration of user interface inside the system, further reducing tool footprint.

"Resist processing and patterning are the most repeated process steps in semiconductor manufacturing. EVG has built up many years of experience with these processes, including optical lithography and spin and spray coating, to address the needs of the most demanding customer requirements," says corporate technology director Dr Thomas Glinsner. "We've incorporated these learnings into our next-generation EVG150 system, which has been redesigned from the ground up to provide breakthrough throughput and cost-of-ownership benefits in a universal platform that offers unsurpassed flexibility to meet the widest variety of resist processing needs," he adds.

EVG is now accepting orders for the next-generation EVG150 automated resist processing system, and is offering product demonstrations at its headquarters.

www.evgroup.com/products/lithography/resist-processing-systems/evg150

3D-Micromac receives order for laser lift-off systems for micro-LED device manufacturing

microMIRA provides uniform, force-free lift-off of material layers at high speeds

3D-Micromac AG of Chemnitz, Germany (which provides laser micromachining and roll-to-roll laser systems for semiconductor, photovoltaic, glass and display applications) says that a leading optical solutions provider has purchased multiple microMIRA laser lift-off (LLO) systems for use in micro-LED device production. The customer will install the new systems in pilot and production lines at its LED chip factory in Asia.

Laser lift-off an enabling process for micro-LEDs

For the display industry, micro-LEDs promise advantages such as superior viewing angle, high dynamic range with perfect black luminance and high brightness, wide color gamut, fast refresh rates, long lifetime, and low power consumption. Potential applications include very large displays for indoor and outdoor use, as well as high-resolution displays for augmented reality (AR) and virtual reality (VR) wearable devices.

However, the micro-LED fabrication process is vastly more complex than LCD and OLED manufacturing, and faces several technical challenges that must be overcome before micro-LEDs can be readily available in the mass market. Among these challenges is detaching and transferring the processed micro-LED chips from the donor or growth substrate (e.g. sapphire) to an intermediate substrate for subsequent testing without damaging the expensive growth substrate, allowing it to be repurposed for future use.

The microMIRA system precisely addresses this task, and is said to provide highly uniform, force-free lift-off of different layers on large-area substrates at high processing speeds without the need for costly and polluting wet-chemical processes. The unique line beam system is built on a highly customizable platform that can incorporate different laser sources, wavelengths and beam paths to meet each customer's unique requirements. The system is capable of processing different substrate materials and sizes, and can achieve processing speeds (including handling) of up to 60 eight-inch wafers per hour.

"This multiple system order is a testament to our ability to provide innovative and enabling laser micromachining solutions for industrial applications serving both mature and emerging markets," says CEO Uwe Wagner. "It also represents an important milestone for 3D-Micromac as we continue to expand our product offerings and services into the display industry, addressing the production needs for exciting new display technologies, including micro-LEDs," he adds. "To date, 3D-Micromac has sold more than 10 laser processing systems for micro-LED applications, including our industry-benchmark microMIRA laser-lift-off system as well as our recently introduced microCETI micromachining platform."

The microMIRA LLO system has been used in mass production by electronics manufacturers globally for years. In addition to gallium nitride (GaN) lift-off from glass and sapphire substrates in micro-LED display manufacturing, the microMIRA system can also be used for layer separation in semiconductor and sensor manufacturing, as well as for laser annealing and crystallization for surface modification.

www.3d-micromac.com/laser-lift-off/micromira

MICLEDI and Kura partner on manufacturing AR glasses

Custom micro-LEDs for high-performance AR glasses, scaling with partners including GlobalFoundries and TSMC

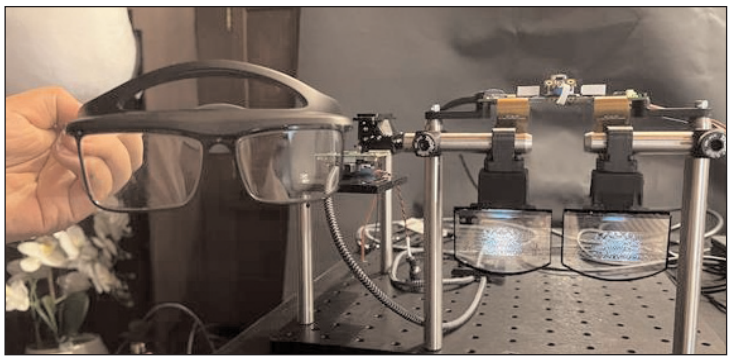
MICLEDI Microdisplays B.V. of Leuven, Belgium — a fabless developer of micro-LED display modules for augmented reality (AR) glasses that was spun off from nanoelectronics research center IMEC in 2019 — and Silicon Valley-based AR headset developer Kura Technologies are collaborating to manufacture AR glasses. Based on Kura's proprietary architecture from the chip level up, the new glasses are designed by Kura and incorporate MICLEDI's unique 300mm micro-LED displays to achieve the performance required for Kura's next generation of AR glasses.

MICLEDI's technology is based on a combination of III/V materials processing, 3D integration and 300mm silicon-based processing combined with a proprietary ASIC to provide a self-contained, compact monolithic AR display with what is said to be high image quality and power efficiency.

The two companies have been working together for over a year, with MICLEDI providing Kura early access to advanced micro-LEDs under a closely held collaboration. Kura was one of the first customers to receive micro-LEDs from MICLEDI, enabling them to build and test its unique approach for driving and controlling micro-LED displays for AR glasses.

Under the partnership, MICLEDI will continue to provide Kura access to devices fabricated in its 200mm fab as well as provide Kura with early access to customized blue, green and red devices as they come from their 300mm wafer foundry.

"We've had a chance to visit Kura's office in the Bay Area, meet their team and see their latest developments and demos," says MICLEDI's CEO Sean Lord. "We were very impressed by their progress over the years, the multi-disciplinary technical expertise and the field-of-view and clarity of their demos," he adds.



Kura's customized AI-generated optics and glasses using MICLEDI micro-LED displays.

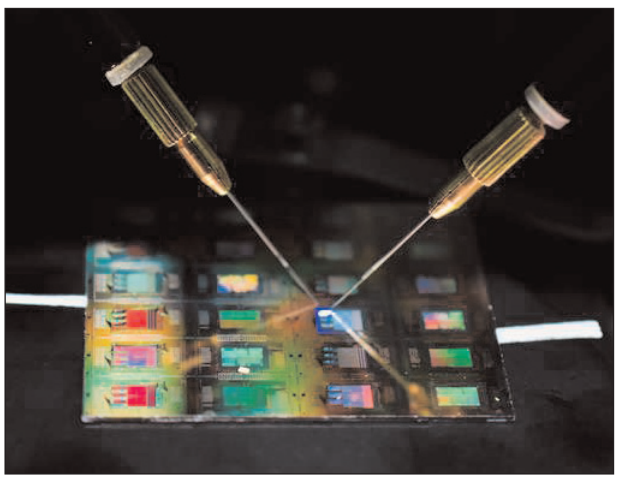
"Kura's fast-paced product engineering team has benefited tremendously from MICLEDI's quick-turn 200mm prototype fabrication capability and responsive team of professional LED design and process experts," comments Kura's founder, CEO & CTO Kelly Peng. "MICLEDI is well positioned to achieve industry leadership in 300mm micro-LED fabrication, offering process advantages and direct compatibility with our high-performance custom 300mm backplane," he believes.

According to the market analyst firm Yole, the global AR market is rising at a compounded annual growth rate of more than 30% over 2021–2027, reaching $88.4bn as it becomes the next consumer platform.

"In May of this year, we announced a partnership with GlobalFoundries to bring our proprietary 300mm micro-LED designs into high-volume, low-cost mass production," says Lord. "Working with Kura should provide mutually attractive timing and mass-production ramp plans for both MICLEDI and GlobalFoundries."

Kura says that its proprietary architecture enables dynamic defect correction, 100x resolution expansion, and can tolerate 10,000x the defect rate and 5x the uniformity variation of its competitors, enabling it to go to market with high-performance 8K AR glasses with micro-LED panels that can be fabricated now and in the next year, not several years from now.

"The partnership with GlobalFoundries allows us to take advantage of their expertise in large-scale, reliable manufacturing in order to reliably ramp our glasses to the 100,000s of units our customers are demanding," says Kura's co-founder & technical lead Bayley Wang, who says that Kura is the only AR company he's aware of that is working with such a large foundry to build custom micro-displays. "Combined with the successful tape-out of our custom mixed-signal display driver IC, which is the world's fastest micro-display driving IC at our partner TSMC, we're on track to reliably build our displays and launch our product at scale."



www.kura.tech
www.micledi.com

MICLEDI demos 50nm-FWHM 630nm red GaN μLEDs

Sampling by the end of 2022 to enable integration into full-color micro-LED displays for augmented reality glasses

MICLEDI Microdisplays has demonstrated 630nm-wavelength red gallium nitride (GaN) with full-width half-maximum (FWHM) in the range of 50nm, enabling the integration of highly optimized monochrome red micro-LEDs into full-color micro-LED display modules. Historically, red micro-LEDs have suffered a reputation as a poor-performing part.

MICLEDI reckons that its approach to micro-LED full-color displays is uniquely positioned to achieve the highest performance standards in AR glasses. Currently, AR glasses for indoor, or semi-darkened, light settings can be less efficient, less bright, and have lower overall performance compared with outdoor sunlight settings. Best-in-class AR glasses with transparent lenses, for use all the way from low indoor light to bright outdoor sunlight, is critical to achieving high-volume consumer adoption of AR glasses. By optimizing the chemistry and physics of each individual color, MICLEDI claims that it enables the highest brightness of any alternative solution on the market.

Consistent with the firm's fundamental and repeating value proposition, the red GaN:

- is compatible with MICLEDI's proprietary CMOS-fab technology;
- follows the identical process recipe of its blue and green arrays for consistency;
- accommodates pixel-level micro-lenses for high-efficiency optics integration; and
- is tailored for industry-standard 300mm commercial foundries for high-volume mass production.

"AR headgear in the market today ranges from monochrome monocles for limited information-only displays to monochrome headsets and heads-up displays to full-color glasses for industrial, enterprise and military applications," notes CEO Sean Lord. "Prices range from $1000 to over $5000 per headset, which is too high for the average consumer. With the addition of red GaN to our tool kit, MICLEDI is perfectly positioned to bring the cost and volume advantages of its 300mm manufacturing flow to open the door to future generations of AR glasses that consumers can afford and enjoy," he adds.

MICLEDI now has all three micro-LED colors coming onto the market. The company continues its close affiliation with IMEC and other significant partners.

"Red GaN is but one option," says Lord. "Alternative approaches vary from AlInGaP [aluminium indium gallium phosphide] to quantum dot, and other techniques. MICLEDI is committed to pushing the cost, reliability and performance envelope of each of these alternatives to provide the best in full-color micro-LED display modules across a broad range of performance parameters for transparent lens AR glasses."

MICLEDI introduced its blue GaN and green GaN LED display test chips earlier this year. The red samples are projected to be available to customers by the end of the year.

www.micledi.com

IQE partners with MICLEDI to develop μLEDs for AR

IQE to provide 200mm platform for high-volume production of red micro-LEDs

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has entered into a partnership with MICLEDI Microdisplays focused on the large-scale commercialization of micro-LED technology.

Spun off from nanoelectronics research center IMEC in 2019, MICLEDI is a fabless semiconductor design and technology company developing unique, high-performance micro-LED displays with a primary focus on augmented reality (AR) products.

Under the agreement, IQE will provide MICLEDI with a 200mm (8-inch) platform to scale and commercialize the technology to achieve high-volume production for red micro-LEDs. This geometry allows for compatibility with both standard 200mm and 300mm silicon foundries, enabling the partnership to deliver economies of scale.

"Micro-LEDs are the future of immersive display technologies and this agreement expands IQE's position in a market which is poised for multi-billion dollar growth across a range of end-market applications, including everyday consumer electronics," says IQE's CEO Americo Lemos. "Compound semiconductors are a critical enabler of scale in this market and we are pleased to be partnering with MICLEDI to offer a differentiated solution," he adds.

"By combining MICLEDI's unique micro-LED arrays with IQE's innovative 8-inch platform, we have formed a natural partnership to commercialize and scale our solution to address the high-growth micro-LED market," says MICLEDI's CEO Sean Lord. "Our augmented reality products will enable new user experiences, and we look forward to delivering this innovative technology under our new partnership."

www.iqep.com

Avicena acquires GaN micro-LED fab and engineering team from Nanosys

Former glo Silicon Valley fab targeted at parallel multi-Tbps chip-to-chip interconnects

Avicena of Mountain View, CA, USA (which develops ultra-low-energy optical links based on micro-LEDs) has acquired a micro-LED fabrication facility and associated engineering team in Sunnyvale, CA, USA from fellow Silicon Valley-based firm Nanosys Inc (which was founded in 2001 and operates the world's largest quantum dot nanomaterials fab — as of 2021, consumer electronics brands have shipped more than 60 million devices in over 750 unique products from tablets to monitors and TVs with Nanosys' proprietary quantum dot technology).

The transaction enhances Avicena's capabilities in the development and manufacturing of high-speed gallium nitride (GaN) micro-LEDs optimized for parallel multi-Tbps interconnects.

The GaN micro-LED fab was previously owned by glo AB, which was spun off from Sweden's Lund University in 2003 and established the R&D and product development pilot line in Sunnyvale in 2010 before investing over $200m in the development of micro-LED displays (including significant investments in manufacturing capabilities). Nanosys acquired glo in May 2021. Avicena had been using the Nanosys fab for the development of unique ultra-fast micro-LEDs, and the firm says that the acquisition of the fab and associated engineering team significantly increases its development and manufacturing capabilities.

Avicena's LightBundle links are based on arrays of ultra-fast GaN micro-LEDs that leverage the micro-LED display ecosystem and can be integrated directly onto high performance CMOS ICs. Each ultra-low-power micro-LED array is connected via a multi-core fiber cable using hundreds of parallel optical lanes to a matching array of CMOS-compatible photodiodes (PDs). This design enables ultra-low-power, low-cost multi-Tbps interconnects with up to 10m reach.

The parallel nature of LightBundle is reckoned to be well matched to parallel chiplet interfaces like UCIe, OpenHBI, and BoW, and can also be used to extend the reach of existing compute interconnects like PCIe/CXL, and HBM/DDR/GDDR memory links, as well as various inter-processor interconnects like NVLink with low power and low latency.

"We have already demonstrated LightBundle links running at less than 1pJ/bit and individual micro-LED links running at 14Gbps NRZ," notes Avicena's founder & CEO Bardia Pezeshki. "With the acquisition of the Nanosys micro-LED development facilities we will be in an excellent position to further advance epitaxy, device process and transfer technology and achieve even lower energy and higher data rates per lane. Compact, low-cost interconnects using hundreds of these links can support a total bandwidth of many terabits per second and help solve the data bottleneck in advanced silicon ICs."

The facilities include epitaxy, wafer processing, and lift-off and transfer tools to post- process silicon ICs with optical interfaces. Together with Avicena's internal ASIC team, the company plans to deliver optical chiplets with high capacity and extremely low power. Compared with laser or silicon photonics-based interconnects, micro-LED optical interconnects are well suited for integration with silicon ICs, and are lower power, lower cost, and target reaches up to 10m.

"We thank the micro-LED fab team for their partnership in developing and manufacturing micro-LEDs as part of Nanosys and wish them well in their future with Avicena," comments Nanosys' president & CEO Jason Hartlove. "Avicena is an exciting company developing cutting-edge micro-LED solutions, and we are pleased to have an equity stake and the opportunity to continue to collaborate with them during their next phase of growth."

www.avicena.tech

Porotech creates 'all-in-one' full-color μLED display

Porotech (a spin off from the Cambridge Centre for Gallium Nitride at the UK's University of Cambridge that has developed porous GaN material) has announced what it says is the world's first public demonstration of an 'all-in-one' full-color display of micro-LED pixels.

Porotech is pioneering the next generation of displays by using a single micro-LED for all colors, moving away from the constraints of the RGB (red-green-blue) sub-pixel model that underpins all existing commercial display technologies.

The firm says that its innovation lies in its DynamicPixelTuning (DPT) technology, which uses PoroGaN material to allow a modulated current to be leveraged to emit visible light covering the entire color spectrum on a single micro-LED chip. Among the colors that it can emit, a DPT micro-LED can achieve what is said to be a world first by emitting pure white light from a single pixel.

By removing the need for RGB sub-pixels, DPT allows a micro-LED-driven display to increase overall pixel density fourfold. As a result, DPT can produce substantial gains in resolution, brightness and efficiency for every type of display. This is of particular interest for small-form-factor displays that demand high resolution, such as augmented reality (AR) and virtual reality (VR) displays, as well as wearable tech.

According to a market report from Grand View Research, the global AR market in 2021 was $25.33bn and is expected to grow by 40.9% per year from 2022 to 2030. Porotech says that its DPT technology has already won 'Best Prototype' at the 2022 Display Week industry gathering.

For future display technology, micro-LEDs offer benefits such as improved brightness, energy efficiency, contrast ratio, longer device lifetimes, along with greater pixel densities and resolutions. Porotech says that its all-in-one pixel technology allows micro-LEDs to achieve what is claimed to be unparalleled commercial viability, removing the reliance on RGB altogether — a cumbersome approach dating back to the days of cathode-ray tube (CRT) displays.

Porotech will debut DPT publically at the Consumer Electronics Show (CES 2023) in Las Vegas, where it is showcasing a 0.26-inch DPT micro-display with a <5μm full-color pixel, followed by various other industry events in first-quarter 2023.

"Mass-produced micro-LEDs will be pivotal for the future of displays, particularly the emerging AR and VR spaces," says CEO & co-founder Dr Tongtong Zhu. "Our technology has solved a fundamental technical and engineering problem facing micro-LED display quality, manufacturability, and — most importantly — system integration," he adds.

"This doesn't just herald widespread adoption of consumer-grade MR, VR and AR. In fact, DPT also offers radical improvements in TV, signage and smart wearables in both consumer and professional contexts," Zhu continues. "By allowing pixels to move beyond RGB and quadrupling the resolution of any given display, DPT is set to unlock new uses for displays in every segment of society."

www.porotech.co.uk

Aledia and QustomDot to co-develop full-color micro-LED displays

Prototypes for video wall & luxury TV markets to roll out in early 2023

Aledia S.A of Echirolles, near Grenoble, France (a developer and manufacturer of 3D micro-LEDs for display applications based on its large-area gallium nitride nanowires-on-silicon platform) and Belgium-based Ghent University spin-off QustomDot (which combines quantum dot synthesis, surface engineering and ink/photoresist formulation into patterned color conversion layers for μED displays) have joined forces to leverage their expertise and co-develop a full-color μLED technology that will address the video wall and luxury TV markets.

Aledia has unique 300mm GaN-on-Si nanowire technology that is said to unlock scalable manufacturing of micro-LEDs, enabling highly efficient blue micro-LEDs to be produced for a first range of high-end products.

"We have worked for several years on combining our unique GaN nanowire micro-LED platform with quantum dots, taking advantage of the exceptional color quality of quantum dots; however, in the past the quantum dots have often been a limiting element in the final micro-LED performance," says Aledia's CEO Giorgio Anania. "Together with QustomDot's innovative quantum dot inks, we believe a higher-performing range of micro-LED products could be within reach," he adds.

QustomDot uses its quantum dot platform to create a heavy-metal-free color conversion solution. "While many technologies are being developed in the field, we believe that Aledia's ambition and vision can drive the micro-LED market to the next phase," comments QustomDot's CEO Kim De Nolf. "We have found that both our technology platforms are a great fit for this emerging market," he adds. The joint collaboration will initially target the video wall and luxury TV markets, and first prototypes are expected to roll out in early 2023.

www.qustomdot.com
www.aledia.com

Ennostar and PlayNitride team up on 6" micro-LED epiwafer production

Display-related micro-LED chip market to reach $542m in 2024

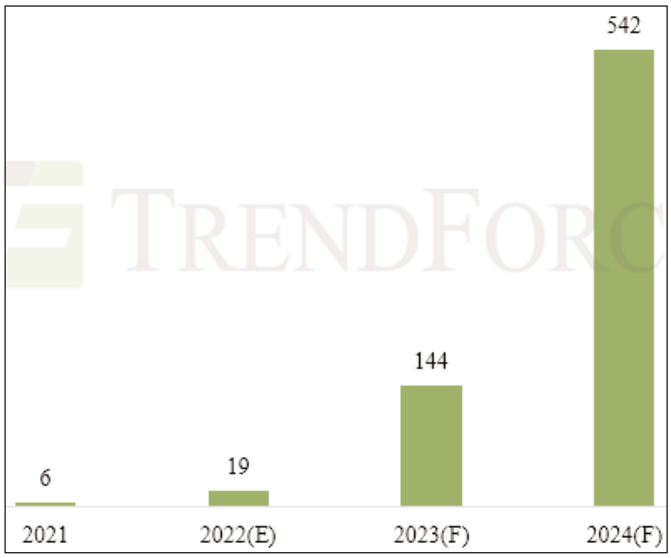
Ennostar subsidiary Epistar and PlayNitride subsidiary PlayNitride Display have teamed up to build a production line for 6-inch micro-LED epiwafers, reports market research firm TrendForce.

Looking at the latest progress in the development of micro-LEDs, large-sized displays are regarded as the forerunners to more advanced end-products. Even though micro-LEDs have unresolved technical bottlenecks and cost-related issues, TrendForce is optimistic that this technology will eventually be adopted for the development of different kinds of displays and end-products.

Examples include transparent augmented reality (AR) smart glasses, displays for wearable devices like smartwatches, automotive displays such as those embedded in a smart cockpit, and other transparent display products.

Furthermore, the latest efforts in product development will likely create new high-end applications for micro-LEDs. TrendForce currently forecasts that the market for micro-LED chips used in displays will reach $542m in 2024, then experience soaring growth starting in 2025 due to the maturation of technologies.

In dealing with a new high-end display technology such as micro-LEDs, there is a high degree of customization in display design, notes TrendForce. Additionally, the technologies responsible for fabricating micro-LED displays must meet a very stringent set of requirements regarding accuracy and precision. Hence, the possibility of creating commercially viable and mass-produced micro-LED displays depends on a high level of synergy among companies that are involved in display panels, LED chips, mass-transfer equipment, driver ICs etc. In the supply chain for traditional types of displays, different sections operate in a relatively independent manner and adhere to a certain division-of-labor scheme. By contrast, the supply chain for micro-LED displays operates under a very different model that requires close integration between sections.



Given this context, three coalitions have now emerged in the micro-LED market. The first comprises Ennostar (including its subsidiaries Epistar, Unikorn Semiconductor, and Lextar), AUO, and Innolux. The second coalition comprises BOE (including its subsidiary BOE Mled and joint venture BOE Pixey) and HC Semitek. The third coalition is formed by TCL CSOT, San'an Optoelectronics, and Extremely PQ Display Technology. It is worth noting that Hisense, through its recent actions such as increasing its stake in Changelight, appears to be forming another new faction in the micro-LED market as well.

TrendForce says that Ennostar, as one of the technology leaders in the global LED industry, has been working internally on micro-LEDs for many years as it looks forward to the explosive growth of related opportunities in the future. To get a firmer grasp of fabrication technologies and entrench itself in the industry ecosystem, Ennostar has taken the step of forming an alliance that prepares for the eventual mass production of micro-LED displays. With respect to the roles of the individual members of this alliance, Ennostar and Epistar will be responsible for high-end micro-LED chips. The development of mass-transfer solutions will center on PlayNitride. AUO and Innolux will be in charge of display backplanes and driver ICs. Their efforts must be closely interconnected and in sync in order to obtain successful results. In this latest chapter of the partnership between Ennostar and PlayNitride, the former will build a new production line by leveraging the expertise and experience that the latter has accumulated for mass-transfer solutions and micro-LED chips.

PlayNitride is currently a leader in micro-LED technology. Apart from meeting its clients' demand as a component supplier, PlayNitride has a well-rounded portfolio of technology patents as well as a wealth of experience. For other companies that manufacture products for various display-related applications (e.g. large-sized, automotive, and wearable), PlayNitride can help them adopt micro-LEDs by providing services such as setting up production capacity and optimizing production flow. Such collaborations would create core competitive advantages for the partnering display manufacturers, says TrendForce. As PlayNitride simultaneously expands into component sales, IP services and construction of production lines, it will be able to create new and profitable business models, the market research firm concludes.

www.ledinside.com

BOE becomes largest shareholder in HC Semitek with RMB2.1bn investment

Partners to jointly develop micro/mini-LED businesses

After making a RMB2.1bn capital investment, BOE has become the largest shareholder in HC Semitek and is now partnering on the development of micro/mini-LED businesses, reports market intelligence firm TrendForce.

BOE has been involved in micro/mini-LEDs since 2017 and now possesses related offerings such as displays and backlight solutions. In 2020, BOE established BOE MLED Technology as a subsidiary dedicated to the R&D and manufacturing of micro/mini-LED products.

HC Semitek is a major Chinese LED chip supplier and has an overarching presence across the LED chip industry chain, producing not only LED chips but also LED epiwafers, sapphire substrates etc. According to data from TrendForce, in 2021 HC Semitek was the fourth largest LED chip supplier by external sales revenue. Also, in a ranking of LED chip suppliers based on revenue that is solely from sales of mini-LED chips, HC Semitek is currently in third place, following Epistar and San'an.

From BOE's perspective, LED chips represent a critical section of the display industry chain. For end-products, the quality of LED chips directly affects their displays in terms of cost, production yield rate, and quality. This connection between chips and end-products is also noticeable in the micro-LED industry. For example, RGB micro-LED chips are already regarded as a key component among the leading brand manufacturers.

At the same time, these firms have taken actions to secure a stable supply of RGB micro-LED chips. For instance, Samsung has invested in PlayNitride in order to advance its micro-LED solutions. Also, TCL CSOT has formed a joint venture with San'an named Xiamen Extremely PQ Display Technology. Another example is Ennostar's partnership with AUO and Innolux for the development of micro-LED displays.

BOE hopes that, by joining forces with HC Semitek, it will be able to further strengthen its already advantageous position in micro/mini-LEDs. Furthermore, in BOE's efforts to develop related technologies, HC Semitek will provide significant support going forward.

In HC Semitek's view, the competition in the LED chip industry has become fiercer in recent years as suppliers such as MTC, San'an and Changelight release new production capacity. This year, the situation in the LED chip market is particularly challenging because of factors such as the resurgence of local COVID-19 outbreaks in China, the Russia–Ukraine military conflict, and ongoing global inflation. With a sharp drop in demand for end-products, the LED chip market has shifted to oversupply, and most LED chip suppliers now operate at a loss. Over these years, HC Semitek has been expanding into the high-end market segments such as mini-LED solutions and automotive LED solutions. However, this move has come at the expense of abandoning some segments of the low-end market. HC Semitek's share of the global LED chip market hence fell by 2 percentage points from 2020 to 7% in 2021, according to TrendForce's data.

TrendForce points out that BOE was among the investors that HC Semitek targeted in its latest share placement, which aimed to raise a total of about RMB2bn. The proceeds are to be used to build a base for not only the production of micro-LED wafers but also the packaging and testing of micro-LED chips. This capacity expansion project, in turn, is expected to raise market share and generate profit for HC Semitek. Additionally, by forming a close partnership with BOE, HC Semitek will be able to develop technologies that are more suited to the needs of end-customers, it is reckoned. Simultaneously, BOE will serve as a major sales channel for HC Semitek's micro/mini-LED chips.

www.trendforce.com
www.ledinside.com
/intelligence/purchase_mi

Table: Global Top 5 LED Chip Suppliers by Revenue Market Share for 2021 (Unit: US$ Million)

	Company	2021	2021 Market Share
1	San'an Optoelectronics	934	26%
2	Epistar	900	25%
3	Changelight	260	7%
4	HC Semitek	253	7%
5	MTC	216	6%
Total		3,610	

Note: Revenue calculations are based on companies' external sales.
Source: TrendForce, Nov., 2022

Lumileds completes financial restructuring and emerges from Chapter 11

Automotive business unit president Steve Barlow succeeds Matt Roney as CEO

LED product and lighting maker Lumileds Holding B.V. of San Jose, CA, USA has completed its financial restructuring and emerged from Chapter 11, having significantly de-leveraged its balance sheet and improved liquidity (reducing its funded debt by about $1.4bn). The firm is now owned by a new group of long-term institutional investors, including Anchorage Capital Group LLC, Nut Tree Capital Management LP and Cerberus Capital Management LP.

Also, Steve Barlow, president of Lumileds' Automotive business unit, is to be appointed CEO and to its board of directors, succeeding Matt Roney (effective on 11 November).

Barlow brings over 30 years of experience in the semiconductor and LED lighting industries and several decades at Lumileds, having most recently served as president of Lumileds' Automotive business unit and prior to that as president of the Lighting Solutions business unit. He first joined the firm in 2003 to help build its LED automotive, camera flash, display and lighting businesses as head of sales & marketing. He previously held management and sales roles at Hewlett Packard, Cree and Intematix Corp. Barlow holds an MBA from Santa Clara University and a B.S. in Electrical Engineering from San Jose State University.

We enter this next stage poised for further growth, positioned to capture opportunities, and in an improved position to address changing global market environments

"We are pleased to have completed this process effectively and within the timeframe we originally projected thanks to the support and dedication of our employees, customers, vendors, suppliers, and our new owners," says Roney. "It has been a privilege to lead this extraordinary company and team," he adds.

"Lumileds holds a strong position as industry leader and innovator, with incredibly talented and committed people," comments Barlow. "We enter this next stage poised for further growth, positioned to capture opportunities, and in an improved position to address changing global market environments."

www.lumileds.com

Lumileds again boosts LUXEON 5050 Round LED performance

Output and efficacy increased by 14% to 693lm and 178lm/W

On the sixth anniversary of its first 5050 LED, Lumileds LLC of San Jose, CA, USA has again raised the light output and efficacy of its LUXEON 5050 Round LED. Launched in October 2016, output and efficacy have increased by 14% to 693 lumens and 178 lumens per Watt at 4000K CCT (correlated color temperature) and 70CRI (color rendering index). Further, the portfolio (available via Lumileds' global distribution network) has grown in breadth and is claimed to be the only 5050 offering with a full array of CCT options at 70, 80, and 90 CRI.

"Sometimes the most obvious element is ignored even though it's the most important factor for a system," says product manager Mei Yi. "A round light-emitting surface is critically important if you want to achieve a symmetrical light distribution with pleasing uniformity and smooth transitions without jeopardizing optical efficiency, lens design complexity, and cost."

In fact, optical solution provider LEDiL lists more than 200 lens and reflector choices to address a wide variety of applications and design parameters.

The LM80 report for LUXEON 5050 covers 17,000 hours of testing, and Lumileds provides customers with a comprehensive and detailed analysis of 16 different test items including: High Temperature Operating Life, Hydrogen Sulfide Test (15ppm H2S, 40C, RH 80%), and Temperature Cycle. Lumileds also reports detailed flux, forward voltage and color maintenance data. The firm says that its extensive testing of LUXEON 5050 Round allows it to claim L70 and L90 above 100,000 hours.

The performance, efficacy and reliability of LUXEON 5050 Round (24V and 6V) and the fact that it's available in the full range of CCTs and CRIs mean that the LED is equally at home in indoor and outdoor applications where the quality of light, sustainability and cost-effectiveness are driving design factors, says Lumileds.

www.lumileds.com/products/high-power-leds/luxeon5050

Nitride Semiconductors releases micro-RGB + UV LED chips trial kit

620nm, 510nm and 450nm phosphors excited by micro-UV-LEDs

Nitride Semiconductors Co Ltd of Tokushima, Japan says that, in addition to micro-ultraviolet (UV) LEDs with a peak wavelength of 385nm, it has developed three types of indium gallium nitride (InGaN)-based visible micro-LEDs with peak wavelengths of 620nm for red, 510nm for green, and 450nm for blue, grown by metal-organic chemical vapor deposition (MOCVD) on a 4-inch or 6-inch sapphire substrate.

In 2018 the firm achieved high-efficiency light emission at a peak wavelength of 385nm from 12μm x 24μm micro-UV-LEDs (subsequently patented), and it has already supplied samples to many users. The firm has since also developed visible LEDs, in response to many customers requesting micro-sized chips for red, blue and green LEDs. In this case, especially for red LEDs (which are considered to be difficult to realize), InGaN has been used instead of the conventional materials gallium arsenide (GaAs) or gallium phosphide (GaP).

Nitride Semiconductors is developing displays by exciting three types of red, blue and green phosphors with micro-UV-LEDs. Furthermore, it has developed mass-production technology for red, green, blue microchips. So, users can achieve mass production of micro-LED displays through conventional method of mounting three types of micro-LED chips (red, blue and green).

To allow users to compare the characteristics of each color, Nitride Semiconductors has created a micro-RGB + UV LED chips trial kit (a complete set of micro-LEDs with four wavelengths: red, blue, green, and UV). Developers of micro-LED displays can hence try chips with various wavelengths and sizes and select the optimum chip for the mass production of micro-LED displays.

www.nitride.co.jp

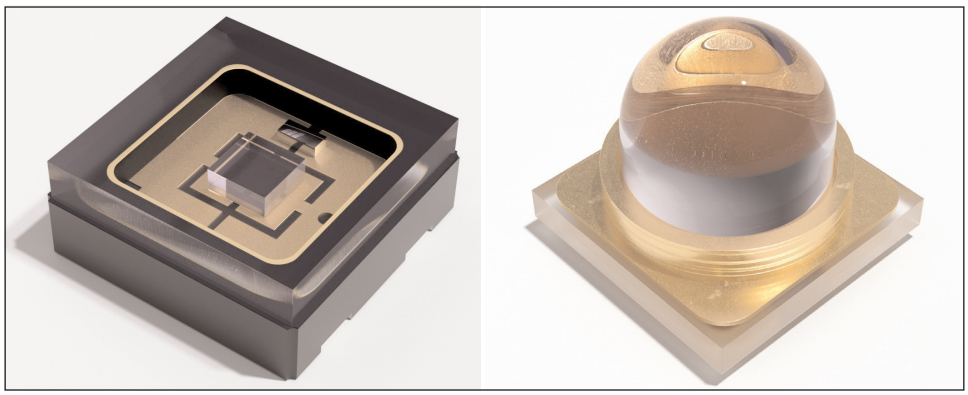
Silanna UV launches short-period superlattice based far UV-C 235nm LEDs and deep UV-C 255nm LEDs

Record output for mass-produced 235nm UV-C LEDs

Silanna UV of Brisbane, Australia has launched far UV-C and deep UV-C LEDs that take advantage of the firm's patented short-period superlattice (SPSL) technology for what it claims is industry-leading performance in the difficult-to-obtain 230–265nm UV range – including the highest output power in any mass-produced UV LED at 235nm.

Silanna UV says that its patented SPSL approach overcomes many of the difficulties that plague competing aluminium gallium nitride (AlGaN) UV-C LED technologies. By engineering a nanostructure from alternating layers of AlN and GaN, Silanna UV has developed a new material that is said to be easier to control and have far superior properties to traditional AlGaN. Silanna says that its SPSL mitigates several issues that AlGaN has for short-wavelength LEDs, particularly the older method's poor light extraction and electrical performance.

The new far UV-C 235nm SF1 series and deep UV-C 255nm SN3 series are both available in either 120º or 30º viewing-angle SMD packages, making them suitable for a wide range of applications. The 30º package's parabolic lens



provides greater irradiance than even traditional UV lamps, the firm says. Both the SF1 and SN3 series have low power consumption and long operating lifetimes.

The new LEDs are suitable for various deep UV and far UV sterilization, water and gas sensing, and instrumentation applications. The SF1 and SN3 series are powerful, small-footprint deep UV-C emitters that deliver long lifetimes and high conversion efficiency.

The 235nm peak-wavelength SF1 series comprises the 120º viewing-angle (SF1-3C3FWL1) and 30º viewing-angle (SF1-3U8P3L1). The far UV LEDs are effective for water quality detection of nitrate (NO_3) and nitrite (NO_2) gas detection and high-performance liquid chromatography (HPLC). Sensing applications can be enhanced by the higher irradiance of the SF1-3U8P3L1's 30º collimated source design.

The 255nm deep UV-C SN3 series is suitable for water quality applications, including UV254 organic compound sensors, chemical oxygen demand monitoring, and the measurement of suspended solids. Other application include ozone gas (O_3) detectors and medical analyzers. Both the 120º (SN3-5C3FWL1) and 30º (SN3-5U8P3L1) package versions are available. The 30º collimated source design of the SN3-5U8P3L1 package offers higher irradiance for enhanced resolution in sensing applications.

www.silannauv.com

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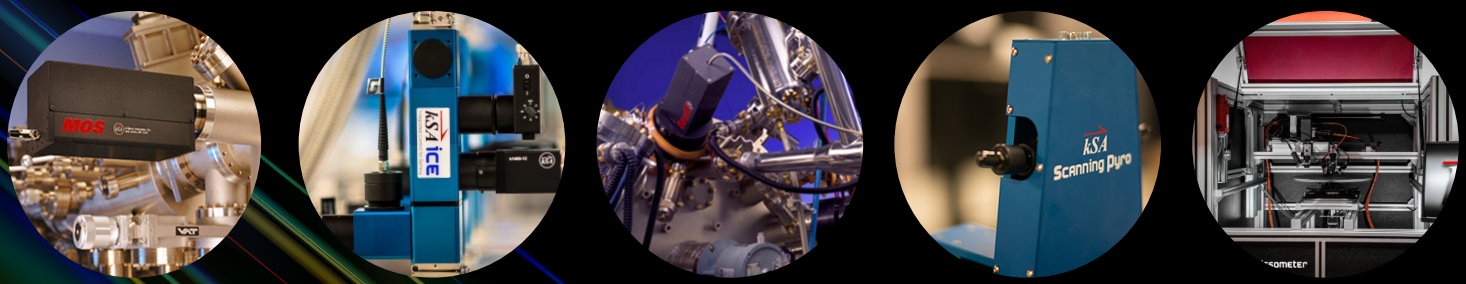

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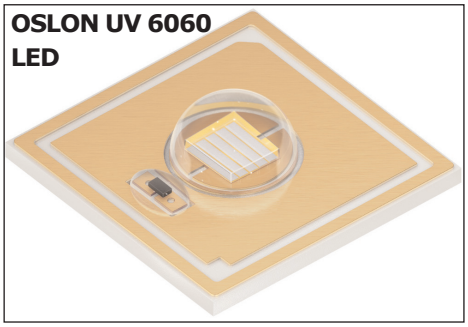
ams OSRAM launches 100mW UV-C LED with 5.7% WPE at peak germicidal wavelength of 265nm

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has complemented its high-power UV-C LED portfolio for purification applications by launching the OSLON UV 6060, which offers typical optical output power of 100mW from a single die source at 265nm (the emission wavelength that provides the highest germicidal effectiveness) combined with what is claimed to be market-leading wall-plug efficiency (WPE) of on average 5.7% (as per internal tests).

The firm says that the OSLON UV 6060 meets the needs of industrial applications delivering sustainable UV-C treatment solutions for a clean and purified environment. "We are accelerating the industrialization of UV-C LEDs in the growing field of purification and sanitization of air, surfaces and water," says senior product manager Nina Reiser. "The new OSLON UV-C LED is ideal for applications which require



OSLON UV 6060 LED

maximum germicidal effectiveness at high power levels while providing outstanding wall-plug efficiency," she adds. "There are a variety of benefits compared to traditional lighting technologies such as adaptability, compactness and instant-on functionality. However, UV-C LEDs gained momentum and enable, with its characteristics, on-demand purification in everyday applications."

The 200–280nm wavelength range (UV-C radiation from the sun) does not pass through the earth's atmosphere, which is why bacteria and viruses have evolutionary little or no defense mechanisms against it. If germs are irradiated with artificially generated UV-C radiation, it attacks the cell structure of microorganisms such as viruses or bacteria as it alters the microbial DNA, which disrupts their capability to replicate.

UV-C light has hence already been used for many years for purification applications. Compared with the bulky and wavelength-limited mercury vapor lamps used in the past, the aluminium gallium nitride (AlGaN)-based UV-C LED has a robust design. The compact 6mm x 6mm footprint gives the added benefit of flexible design for space-critical applications, allowing the LED to be installed directly at the point of use such as in washing machines or air conditioners. The high-power version of the OSLON UV family achieves on average 100mW of optical power from an injection current of 250mA.

OSLON P1616 high-power IR LEDs optimized for cameras

ams OSRAM has extended its OSLON P1616 family of small, high-power infrared LEDs, launching emitters that produce a field of illumination optimized for the square or rectangular field of view (FoV) of IR cameras. The OSLON P1616 products, which have a footprint of 1.6mm x 1.6mm, are said to be among the industry's smallest high-power IR LEDs. Also, a low profile makes them suitable for use in the face recognition camera system mounted in the thin bezel of a laptop computer, or in smart doorbells.

Benefiting from advanced optical technology, the new OSLON P1616 LEDs produce a precisely shaped beam that matches the square or rectangular FoV of IR cameras. The new LEDs provide up to 25% more light in the FoV and more homogeneous illumination than LEDs without dedicated optics and a pure Lambertian light distribution.

"These latest members of the P1616 family produce remarkably high optical output power from such a small package," says Dominic Bergmann, product marketing manager for the Visualization and Sensing business line. "The excellent performance-to-size ratio of these LEDs makes them the ideal solution for applications in which board space or height — or both — are limited."

The new LEDs' optimized beam shape reduces the development effort for manufacturers of IR camera modules and systems, providing more uniform illumination of the FoV and easing system calibration.

The new OSLON P1616 LEDs are:

- the 850nm SFH4172 and 940nm SFH4182S in a lensed package that is just 1.31mm high) produce homogeneous illumination that has a half-angle of ±65° to fit the square field of view of IR cameras;
- the 850nm SFH 41747 and 940nm SFH 41847S (in a lensed package 1.36mm high) produce homogeneous illumination with a 100° x 140° radiation pattern to fit the rectangular FoV of IR cameras.

The optical output (total radiant flux) from the new OSLON P1616 LEDs is 800mW for the SFH4172, 1320mW for the SFH4182S, 700mW for the SFH41747, and 1150mW for the SFH41847S.

In addition to laptop computers and smart doorbells, applications include CCTV cameras, access control, eye tracking and gesture recognition as well as emerging applications such as machine vision and medical treatment.

www.osram-os.com

CrayoNano launches CrayoLED H-series of UV-C LEDs

CLH-N3S optimized for disinfection at 275nm peak wavelength

CrayoNano AS of Trondheim, Norway — which develops and makes semiconductor components based on patented and proprietary nanomaterials technology — has launched the CrayoLED H-Series (CLH-N3S) of ultraviolet-C light-emitting diode (UV-C LED) packaged components. The firm says that CrayoLED's quality-driven design meets the high standards for reliability and performance in the fast-growing industrial and commercial disinfection and sanitization market.

"CrayoLED is a robust and powerful UV-C LED component tailored to the needs of our partners," says chief revenue officer Michael Peil. "Our team has developed — in close collaboration with our key customers — a high-performance, reliable technology that enables downstream improvements in disinfection that will ultimately result in a cleaner and safer environment."

The CrayoLED is optimized for disinfection at a typical peak wavelength of 275nm. Its small package footprint (3.5mm x 3.5mm) and high power performance (typically 80mW optical power at 350mA) easily integrates into systems for residential, commercial and industrial segments, enabling system miniaturization and longer-lasting solutions, CrayoNano says.

The CrayoLED H-series (CLH-N3S) is available in both sample quantities and in stock for volume production.

www.crayonano.com/uvc-led

Seoul wins high-power LED patent lawsuit in Germany

Preliminary injunction against LEDs made by Luminus and Lite-On and distributed by Mouser

South Korean LED maker Seoul Semiconductor Co Ltd has announced another victory in a patent infringement lawsuit against a global electronic components distributor of high-power LEDs in Germany. This continues Seoul's record of success in patent litigation.

In October, the Düsseldorf Court issued a preliminary injunction for infringement of Seoul's patent against various LEDs manufactured by Luminus Devices Inc and Lite-On Inc, and distributed by Mouser Electronics Inc.

Lite-On, which manufactured LEDs subject to the injunction, was also sued for patent infringement in the USA in April 2021 by Seoul's affiliate Sensor Electronic Technology Inc (SETi). Nitride Semiconductors Co Ltd and Nitek Inc have also filed patent infringement lawsuits against Lite-On in US courts.

Seoul and its affiliates say they have prioritized patent enforcement against companies that have refused to take responsibility for selling infringing products, including Seoul's prior litigation against Enplas Corp and Everlight Electronics Co Ltd.

In the past four years, Seoul has secured eight injunctions in Europe against the sale of infringing products, including cell phones, electronic home appliances, and general lighting products.

www.SeoulSemicon.com

Lowe's LED filament bulbs infringe EPISTAR patents

On 4 October, in 'EPISTAR Corp versus Lowe's Home Centers LLC', the United States District Court of the Central District of California issued its post-trial decision that confirmed the jury verdict that Lowe's Home Centers' LED filament bulbs infringed three patents of EPISTAR of Hsinchu, Taiwan (a subsidiary of Ennostar Inc) and rejected Lowe's arguments that challenged the validity of the EPISTAR patents, i.e. (1) US Patent No. 7,560,738 ('Light-Emitting Diode Array Having An Adhesive Layer'), (2) US Patent No. 8,492,780 ('Light-Emitting Device And Manufacturing Method Thereof'), and (3) US Patent No. 6,346,771 ('High Power LED Lamp').

In its decision, the court specifically upheld the jury finding that Lowe's LED filament bulbs manufactured by Zhejiang Yankon Group Co Ltd infringed claims 1-3 and 8 of the '738 Patent, claims 1, 3 and 7 of the '780 Patent and claim 38 of the '771 Patent.

The post-trial decision confirmed that each of the claims infringed by Lowe's were valid over the prior art.

EPISTAR says that it has invested millions of dollars in the R&D of LED technologies that has led to a patent portfolio consisting of more than 4000 issued patents and pending patent applications. This investment has laid the foundation of LED lighting technologies that have empowered products including the LED filament bulb at issue in this case. "Innovation is extremely important to the industry and should be respected and awarded fairly to drive the evolution of technology," says the firm. EPISTAR adds that it will continue its enforcement activities against those using its technology without authorization.

www.Lowes.com
www.epistar.com.tw

Kyocera develops first laser headlight with white and near-IR diodes on same optical axis

Automotive night-vision system based on single GaN laser device

Japan's Kyocera Corp has developed an Automotive Night Vision System that can accurately identify collision-risk objects in low-visibility driving conditions, such as at night, or in rain, snow, fog or smoke. The system is expected to reduce traffic accidents and promote safer driving.

The Automotive Night Vision features what is claimed to be the first laser-based headlight that can emit both white (RGB) and near-infrared (NIR) light on the same optical axis, eliminating image parallax and allowing higher-accuracy object recognition than alternative technologies.

The headlight incorporates an extremely bright, high-efficiency, miniaturized gallium nitride (GaN) laser developed by KYOCERA SLD Laser Inc. Furthermore, the system has automatic beam-shaping functionality for the RGB and NIR light that prevents glare for oncoming drivers by automatically shifting visible light into a low-beam pattern when necessary, while the NIR light can remain in high-beam mode.

The system integrates RGB–NIR sensors and a unique 'Image-Fusion AI Recognition Technology' (developed by Kyocera's Advanced Technology Laboratories) for high-performance object recognition. Instead of simply combining the image data from the two sources, Kyocera's system uses qualitative AI to compare and assess both RGB and NIR images, differentiating between pedestrians and vehicles with high accuracy even in low-visibility conditions.

In addition, the firm has developed another generative AI feature to create training data for more c ost-efficient learning and product development. Conventional methods require the collection of vast amounts of NIR training data (a time-consuming and costly process). Kyocera's AI technology generates training data automatically. This approach can significantly reduce training costs while maintaining high accuracy in recognition performance.

Kyocera says that it will continue R&D for this system, aiming for commercialization after 2027. The global market for automotive night vision systems was estimated to be $2.17bn+ in 2020 and is expected to grow at a compounded annual rate of more than 16.5% from 2020 to 2027.

www.kyocera-sldlaser.com

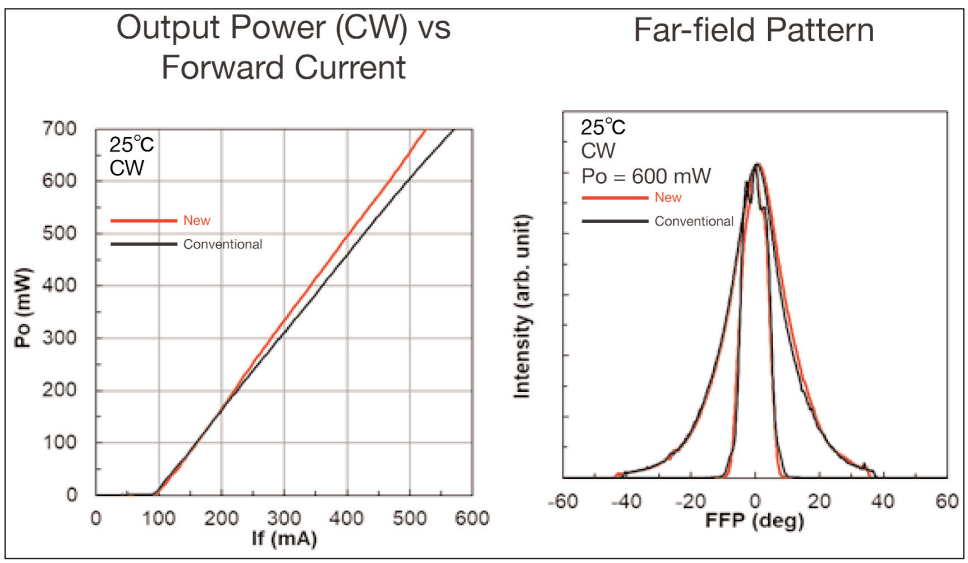
Ushio launches longer-life, 600mW ESD-resistant 405nm violet lasers

Zener diode provides increased voltage protection, doubling lifetime

Ushio Inc has launched the HL40173MG and HL40175MG 600mW (CW) 405nm violet laser diodes, which maintain pin layout compatibility with the conventional products (HL40113MG and HL40115MG) while achieving about twice the lifetime (mean-time-to-failure, MTTF).

Light source demand for mask-less (direct imaging) exposure systems, which expose high-definition circuit patterns on substrates, has grown significantly alongside consumer demand for smaller and higher-performance smartphones. There is also increasing demand for laser diodes in the 405nm violet band, with common usage in biomedical, measurement and 3D printing applications, and require further improvements in reliability and longer service life.

The HL40173MG and HL40175MG both feature a Zener diode in the 5.6mm CAN package as a built-in resistance to electrostatic discharge (ESD), over-voltage and reverse voltage, making them easier for customers to handle, the company says.



The firm adds that, due to the improvements over previously released 405nm, 600mW violet laser diodes, it encourages existing 405nm laser customers to consider switching to the HL40173MG and HL40175MG.

www.ushio.eu

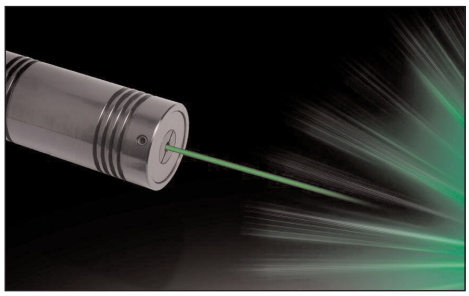
ams OSRAM launches 514nm laser diode as small, low-cost alternative to argon-ion lasers

PLT5 522FA_P family provides precision wavelength required in life science applications

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has released the Metal Can PLT5 522FA_P-M12, its first commercial off-the-shelf semiconductor laser emitter to produce the specific 514nm wavelength output required by many applications for life science in research and diagnostics.

The introduction of a 514nm (±1nm) laser diode as a standard, non-custom product enables manufacturers of scientific and measurement equipment to replace the argon-ion lasers that have traditionally been used to generate laser emission at a peak wavelength of 514.5nm. A semiconductor laser such as the PLT5 522FA_P-M12 is in general more cost-effective and much smaller than an argon-ion laser, has a longer operating lifetime, and eliminates the need for a cumbersome water cooling mechanism. The weight of a single-mode laser diode is just a few grams, compared with several kilograms for cooling and the power supply of an argon-ion laser.

Previous attempts to produce laser-diode-based 514nm emitter modules have been hampered by the substantial logistics effort required in the past to customize laser diodes binned by a specific wavelength, notes ams OSRAM. The new 514nm laser diode will enable customers to produce a narrow bandwidth using a volume Bragg grating (VBG) or external cavity design, reducing the bandwidth even further to <0.1nm for applications including Raman spectroscopy and holography.



ams OSRAM's Metal Can PLT5 522FA_P-M12 514nm laser.

The PLT5 522FA_P laser diode with 50mW optical power output at 514nm±1nm (Bin M12) is compatible with fluorescent dyes in the 514nm range as well as with various third-party lenses. This makes the laser diode suitable for many applications in the field of life sciences, including:

- flow cytometry, confocal microscopy and spectroscopy;
- material identification and analysis;
- diagnostics;
- DNA sequencing;
- forensic analysis.

The PLT5 522FA_P-M12 laser diode is supplied as standard parts manufactured by ams OSRAM and readily available via authorized sales channels.

"The scientific equipment market will benefit from a sustainable, production-friendly option to replace bulky, expensive argon-ion lasers with no loss of optical precision or performance," says senior product marketing manager Thomas Brandes. "The 514nm version of the PLT5 522FA_P laser diode family, which maintains performance within its operating parameters with a high degree of precision, provides exactly this option, enabling customers to reduce their materials cost and save space while enjoying the much longer lifetime before replacement of a high-quality laser diode," he adds.

Samples of the PLT5 522FA_P-M12 laser diode are available now. ams OSRAM is also developing a demonstrator module that combines the laser emitter with a driver and a lens to produce a collimated beam.

www.ams-osram.com

Ganvix and ITRI sign phase II deal extending JV to commercialize blue-green laser technology

First blue GaN VCSELs demoed using proprietary nanoporous GaN

Working with Taiwan's Industrial Technology Research Institute (ITRI), early-stage startup company Ganvix Inc of Wilmington, DE, USA, which specializes in the development of gallium nitride (GaN) vertical-cavity surface-emitting lasers (VCSELs), has completed the development of its first blue GaN lasers and signed a phase II agreement to extend their joint venture relationship (established in November 2021).

GaN VCSELs operating in the blue wavelength range have been demonstrated based on collaboration between the core technology of Ganvix's design and ITRI manufacturability.

Founded by Yale University's Dr Jung Han, Dr Rami Elafandy and Dr Jin-Ho Kim, Ganvix received funding from IP Group Inc, an intellectual property commercialization company that focuses on evolving ideas from its partner universities and national labs. Ganvix utilizes nanoporous technology to deliver compact, lightweight blue/green/ultraviolet (UV) VCSELs that produce what is said to be superior wavelength control, smaller spot size, and array architectures, allowing substantial innovation across a wide range of applications.

VCSELs based on gallium arsenide (GaAs) that operate in the infrared spectrum currently comprise one of the fastest-growing technologies in electro-optics. However, GaAs cannot emit light in the ultraviolet or visible (blue and green) wavelengths. For these applications, GaN is required, but there has been no commercially viable solution to form the laser cavity mirrors required until now. Ganvix says that it has solved this problem by using nanoporous technology to engineer the optical properties of GaN. The underlying nanoporous technology was developed by professor Jung Han at Yale over a period of more than a decade, is protected by more than 30 patents, and has been exclusively licensed by Ganvix.

"We are excited to announce the successful demonstration of blue VCSEL lasers using our proprietary nanoporous GaN fabricated in collaboration with ITRI. This marks a critical achievement enabling commercialization of these new laser devices," says CEO John Fijol. "We look forward to the next phase of our relationship working with ITRI to bring these devices to market," he adds.

The next phase of development under the agreement will include the following:

- expanding the wavelength range from blue to green;
- qualification testing (of environmental and lifetime testing);
- packaging of discreet lasers and laser arrays.

ITRI will continue to apply its capability and infrastructure to manufacture the electro-optic devices to accelerate Ganvix's time to market. The resulting products will address the nascent opportunity for high-performance, low-cost GaN VCSELs in billion-dollar global markets.

The target markets include consumer electronics, industrial, medical and life sciences, communications, and metaverse applications such as augmented reality (AR). Near-term applications include red, green and blue VCSEL light engines for laser scanning displays, lasers and laser arrays for free space and polymer fiber-based communications.

"For future Metaverse applications, the three-primary-color VCSELs will play a key role," comments Dr Shih-Chieh Chang, general director of ITRI's Electronic and Optoelectronic System Research Laboratories. "We are very happy to continue to deepen the cooperation with Ganvix and launch commercialized products, which can also drive Taiwanese industries to enter the Metaverse market."

www.itri.org.tw/eng

BluGlass demos feasible reliability of GaN laser diodes

Lasers pass 500 hours of continuous operation with stable optical and electrical performance

BluGlass Ltd of Silverwater, Australia — which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — says that its gallium nitride (GaN) laser diodes have achieved feasible reliability, demonstrating more than 500 hours of continuous operation with stable optical power and voltage in reliability testing.

BluGlass adds that the lasers maintained good performance during testing at 20-25°C, demonstrating light output with less than 20% degradation — a key commercial standard for laser diodes. Reliability testing of these lasers is ongoing.

Reliability feasibility is a critical prerequisite milestone for beta production and commercial product launches. BluGlass says that these performance metrics enable it to increase its engagement with potential customers awaiting alpha and beta products, and indicate that the design is ready for increased volume.

Improvements in reliability are directly attributable to enhanced metals, facets and bonds, completed by BluGlass' contract manufacturers. Newer iterations with further improvements to the four key components of laser diodes are currently progressing through BluGlass' supply chain, and the firm is working to increase manufacturing quality and yields with its Silicon Valley production facility and team.

"Demonstrating reliable laser diodes is a significant milestone, reflecting the suitability of our lasers for use in a vast number of applications," says president Jim Haden. "Commercial reliability is not a one-size fits all approach, varying greatly depending on the application. At one end of the spectrum, we have single-use applications such as pyrotechnics, which require one-shot reliability and good 'shelf-life.' At the other end of the spectrum are very sophisticated space-based and industrial applications, which often require reliability of more than 10,000 hours and even years of operation. Many applications, including medical and scientific applications, require less than 1000 hours' reliability," he adds.

"Reliability testing is ongoing and, with our recent achievements and progress, we are moving toward a fixed beta design. This reliability milestone also enables us to increase our engagement with customers who are eagerly awaiting products to meet unmet market needs," continues Haden.

"Encouragingly, we have achieved these results with older iterations made by our contract manufacturers. We expect current iterations featuring new epitaxy designs and enhanced processing through our Silicon Valley fab will demonstrate improved yield, reliability and performance as we continue to refine our laser diodes ahead of product launches."

www.bluglass.com.au

Coherent promotes Optoelectronic Devices and Modules general manager to chief technology officer

Eng to focus on extending technology platforms across company

Materials, networking and laser technology firm Coherent Corp says that Dr Julie Sheridan Eng, previously senior VP & general manager of Optoelectronic Devices and Modules, has become its chief technology officer.

"The appointment of Julie Eng as chief technology officer not only recognizes her sustained contributions to the development of an entire industry but also reveals an important step in the evolution of our exciting growth plans," says chair & CEO Dr Vincent D Mattera Jr. "Dr Eng will focus on Coherent's future technology platforms that will enable us to address the long-term and irreversible market trends that are core to our strategy and to our drive for sustainably profitable growth," he adds. "She will focus on the opportunity for us to extend our technology platforms across the company including the creation of new materials for energy generation, transmission and storage, basic research around next-generation quantum technologies, breakthroughs required for the sixth generation of wireless networks, and the adoption of digital technologies, machine learning, and artificial intelligence across our operations and in our products and services."

Julie Sheridan Eng.

As senior VP & general manager of the Optoelectronic Devices and Modules business unit, Eng oversaw engineering, product management and operations for gallium arsenide (GaAs) vertical-cavity surface-emitting lasers (VCSELs), indium phosphide (InP) directly modulated lasers (DMLs) and detectors, and CMOS/BiCMOS integrated circuits for datacom, 3D sensing and high-volume consumer applications.

Previous to Coherent, Eng held senior management positions at Finisar Corp since 2003, including executive VP & general manager of 3D Sensing and executive VP of Datacom Engineering. Over the 15 years that she managed datacom and transceiver engineering, her teams released over 180 fiber-optic transceiver products and achieved numerous industry firsts. Eng began her career at AT&T Bell Laboratories, where she led the development of laser-based datacom transceivers.

Eng has been an advocate of women's contributions to STEM. She is a past chair of the IEEE Committee on Women in Engineering and presently serves on the SPIE Executive Advisory Group. She has published over a dozen papers, co-authored a book chapter, holds six US patents, and has given numerous invited talks. Eng graduated summa cum laude from Bryn Mawr College with a bachelor's degree in Physics and also holds a B.S. in Electrical Engineering with honors from the California Institute of Technology (Caltech). She also earned M.S. and Ph.D. degrees in Electrical Engineering from Stanford University. In 2022, Eng was elected a Fellow of Optica (formerly the Optical Society of America) for distinguished contributions to the advancement of optics and photonics.

www.coherent.com

Vector Photonics' CTO wins IET's Sir Henry Royce Memorial Foundation Medal

Richard Taylor honored for developing all-semiconductor PCSELs

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK says that its chief technology officer Dr Richard Taylor has won the Sir Henry Royce Memorial Foundation Medal at the annual IET (Institution of Engineering and Technology) Achievement Awards, which aim to recognize and inspire engineering excellence.

The Sir Henry Royce Medal is awarded to individuals who have made an exceptional contribution to the advancement of science, engineering or technology. The award is for Early Career Professionals who have excelled in the workplace within the last three years.

Dr Richard Taylor.

Vector Photonics says that Taylor is recognized globally for his pioneering work in developing all-semiconductor PCSELs, which are claimed to deliver a unique combination of low cost with high speed and power. This technology development led him to co-found Vector Photonics in 2020. The firm is focused on commercializing the technology for fast-growing data communications, metal and plastic printing, LiDAR, and optical sensing markets.

Vector Photonics' design engineer O'Dowd short-listed for TechWomen100 awards

WeAreTechWomen initiative helping to raise profile of women in technology

Vector Photonics' design engineer Anna O'Dowd has been short-listed for the TechWomen100 awards, a WeAreTechWomen initiative helping to raise the profile of women in technology.

WeAreTechWomen aims to increase the number of women in tech; support companies wishing to attract, retain and develop female talent; upskill and enhance womens' careers; encourage girls into STEM; and share effective initiatives that build awareness of successful women in technology careers.

At Vector Photonics O'Dowd has built a design simulation package for the company's all-semiconductor, PCSEL devices that allows multiple elements of a PCSEL to be designed simultaneously, accelerating commercialization of the technology into data-center and co-located optics markets.

Design engineer Anna O'Dowd.

"It's a privilege to work in Vector Photonics on PCSELs, a new class of laser. It is exciting to be involved from the beginning, making me one of the first women in the sector," says O'Dowd. "I am passionate about science and technology and see these awards as my chance to role model, influence and mentor other women," she adds. "Vector Photonics has supported OUP (Opening up Photonics) since the beginning, which champions inclusivity, accessibility and diversity, and we have staff on its steering committee. The TechWomen100 awards align with that agenda."

O'Dowd has a first-class degree in Physics with Particle Physics and Cosmology, from Lancaster University, where she was amongst the top students, course representative and Physics ambassador. She went on to do an MSc in Nanoscience and Nanotechnology at the University of Glasgow — graduating top in her class. She is a member of the Institute of Engineering and Technology (IET) and is currently working towards chartered engineer status.

www.wearetechwomen.com/

Spain launches its first commercial III–Vs foundry, targeting integrated photonics

SPARC (III–V Semiconductor Foundry and Advanced Photonics Research Center) to be operational in late 2023

The city of Vigo in Spain is to be the location of a new foundry for III–V semiconductor-based photonics. SPARC (the III–V Semiconductor Foundry and Advanced Photonics Research Center) will have a 1600m^2 cleanroom for wafer production, and assist customers in bringing fully certified integrated photonic products to market.

SPARC aims to capitalize on the potential of gallium arsenide (GaAs), indium phosphide (InP), gallium nitride (GaN) etc to accommodate the increasing number of markets and applications that rely heavily on photonics and high-speed electronics.

SPARC aims to capitalize on the potential of GaAs, InP, GaN etc to accommodate the increasing number of markets and applications

Specifically, it targets having the capability and capacity to address a large customer base across a wide range of markets including optical communications, displays, lighting, aerospace, automotive, biomedical, sensing, and quantum technologies, as well as high-speed and/or high-power electronic applications.

SPARC should be operational in about late 2023.

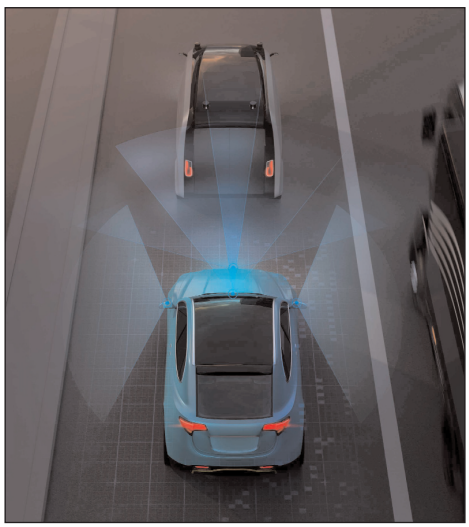
www.sparcfoundry.com

TRUMPF adds multi-junction option for VCSEL arrays

Greater system efficiency supports miniaturization trends in consumer electronics and automotive

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets — says that it is supporting the demand for miniaturization in consumer electronics and automotive applications by expanding its VCSEL array portfolio with a multi-junction option.

The tunnel function technology is said to offer a highly efficient solution for the demanding trend towards miniaturization. With tunnel functions, the performance of a single VCSEL is increased, as multiple active zones are put into series in the same VCSEL component. Up to three times the output can be generated from the same VCSEL device. Most illumination applications benefit from higher efficiency and increase in output power with the same VCSEL light source. "Our customers also benefit from an increase in flexibility," says Alexander Weigl, head of product management. "Based on their application needs, they can configure their VCSEL components with a single, double or triple junction."



Multi-junction VCSELs support LiDAR applications, which require high output power within limited space.

The multi-junction technology supports applications such as light detection & ranging (LiDAR), as this application in the automotive sector requires high output power within limited space for the short- and long-range identification of objects. "We even combine the multi-junction technology with our ViBO technology platform," says Weigl. "Due to our integration approach to make our VCSELs smarter, this unique VCSEL comes with integrated backside optics and is already up to 5–10 times smaller compared to other VCSELs," he adds. "This is a big step towards miniaturization, while increasing output power and reliability of the VCSEL components."

VCSELs will remain a major light source for applications in smartphones, consumer electronics and automotive applications, reckons TRUMPF, as they are highly efficient and boast a long service life. Based on the application requirements, the firm offers options with highly integrated optical structures for the best fit. Therefore, along with the multi-junction option and monolithically integrated optics, VCSELs can offer polarization control for improved illumination quality, or integrated photodiodes to enable the further processing of light signals.

To offer robust VCSEL devices with high performance, TRUMPF covers the whole process chain, from the developing and designing right to its manufacturing of its VCSELs solutions.

www.trumpf.com/s/VCSEL-solutions

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OpenLight makes available PDK for first unified electronic and photonic design platform

Fast, accurate and reliable photonic IC designs with on-chip lasers

To streamline the end-to-end design of photonic integrated circuits (PICs) and meet future demands of applications including datacom, telecom, LiDAR, healthcare, high-performance computing (HPC), artificial intelligence (AI) and optical computing, OpenLight of Santa Barbara, CA, USA has announced the general availability of its process design kit (PDK).

OpenLight launched as an independent company in June, introducing the world's first open silicon photonics platform with integrated lasers to improve the performance, power efficiency and reliability of designs. The firm says that it is already seeing success among customers with its first 400G and 800G reference designs with integrated lasers made available this summer.

The OpenLight PDK is now ready to be used with the Synopsys photonic IC design solution, and includes indium phosphide (InP) active optical elements on-chip that can be directly used by Synopsys OptoCompiler and simulated with the Synopsys OptSim photonic simulator, providing a superior method to create PICs with optical amplifiers, on-chip lasers, and high-speed, low-loss modulators tailored to design requirements.

Customers can access an extensive library of tested and proven photonic components to enhance first-time PIC success and deliver more reliable design and fabrication. The technology has passed qualification and reliability tests on Tower Semiconductor's silicon photonics production flow (PH18DA).

"We strongly believe in the ability of OpenLight's technology implemented in Tower's foundry platform to push the envelope and enable the next generation of photonic IC products," comments Dr Marco Racanelli, senior VP & general manager of Tower Semiconductor's Analog business unit. "With PDKs now available to the world, mutual customers can benefit from access to this advanced technology through an open foundry model," he adds. "Results of PICs fabricated to date are impressive and the PDK announced here will speed up further PIC innovation from the industry as designers confidently develop and bring to market new products faster with on-chip lasers and optical amplifiers."

Synopsys supports OpenLight's PDK through Synopsys OptoCompiler, bridging the gap between photonic experts and IC designers to make photonic designs as productive as electronic designs. Synopsys OptoCompiler is a complete end-to-end design, verification and signoff solution for photonic ICs. The solution combines specific capabilities for photonic design with industry-proven electronic design methods in a unique, unified platform to make photonic IC design accessible, fast and flexible.

"The combination of Synopsys' industry-leading photonic IC design solution and OpenLight's integrated laser technology in one cohesive platform empowers teams to design real-world PICs in a way that has never been done before," says Aveek Sarkar, VP of engineering at Synopsys. "We look forward to supporting mutual customers together with Tower and OpenLight to accelerate adoption of silicon photonics with integrated lasers," he adds.

"Until now, there has never been an open silicon photonics platform with active on-chip optical elements," says OpenLight's chief operating officer Dr Thomas Mader. "We are at the vanguard of discovering the extent to which integrated lasers can reduce barriers to entry and transform the way teams design PICs for a large variety of applications," he adds. "With the general release of the PDK, OpenLight is also reducing barriers to entry on the design side, enabling customers to quickly design PICs and get to market and production faster. This is just the beginning, and we expect to see continued scale, speed and power advancements from our platform."

www.openlightphotonics.com
www.synopsys.com/photonic-solutions/optocompiler.html

Ayar granted $15m for US DoD Project KANAGAWA

Chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA has been awarded a $15m multi-year prototype Other Transaction Agreement (OTA) in support of Project KANAGAWA (Co-Packaged Analog-Drive High-Bandwidth Optical Input/Output). The OTA, a non-traditional government contracting method for fast-tracking research and innovation, was issued by Naval Surface Warfare Center (NSWC) Crane Division to support the Office of the Under Secretary of Defense, Research & Engineering (OUSD(R&E)) Trusted & Assured Microelectronics (T&AM) program.

The project will promote the next-level development of Ayar's optical interconnects to lead its transition into the Defense Department's advanced packaging ecosystem.

"We look forward to working closely with Ayar Labs as part of Project KANAGAWA to benchmark its optical I/O chiplets and lasers toward the transition of this technology into large-scale defense applications," says Dr Joshua Hawke, chief engineer of RF & Optoelectronics, NSWC Crane, Radar Technologies Division and execution lead of the OUSD(R&E) Trusted & Assured Microelectronics program.

During the first phase of Project KANAGAWA (Task A), Ayar Labs will deliver its optical I/O chiplets and lasers at data-rate bandwidth levels exceeding 2Tbps and energy losses below 5pJ/bit. In phase two of the project, running parallel to Task A, Ayar will collaborate with Intel, Lockheed Martin and Qorvo to develop and demonstrate co-packaged optical I/O solutions built on TeraPHY optical I/O chiplets and SuperNova multi-wavelength lasers, with the goal of advancing the supply chain ecosystem for domestic manufacturing of Ayar Labs' optical I/O solution.

"Project KANAGAWA comes at an important time for both our nation and Ayar Labs as we look to mature US-based manufacturing for our optical I/O solutions," says Ayar's CEO Charles Wuischpard. "We are excited to partner with the DoD, Intel, Lockheed Martin and Qorvo to not only strengthen our nation's security by establishing domestic production of our optical I/O chiplets but also introduce next-generation defense architectures and systems," he adds.

Co-packaged optics, which brings together photonic integrated circuits with electronic integrated circuits inside multi-chip packages (MCP), extends the reach of high-bandwidth data I/O. MCPs leveraging Ayar's optical I/O are poised to significantly expand the capabilities of defense microelectronics. For example, this technology can generate much higher data rates from the field-programmable gate arrays (FPGA) that process digital beamforming signals, opening the door to new phased-array radar architectures.

www.ayarlabs.com

VPs of products, strategy & ecosystem and manufacturing & operations

To further its commercial development, Ayar Labs has expanded its executive team by adding Lakshmikant (LK) Bhupathi as VP of products, strategy & ecosystem and Scott Clark as VP of manufacturing & operations.

In these newly created roles, Bhupathi and Clark will focus on product management, manufacturing, supply chain, ecosystem and partner development to build scale for Ayar's optical I/O solution with new and existing partners and customers such as NVIDIA, Intel, Hewlett Packard Enterprise, Lockheed Martin, GlobalFoundries, Lumentum, Macom and Sivers.

"As Ayar Labs moves aggressively into the production of our core optical I/O technology, we're turning our attention to scaling commercial efforts and expanding our product line both horizontally and vertically," says CEO Charles Wuischpard. "LK and Scott play a critical role in helping position us for the next exciting phase of growth as we lead not just the technical development but also the production of optical I/O."

Bhupathi joins Ayar after 20 years with Marvell Semiconductor in design, technical marketing and product roles, including a position as VP, product management/marketing at high-performance networking company Aquantia (acquired by Marvell), as well as driving CXL and Ethernet NIC product strategy and roadmap for Marvell's next-generation cloud and enterprise data-center applications. Bhupathi also served as the president and marketing chair for the NBASE-T alliance (since merged with the Ethernet Alliance).

Clark has extensive manufacturing, supply chain and operations senior leadership experience, most recently as VP of supply chain at Corsair Gaming. He has spent the past two decades leading global supply chain management, procurement, operations and manufacturing transformations for public and private companies, including in the optical market and a period living and working in Asia, through roles at Allied Telesis in Japan, Stratalight Communications (acquired by OpNext), Arecont Vision, AOptix Technologies and Tascent (a spin-off of AOptix).

Ayar has also expanded its office footprint in the San Francisco Bay Area and opened a new office in Cambridge, MA, USA. The new office in San Jose, CA has eight times as much cleanroom space as the existing Santa Clara office and will facilitate the firm's test, measurement, validation and qualification efforts (completion of this move is planned for early 2023).

POET unveils 800G & 1.6T optical engines for hyperscale data centers

High-speed DMLs and photodiodes, integrated drivers and TIAs combine with wafer-level chip-scale packaging

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — is to use directly modulated lasers (DMLs) with integrated drivers in its transmit optical engines and high-speed photodiodes and integrated transimpedance amplifiers (TIAs) in its receive optical engines to enable low-power, cost-efficient and highly scalable 800G and 1.6T pluggable transceivers for hyperscale data centers.

Working with what's described as a market-leading designer and manufacturer of lasers, POET's optical engines will be the industry's first implementation of DMLs at these data rates, it is reckoned. POET will use the DMLs for its modulator-free design of its 400G transmit engine. Its small size and chip-on-board design will allow 800G and 1.6T designs to easily fit in an industry-standard 1.6T OSFP-XD form factor. DML technology has a proven track record of enabling high-volume transceiver deployments at every generation of speeds in hyperscale data centers. The 100G PAM4 DML passively integrated on the POET optical engine not only addresses existing 400G solutions at mass volume but also enables future intra-data-center interconnects as the industry moves to higher speeds.

"POET's optical engines are 'photonic chiplets', unique to POET, which enable a scalable, elegant solution to module design that can extend the use of pluggable transceivers in data centers to 1.6T and even 3.2T," says chairman & CEO Dr Suresh Venkatesan. "Extending pluggables to these speeds with industry-standard form factors was previously thought to be impossible but, because of the small size and extent of integration of devices in our optical engines, data-center customers will have more flexibility in network design than ever before," he adds. "As we continue to integrate more devices on our platform we build more value into our optical engines, increase transceiver module performance, reduce power and cost, and provide unparalleled levels of flexibility for data-center customers."

POET says that pluggable transceiver customers will benefit from its proven optical engine platform with chip-scale assembly, monolithically integrated multiplexer/demultiplexer and passive alignments for use in 400G, 800G and 1.6T FR4 modules. The optical engine solutions will simplify the transceiver design and eliminate the need for cumbersome and costly active alignments, it adds.

POET expects to start sampling 800G/1.6T optical engines in first-half 2023.

www.poet-technologies.com

Lumentum's high-speed DMLs to be used in POET's 400G FR4 transmit optical engines

Chiplets enable 400G/800G/1.6T pluggable transceivers for hyperscale data centers

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — is to use high-speed directly modulated laser (DML) technology from Lumentum Holdings Inc of San Jose, CA, USA in its transmit optical engines to enable high-volume, low-power and cost-efficient 400G, 800G and 1.6T pluggable transceivers for hyperscale data centers.

Working with Lumentum, POET expects to start sampling the 400G FR4 transmit optical engines with integrated drivers in first-half 2023 and production by second-half 2023. The 400G FR4 optical engines are architected as photonic chiplets and will be the industry's first implementation of DMLs with flip-chip integration on an optical interposer at these data rates, POET says.

With the small size and design of POET's optical engines, customers will have the flexibility to design 400G, 800G and 1.6T pluggable transceivers using the same 400G FR4 chiplets.

"The majority of the 400G transceivers in the market today use either externally modulated lasers or silicon photonics combined with external lasers. These solutions require multiple components and involve several cumbersome and costly active alignments," notes POET's chairman & CEO Suresh Venkatesan. "POET has a significant opportunity to disrupt the market with a highly integrated solution with all-passive alignments and monolithically integrated waveguides and multiplexers, which translates to lower cost, power and size benefits to our customers," he adds.

"With the continued deployment of 400G, plus 800G on the horizon in hyperscale data centers, there is a need for laser technologies that lower power consumption and cost and are easier to scale to high volumes," says Wupen Yuen, Lumentum's senior VP & general manager of the Datacom business unit. "Lumentum's high-performance 100G DML provides customers with an additional laser technology choice to help them optimize their transceiver solutions to best meet the needs of hyperscale data-center operators while leveraging Lumentum's proven high-speed laser manufacturing scale and quality."

The market opportunity for 400G/800G/1.6T pluggable transceivers is forecasted in LightCounting's April 2022 report to grow from $2bn in 2023 to $6.5bn in 2027.

www.lumentum.com
www.poet-technologies.com

CompoundTek collaborates with Siemens and Ansys to launch PDK 3.0

18 new and enhanced components boost performance in both O and C wavelength bands

Singapore-based silicon photonic (SiPh) foundry services provider CompoundTek Pte Ltd has partnered with Siemens Digital Industries Software and Ansys-Lumerical to develop and release CompoundTek's process design kit (PDK) version 3.0. With the vision of enabling best-in-class photonic circuit simulation for customers, PDK 3.0's Component Model Library (CML) offers new elements and enhanced performance.

Formerly Mentor Graphics, Siemens' Electronic Design Automation (EDA) solutions provide a broad array of design and verification

solutions for photonic designers, including L-Edit Photonics and LightSuite Photonic Compiler, both of which work with CompoundTek's PDK 3.0. These tools provide productivity improvements for photonics experts and IC designers through automation and custom layout. Siemens' Calibre verification platform, which includes Calibre nmDRC with its proprietary equation-based functionally, has extended its golden signoff status to include silicon photonic designs.

A total of 18 new components/enhanced performance in both O and C wavelength bands; SiN Y-splitter, SOI Y-splitter, SiN MMI 1x1, SiN MMI 2x2 and new black box cells etc are added in this latest PDK release.

https://compoundtek.com

5N Plus renews and increases multi-year supply agreement with First Solar

Production capacity to grow 35% in 2023 and more than double by 2024

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada has renewed and increased its multi-year agreement for the supply of semiconductor materials for the manufacture of cadmium telluride (CdTe) thin-film photovoltaic (PV) modules by First Solar Inc of Tempe, AZ, USA

This latest agreement is the largest award to date and signals a transition to higher volumes of value-added compound semiconductor materials. In line with First Solar's recently announced growth plans, annual volume is expected to increase by 35% in 2023 and by more than 100% in 2024 from current levels.

As with previous agreements, the contract is structured asymmetrically, allowing 5N Plus to make the necessary planned investments in its Montreal facility to significantly increase the domestic supply of materials to the North American market by late 2023, incrementally to its current international offering. Investments in 5N Plus' manufacturing assets to increase production capacity will be in addition to those already being made to consolidate the firm's recycling and refining activities in Montreal. 5N Plus is also expanding the development and manufacturing of critical materials, including advanced semiconductor compounds and engineered powders used in solar, medical and security technologies, at this location.

"Not only does this renewal stand as a testament to the strong 15-year partnership between 5N Plus and First Solar but also to our essential role and the unique expertise we bring to critical industries, offering sustainable sourcing solutions," says 5N Plus' president & CEO Gervais Jacques. "As we execute on our strategy focused on value-added business opportunities, this agreement further cements our standing as a leading global supplier of engineered semiconductor compounds to the thin-film renewable energy industry. We remain extremely motivated by the sector's long-term outlook and the opportunities ahead for 5N Plus," he adds.

"As we continue to scale our ability to deliver responsibly produced PV modules in support of America's transition to a sustainable energy future, it is crucial that we can rely on a partner like 5N Plus to deliver the semiconductor materials we need," says Mike Koralewski, chief manufacturing operations officer, First Solar. "We're pleased to renew this already long-standing relationship and look forward to working with 5N Plus as we work to grow our global annual capacity to more than 20GW by 2025."

5N Plus' specialty semiconductor materials are used in First Solar's Series 6 and 7 PV modules. First Solar PV modules currently deliver carbon and water footprints that are reckoned to be 2–3 times lower than crystalline silicon PV panels. As part of the agreement in place, 5N Plus and First Solar will also collaborate on developing and supplying other renewable energy products to support the growth and improvement of cadmium telluride thin-film technology.

www.5nplus.com
www.firstsolar.com

5N Plus' AZUR to supply new space solar cell to Sierra

Ten-year extension to exclusive teaming arrangement

Through its subsidiary AZUR SPACE Solar Power GmbH of Heilbronn, Germany (acquired in 2021, which makes multi-junction solar cells based on III-V compound semiconductor materials), 5N Plus has signed a ten-year extension to its exclusive teaming arrangement with US-based commercial space company Sierra Space.

AZUR will produce the new MWT solar cell, for use exclusively in the production of Sierra Space's patented Space Solar Surface Mount Technology solar array systems. Developed in partnership by both companies, this solar cell technology enables automated production and assembly, and is expected to revolutionize solar array cost of assembly, resiliency and power density. The MWT solar cells enable arrays with higher power density, reducing the size of the arrays for equivalent power of a conventional design. They are also more cost-effective when completing the laydown to satellite solar power arrays. The automation enables Sierra Space to deliver solar power arrays with less than one-half of the conventional array lead times. In addition, the panel configurations can be easily modified for specific applications and accommodate a wide range of power levels, from a few watts to Megawatts.

"This strategic agreement is the culmination of several years of collaboration between AZUR and Sierra Space and we are extremely proud to begin a commercial relationship with a space industry innovator," comments 5N Plus' president & CEO Gervais Jacques. "AZUR continues to expand its global client base as the partner of choice in high-end solar cell technology, further reinforcing 5N Plus' leadership as a trusted partner for the supply of critical specialty semiconductor materials for sectors powering the future both on Earth and in space."

The innovation comes at a time when demand for solar power for space applications is rapidly accelerating and is expected to exceed existing available capacity. According to independent market studies, the global space power market is expected to increase approximately tenfold by 2030 from 2019 levels, with solar cells representing the largest growth outlook.

"This agreement will be incremental to AZUR's earnings/revenues, which are expected to become more meaningful over time as we mutually ramp up capacity to meet the growing demand in this critical sector," says Jacques. "This aligns with our long-term strategy of focusing on value-added markets that present strong opportunities to leverage our expertise and expand our total addressable markets."

www.azurspace.com

Arevon secures 2GW supply of First Solar's Series 7 modules

Arevon Energy Inc of Scottsdale, AZ and New York City (which supplies renewable energy to utilities and corporations across North America) has secured a more than $2GW_{DC}$ supply of Series 7 CdTe PV modules from First Solar to support its growing renewable energy portfolio. About $700MW_{DC}$ of the total volume secured includes purchase orders issued prior to the release of First Solar's Q2/2022 earnings in July. These orders will add to Arevon's existing 2GW portfolio of operating assets with First Solar modules and will support projects under development in the Midwest and Southwest regions of the USA.

A September forecast from Wood Mackenzie estimates that, due to recent legislation, the USA saw its largest quarter-on-quarter growth, with 10GW of new utility-scale solar capacity contracts. These orders for modules will ensure that Arevon can execute projects planned to deploy in the next five years.

"We are pleased to further expand our relationship with First Solar and contribute to the expansion of the US solar value chain," says Arevon's CEO John Breckenridge. "Sourcing American solar technology from First Solar allows us certainty of supply and helps mitigate the risk of supply shortages and project delays. More broadly, it also allows us to support US innovation in photovoltaics, and the expansion of domestic solar manufacturing capacity through our procurement strategy."

Designed and developed at its R&D centers in California and Ohio, First Solar's modules, which are also claimed to have the lowest carbon and water footprint of any commercially available PV technology currently, will support Arevon's project pipeline through 2027.

"These multi-year orders reflects a broader trend in the industry where developers are de-risking their project portfolios with strategic, long-term procurement frameworks and sourcing American solar," says First Solar's chief commercial officer Georges Antoun. "We are proud to be in a position to enable the growth of leading American developers like Arevon, by providing them with the certainty and long-term visibility they need."

Developed in collaboration with engineering, procurement & construction (EPC) firms, and structure and component providers, Series 7 modules combine First Solar's CdTe technology with a larger form factor and a new back rail mounting system to deliver improved efficiency, enhanced installation velocity, and superior lifetime energy performance for US utility-scale PV projects.

www.arevonenergy.com

First Solar investing $270m in R&D innovation center in Perrysburg, Ohio

New 1.3 million square-foot facility to fast-track validation of technology and process improvements

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA plans to invest $270m in a dedicated R&D innovation center near its existing manufacturing facility in Perrysburg, Ohio. The new facility is believed to be the first of its scale in the USA.

Covering an area of about 1.3 million square feet, the new R&D center will feature a pilot manufacturing line allowing the production of full-sized prototypes of thin-film and tandem PV modules. Contingent upon permitting and pending approval of various state, regional and local incentives, the facility is expected to be completed in 2024.

"With a record shipment backlog and consistent demand for our modules, we face the twin challenges of optimizing existing and planned production capacity to deliver on our commitments, while ensuring that our technology roadmap does not lose momentum," notes CEO Mark Widmar. "This investment allows us to create an R&D sandbox separate from our commercial manufacturing operations, ensuring that we can accelerate innovation without the cost of taking mission-critical tools offline."

First Solar, which has already invested over $1.5bn in R&D, currently operates a dual purpose manufacturing line in Perrysburg that handles both commercial production of solar modules and product development efforts. However, the line cannot handle both activities simultaneously.

"This new facility will play a pivotal role in solidifying America's leadership in the development and responsible production of high-performance thin-film photovoltaic semiconductors," believes chief

technology officer Markus Gloeckler. "This facility will be designed with the future in mind, and we expect that it will directly enable the next generation of advanced photovoltaics."

First Solar is unique among the world's ten largest solar manufacturers for being the only US-headquartered company and only manufacturer of thin-film PV modules. The firm says that its investment in developing cadmium telluride since 1999 has made the semiconductor the second most common PV technology in the world after crystalline silicon, while safeguarding vital intellectual property related to the semiconductor material and its unique manufacturing processes.

First Solar also recently announced an investment of up to $1.2bn in scaling production of American-made, responsibly-produced solar modules, expanding the company's US manufacturing footprint to over 10GW$_{DC}$ by 2025.

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance, with the lowest carbon and water footprint of any commercially available PV technology. Also, the firm continues to optimize the amount of semiconductor material used by enhancing its vapor deposition process through continued investment in R&D focused on more efficient module technology with a thinner semiconductor layer. First Solar also operates a recycling program that provides closed-loop semiconductor recovery for use in new modules.

Additionally, First Solar says that its thin-film semiconductor, integrated manufacturing process and tightly controlled supply chain help to eliminate the risk of exposure to solar supply chains identified by the US Department of Labor's 2022 List of Goods Produced by Child Labor or Forced Labor as being tainted by forced labor. First Solar is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain. The company is also the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics.

In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia, and is building its first new manufacturing facility in India (to begin operation in second-half 2023). On completion of its expansion plans in the USA and India, the firm expects to have over 20GW$_{DC}$ of annual global manufacturing capacity in 2025.

www.firstsolar.com

First Solar selects Alabama for fourth US manufacturing facility

$1.1bn, 3.5GW$_{DC}$ plant in Lawrence County to be commissioned by 2025, creating over 700 jobs

First Solar Inc of Tempe, AZ, USA has selected Lawrence County, North Alabama, as the location for its fourth American cadmium telluride (CdTe) photovoltaic (PV) solar module manufacturing facility. The new factory is part of a previously announced investment in scaling First Solar's American manufacturing footprint to over 10GW$_{DC}$ by 2025, and is expected to create over 700 new direct jobs in the state.

The planned factory in Lawrence County's Mallard Fox Industrial Park represents an investment of about $1.1bn and is expected to be commissioned by 2025, with a planned annual capacity of 3.5GW$_{DC}$. The new fully vertically integrated facility will join three factories in Ohio, including one that is scheduled to come online in first-half 2023, to form part of First Solar's expanded domestic manufacturing footprint.

"First Solar is a world-class manufacturer, and its solar modules are poised to play an increasingly important role in US energy self-sufficiency," comments Governor of Alabama Kay Ivey.

The new facility is expected to advance a strategic push by the firm to scale its US manufacturing base in support of the effort to decarbonize the American economy and achieve self-sufficiency in renewable energy technologies.

"The passage of the Inflation Reduction Act of 2022 has firmly placed America on the path to a sustainable energy future," believes First Solar's CEO Mark Widmar. "This facility, along with its sister factories in Ohio, will form part of the industrial foundation that helps ensure this transition is powered by American innovation and ingenuity."

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are said to set industry benchmarks for quality, durability, reliability, design and environmental performance. "Our commitment to Responsible Solar includes operating facilities that are among the cleanest, safest, and most diverse in the country," says Widmar.

First Solar is unique among the world's ten largest solar manufacturers for being the only US-headquartered company and for not manufacturing in China, and its latest investment is expected to bring the firm's total investment in American manufacturing to over $4bn.

In addition to the new Alabama facility, First Solar previously announced that it is investing $185m in upgrading and expanding its Northwest Ohio manufacturing footprint (currently the largest vertically integrated complex of its kind in the Western Hemisphere) by 0.9GW$_{DC}$. In October, First Solar also announced that it plans to invest about $270m in a dedicated R&D innovation center in Perrysburg, Ohio. The new facility is believed to be the first of its scale in the USA and is expected to accelerate American development and production of thin-film photovoltaics.

First Solar estimates that its new investments in Alabama and Ohio, now estimated at $1.3bn, will add at least 850 new manufacturing jobs and over 100 new R&D jobs, taking its total number of direct jobs in the US to over 3000 people in four states by 2025 (making it the largest employer in the American solar manufacturing sector). By 2025, First Solar is also expected to support an estimated 15,000 indirect and induced jobs as a result of its ongoing and future manufacturing operations.

www.firstsolar.com

First Solar sells 665MW Japan O&M platform to PAG

Sale joins 293MW Japan project development platform sold in July

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has completed the sale of its solar operations and maintenance (O&M) platform in Japan (announced in May) to funds managed by Tokyo-based PAG Real Assets (PAG), an Asia–Pacific-focused private investment manager with more than $50bn in assets under its management.

The platform has about 665MW$_{DC}$ of solar assets under management in the country. As part of the sale, the majority of First Solar O&M staff in Japan have joined PAG.

Previously, in July, First Solar had completed the sale to PAG (also announced in May) of a 293MW$_{DC}$ utility-scale solar project development platform in Japan.

www.pag.com
www.firstsolar.com

First Solar to supply 2GW of PV modules to Swift Current Energy

Multi-year order to be delivered in 2025–2026

First Solar has agreed to supply 2GW$_{DC}$ of its thin-film solar modules in 2025 and 2026 to Boston-headquartered Swift Current Energy, which develops, owns and operates utility-scale wind, solar and energy storage projects across the USA.

The deal represents Swift Current's second gigawatt-plus order for First Solar modules, following an order in January for 1.27GW$_{DC}$. Founded in 2016, Swift Current has commercialized over 1GW of renewable energy projects, including utility-scale solar and wind. The company also has a growing pipeline of over 9GW of planned renewable assets across North America.

"With the US rapidly advancing its energy infrastructure, our project pipeline is growing and we're focused on ensuring that our capacity comes online as planned," says Swift Current Energy's CEO Eric Lammers. "Against this backdrop, it's crucial that we work with partners like First Solar that will deliver not only high-quality, responsibly made products but also certainty of supply," he adds.

"As America's energy transition gathers pace, it must be underpinned by supply chains that are reliable and robust, and our customers recognize that First Solar is well positioned to provide the long-term certainty they need," says First Solar's chief commercial

officer Georges Antoun. "Swift Current's latest order demonstrates that our commitment to Responsible Solar and enabling certainty for our customers are key drivers of demand."

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance. The company continues to optimize the amount of semiconductor material used by enhancing its vapor deposition process through continued investment in R&D focused on more efficient module technology with a thinner semiconductor layer. First Solar also operates a recycling program that provides closed-loop semiconductor recovery for use in new modules.

Already the only US-headquartered company among the world's largest solar manufacturers, First Solar is expanding its manufacturing capacity at home and abroad. In addition to a third factory under construction in Ohio, at the end of August the firm announced an investment of up to $1.2bn in expanding its Ohio manufacturing footprint and a new manufacturing facility (its fourth American manufacturing facility) in the US Southeast. This latest investment is expected to bring First Solar's total investment in American manufacturing to $4bn, while its annual US manufacturing capacity is forecasted to expand to over 10GW by 2025.

In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia, and is building its first new manufacturing facility in India (with a capacity of 3.3GW), which is scheduled to begin operations in second-half 2023. On completion of its expansion plans in the USA and India, the firm expects to have over 20GW$_{DC}$ of annual global manufacturing capacity in 2025.

www.swiftcurrentenergy.com

Intersect Power orders 4.9GW more First Solar PV modules, for 2025–2029 delivery

Total 2022 orders rise to 7.3GW; Intersect to be largest First Solar buyer and operator by 2029

First Solar Inc of Tempe, AZ, USA has entered into agreements to supply an additional 4.9GW$_{DC}$ of its cadmium telluride (CdTe) thin-film photovoltaic (PV) solar modules to Intersect Power LLC, taking the total ordered this year to 7.3GW$_{DC}$ after an agreement for 2.4GW$_{DC}$ signed in July.

Of the latest 4.9GW$_{DC}$, a deal for 1GWDC was signed prior to First Solar's third-quarter 2022 earnings call in October, followed by subsequent deal for the remaining 3.9GW$_{DC}$.

Intersect's orders this year will see a combination of First Solar's Series 6 Plus and Series 7 modules deployed in its solar, storage and green hydrogen projects coming online across the USA from 2025 to 2029.

"We have an unprecedented opportunity to decarbonize our economy while simultaneously bolstering our manufacturing sector and providing clean energy security," says Intersect Power's CEO Sheldon Kimber. "First Solar's responsibly produced, high-performance modules are the cornerstone of our commitment to American technology and workers," he adds.

Prior to 2022, Intersect Power had placed orders for a total of 4.1GW$_{DC}$ of modules in deals signed in 2019 and 2021. The latest transaction is expected to solidify its position as the world's largest buyer and operator of First Solar's PV modules, with an estimated deployed capacity of 11.4GW$_{DC}$ by 2029.

"Intersect Power was one of the early pioneers of long-term, multi-year procurement and has benefitted from the certainty of supply and stable pricing that this approach delivers," says First Solar's chief commercial officer Georges Antoun.

Intersect Powe's Radian solar project.

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are said to set industry benchmarks for quality, durability, reliability, design and environmental performance. The modules are claimed to have the lowest carbon and water footprint of any commercially available PV technology.

Additionally, First Solar's thin-film semiconductor, integrated manufacturing process and tightly controlled supply chain helps to eliminate the risk of exposure to solar supply chains identified by the US Department of Labor's 2022 List of Goods Produced by Child Labor or Forced Labor as being tainted by forced labor. First Solar is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain. The firm is also the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics.

As the only US-headquartered company among the world's largest solar manufacturers, First Solar is expanding its manufacturing capacity at home and abroad. In addition to a third factory under construction in Ohio, the firm recently announced that it is expanding its Ohio manufacturing footprint and establishing a new manufacturing facility (its fourth American manufacturing facility) in the US Southeast. These latest investments are expected to bring First Solar's total investment in American manufacturing to $4bn, while its annual US manufacturing capacity is forecast to expand to over 10GW$_{DC}$ by 2025. The firm also plans to invest about $270m in a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

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GeSn resonant-cavity LEDs

Mid-infrared-emitting devices with lateral p-i-n structure could enhance optoelectronic silicon-on-insulator platform.

Researchers in Taiwan report room-temperature mid-infrared resonant electroluminescence from germanium tin (GeSn) resonant-cavity light-emitting diodes (RCLEDs) with a lateral p-i-n configuration on a silicon-on-insulator (SOI) substrate [Chen-Yang Chang et al, Photonics Research, v10, p2278, 2022].

The team from National Chung Cheng University and National Taiwan University see the group IV elements GeSn as being more compatible with silicon-based electronic–photonic integrated circuits (EPICs) than hybrid or monolithic combinations with III–V light-emitting devices.

Group IV light emission is hampered by the indirectness of the bandgap, which inhibits electron-hole recombination into photons. However, the Ge energy band structure has a direct valley at the Γ point that is only 136.5meV higher than the indirect L-valley.

The team theoretically calculated that the band structure of GeSn with 4.3% Sn content and 0.52% compressive strain showed a decrease in the energy difference between the conduction-band valleys at the direct Γ point and in the L-direction to 89meV (Figure 1). The researchers comment: "Thus, the electron density populating the direct conduction band can be significantly enhanced under current injection, thereby enhancing the direct-gap light emission efficiency."

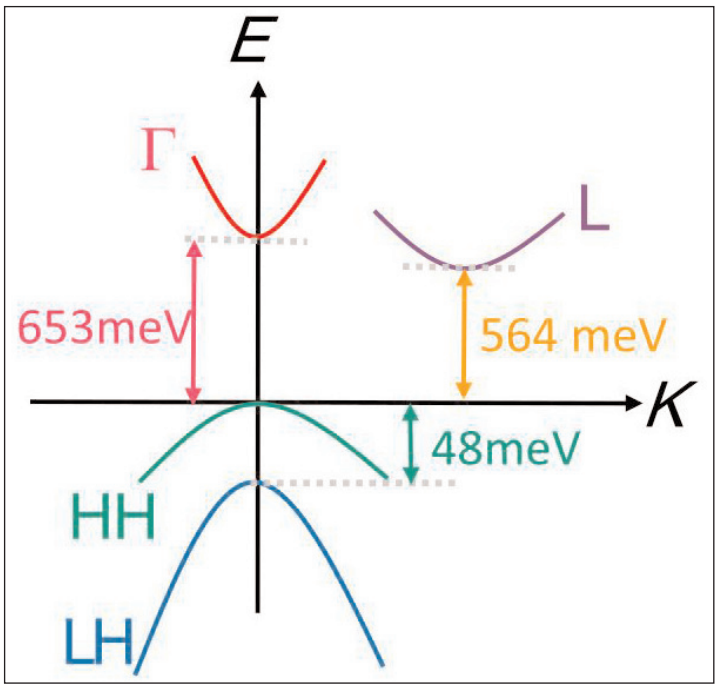

Figure 1. Calculated band structure of the GeSn active layer at 300K.

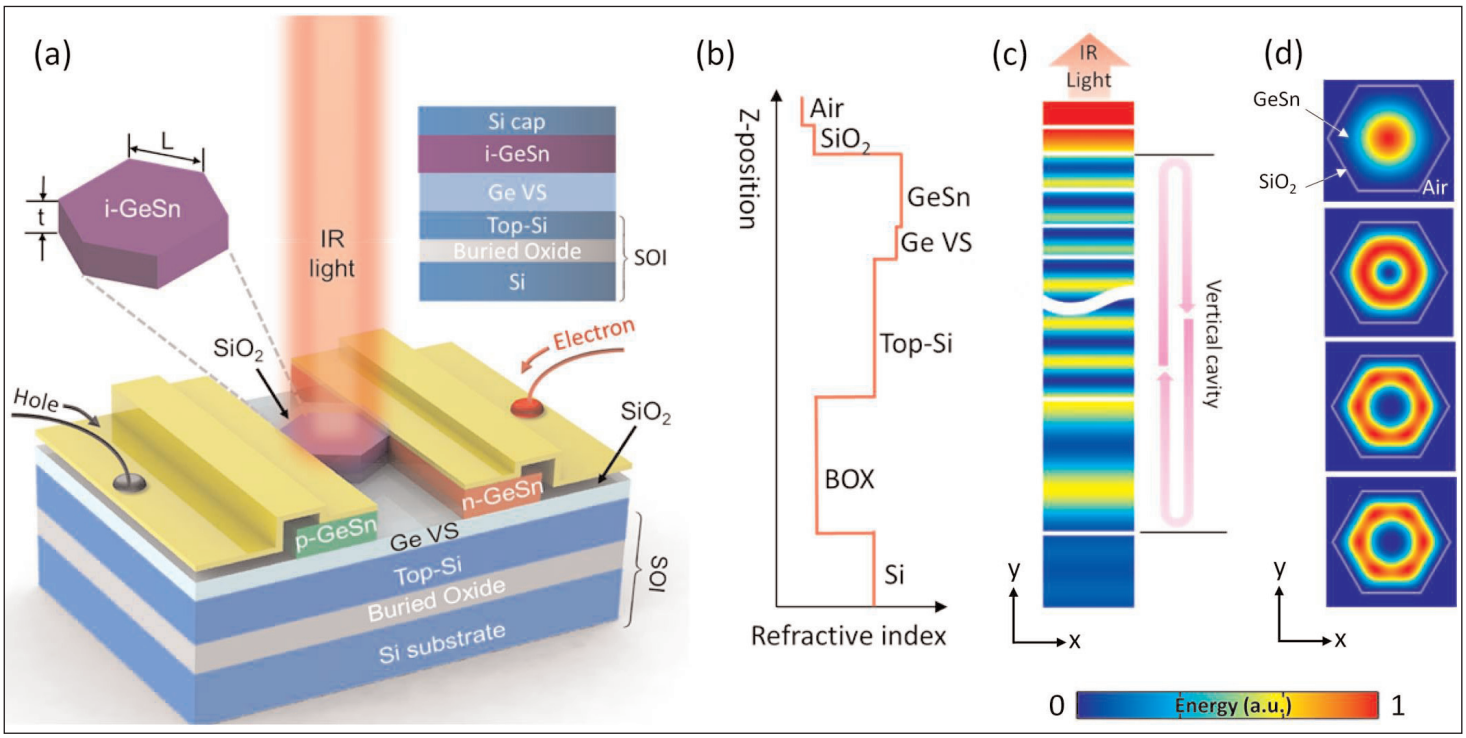

Figure 2. (a) Schematic diagram of lateral GeSn p-i-n diodes on SOI substrate. Inset: layer structure of grown sample (not to scale). (b) Refractive index profile along z direction without thin Si cap. (c) Finite element simulation of energy distribution along z direction at 1980nm, and (d) of selected transverse modes.

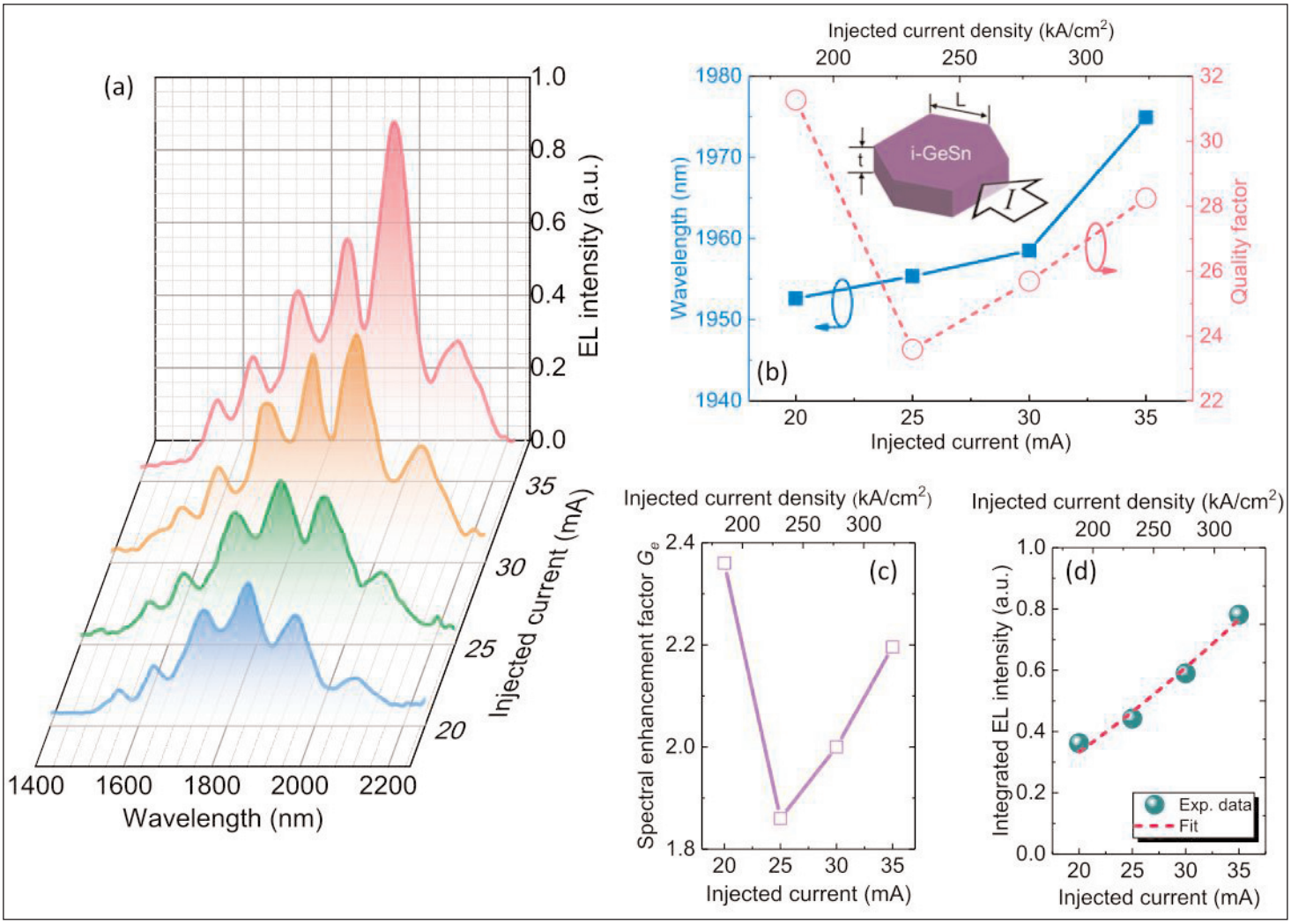

Figure 3. (a) Room-temperature electroluminescence (EL) spectra of the fabricated GeSn devices at various injected currents. (b) Extracted Q factor and resonant emission wavelength. Inset: schematic diagram of current injection into GeSn active region. (c) Spectral enhancement factor as function of injected current. (d) Integrated EL intensity as function of injected current.

The heavy-hole (HH) band peak is also raised some 48meV above the light-hole (LH) band. It has been found that GeSn with Sn content greater than 6% has a direct bandgap, but devices, including optically pumped lasers, constructed from such material tend to only perform at cryogenic temperatures so far. Achieving high Sn content is difficult due to the low solubility of Sn in Ge.

The researchers comment: "Most of the demonstrated group IV GeSn LEDs and lasers are vertical p-i-n diode structures, which suffer from a strong optical loss induced by the metal pads and heavily doped regions that could significantly increase the threshold and/or decrease the lasing temperature. To overcome this problem, lateral p-i-n structures have been proposed by keeping the lossy metal pads and heavily doped regions far away from the active region."

Also, EPICs would be easier to achieve with lateral laser structures. EPICs have a wide range of deployments in telecommunications, on-chip optical interconnection, sensing, and quantum computing.

The RCLED material was grown by molecular beam epitaxy (MBE) on silicon-on-insulator (SOI) substrate with a Ge virtual substrate (VS) template layer (Figure 2). The buried oxide (BOX) of the substrate was 1μm, and the top silicon (Si) was 2.5μm.

The VS consisted of 100nm Si grown at 600°C, 100nm Si at 350°C, 117.5nm Ge at 350°C, and 117.5m Ge at 550°C. The structure was also subject to in-situ annealing at 800°C for 5 minutes between the low- and high-temperature Ge depositions.

The 540nm GeSn with 4.3% Sn content was grown at the very low temperature (as these things go) of 150°C to avoid Sn segregation. The final Si cap was also grown at the same temperature.

Photoluminescence (PL) spectra showed a series of peaks from the resonant Fabry-Pérot cavity with an envelope maximum around 1980nm, corresponding to a photon energy of 626meV, consistent with expectations from the calculated bandstructure. The researchers assign the maximum to the lowest direct bandgap of the GeSn active layer.

The intrinsic i-GeSn layer was fabricated into a hexagonal cavity with lateral phosphorus and boron implanted p and n contact regions, respectively, forming a lateral p-i-n structure. Dopant activation was through 100s microwave thermal annealing, again avoiding Sn segregation. Plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2) was applied for surface passivation. The contact electrodes were gold/chromium.

The resonant cavity was formed from the low refractive index of the BOX and top SiO_2 passivation providing vertical optical confinement. The passivation also provided horizontal confinement.

Current-voltage measurements gave a relatively high value for the series resistance of the device at 1.84kΩ. The team suggests that this is due to "the metal–semiconductor contact and the large quasi-neutral region, which may induce significant Joule heating during CW current injection." The diode turn-on voltage was around 0.51V.

EL spectra of a device with hexagonal cavities of side (L) 20μm showed a similar series of peaks to the PL measurements (Figure 3). The envelope maximum was at the slightly shorter wavelength of 1960nm, with some red-shifting at higher currents (an effect attributed to Joule heating). The free spectral range of the emissions was around 110nm and the full-width at half maximum (FWHM) of order 70nm.

Although laser emissions were not achieved, the emissions did show evidence of resonant EL, suggesting some stimulated photon transitions in addition to spontaneous photon transitions. The researchers blame the low quality (Q)-factor of the cavity for the absence of laser action. A boost to the optical confinement/Q-factor to the 100–10,000 range from Si/SiO_2 distributed Bragg reflectors (DBRs) could overcome this limitation.

Increased Sn content is also another aspect that needs optimizing to further enhance the directness of the bandgap. The team suggests that the Sn content could be increased to higher than 14% by using composition-graded growth methods via MBE and CVD. ■

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Indium phosphide industry moving into consumer applications

Ali Jaffal of Yole Intelligence outlines how the indium phosphide market is evolving, including challenging gallium arsenide.

According to our latest InP analysis , a global increase in the indium phosphide (InP) photonics market from US$2.5bn in 2021 to more than US$5.6bn in 2027 is forecast, with a compound annual growth rate (CAGR) of 14%. Originally developed for solar cells in the 1960s, InP is garnering considerable interest for fiber communications and wireless equipment. Its multi-functional role as a light source, modulator, amplifier and detector at 13xx- and 15xx-nanometer wavelengths makes it the primary material for the fabrication of current and future optical devices in telecom and datacom. With the need for higher transmission data rates and longer communication distances generated by the explosion of social networks, cloud computing and IoT, the future of InP is well secured. In addition, this semiconductor compound is starting to make eyes at several evolving consumer and automotive applications. This could elevate it from its niche market and propel it to a prominent position.

InP industry boosted by new needs in several applications

● The well-established datacom & telecom sector

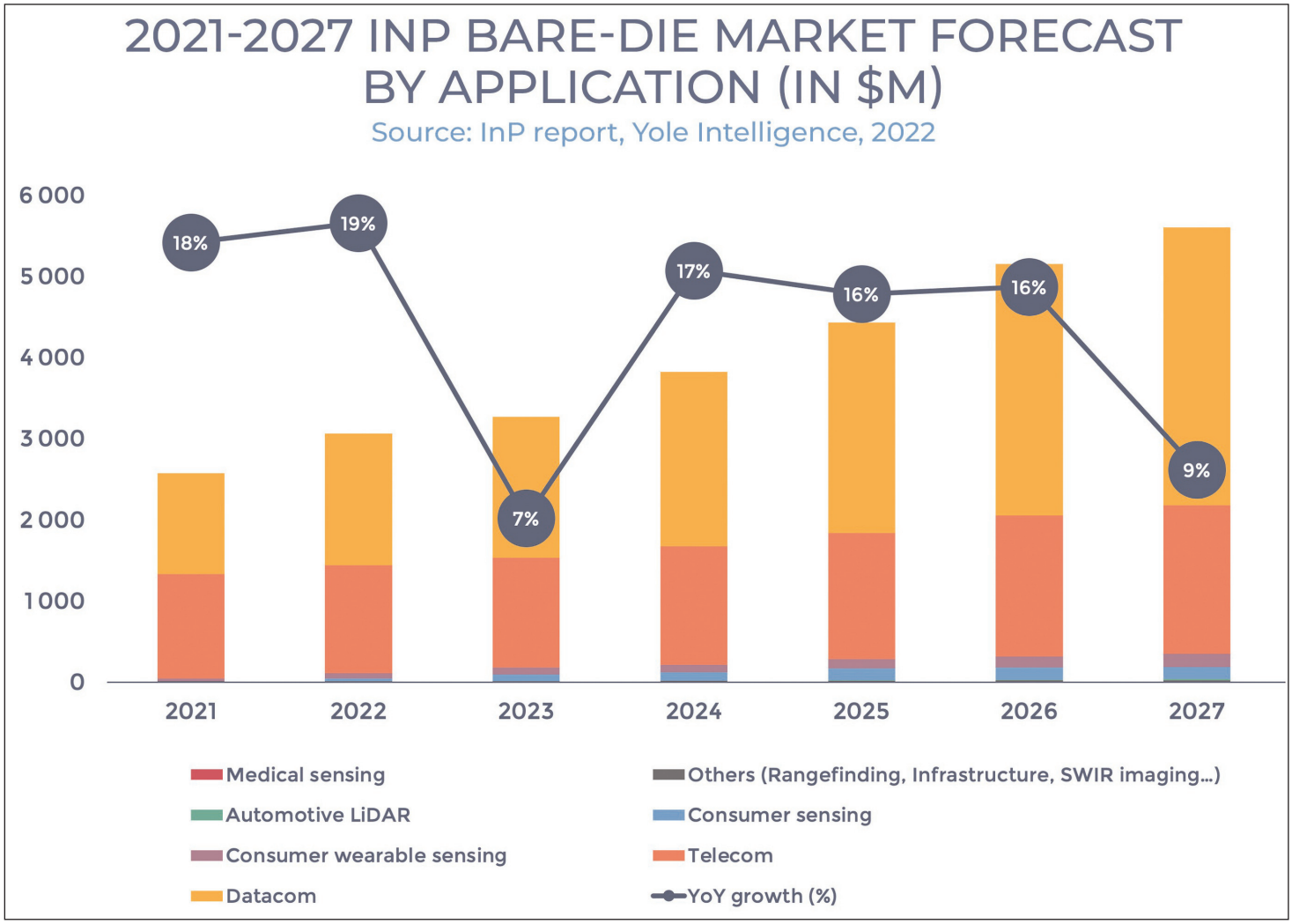
With the capacity to emit and detect at wavelengths above 1000nm, InP has been considered a key technology in datacom and telecom applications for over 30 years. In perfect accordance with the optimum operating range for fiber-optic transmission (13xx & 15xx nm), InP is mainly used for high-power and high-frequency optoelectronic devices such as lasers and photodetectors. Its outstanding structural and electronic properties — high electron mobility, low dielectric constant, and direct bandgap — leave little room for other semiconductors to support the exploding demand for higher data rates and increased range. Technological development efforts tend to focus on optical transceivers that will deliver 100Gb/s, 400Gb/s, 800Gb/s and even 1.6Tb/s data rates, for which InP is the best option. The use of emerging coherent transmission technology to carry considerably more information through a fiber-optic cable will mean moving to integrated photonic solutions where InP photonic integrated circuits (PICs) also have a role to play.

● Mobile: under-display 3D sensing for smartphones

Beyond the telecom and datacom markets, the consumer industry also seems interested in InP solutions. The first submarket segment to mention is smartphone sensing. Integration of InP-based short-wave infrared (SWIR) sensors in late 2021 in Apple's AirPods 3 paved the way for the penetration of InP for under-display 3D sensing in smartphones. Apple's iPhone roadmap confirms the committed development to enlarge the screen to the total size of the phone, reducing the current notch (for imaging, proximity sensor, flood illuminator, and dot projector functionalities) first to a smaller pill-shaped hole and then to a tiny punch-hole. It implies a shift from 940nm to 13xx nm or 15xx nm wavelengths which are organic light-emitting diode (OLED) transmissive, and therefore from gallium arsenide (GaAs) to InP sensors. A transition phase has already begun with the release of the iPhone 14 Pro model this year that combines a SWIR proximity sensor and an InP edge-emitting laser (EEL) placed under the screen, with GaAs vertical-cavity surface-emitting lasers (VCSELs) squeezed into a small pill-shaped opening. The pill shape is expected to remain for the next 3–4 years for the next standard and pro iPhone models before the eventual integration of the complete set of sensors under the screen in 2025–2026.

● Consumer wearable sensing: from well-being to health monitoring

Wearable devices are already widely available to consumers for monitoring well-being parameters in real time. However, the use of optical sensors to track multiple vital signs non-invasively is gaining ground, pushed by the development of telemedicine. Limited by the detection capabilities provided by visible and near-infrared LED-based sensors, wearable sensing technologies could turn increasingly towards InP to benefit from its mid-IR wavelength range and track a wider variety of biomarkers in blood, such as glucose, lactate and alcohol. There is still a long way to go, however. To date, Rockley Photonics seems to be the only player developing silicon photonic solutions



incorporating an InP-based laser and detector targeting this specific market segment. Although at the very early stages of a discussion with certain OEMs for the next generations of smartwatches, the company will certainly still need 2–3 years before its technology is available for consumer-wearable sensing applications.

Automotive-grade LiDAR: on the way for autonomous driving

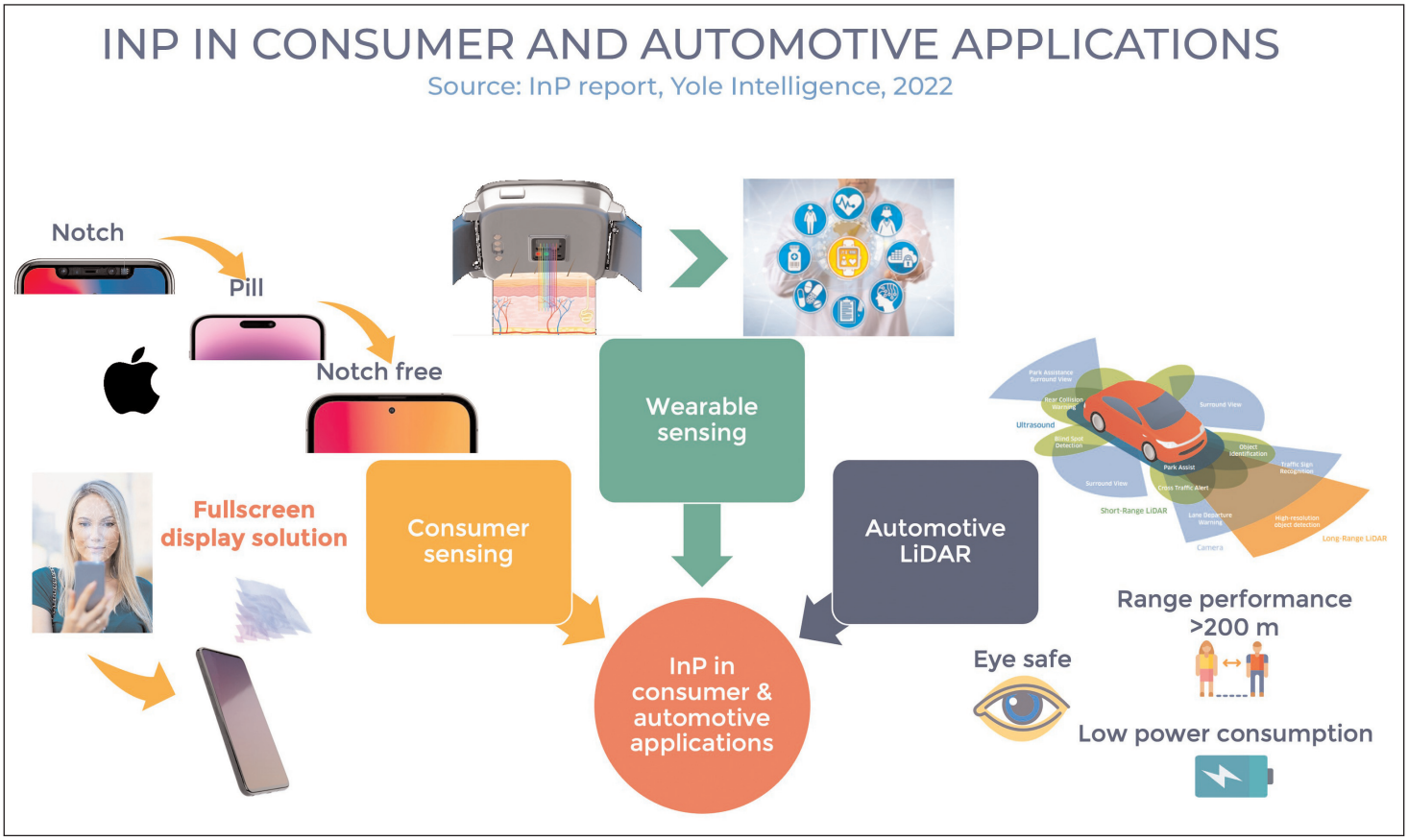
A flurry of interest in automotive-grade light detection & ranging (LiDAR) was stimulated four years ago after Valeo opened up the field with the implementation of its Scala

Apple's iPhone roadmap confirms the committed development to enlarge the screen to the total size of the phone, reducing the current notch (for imaging, proximity sensor, flood illuminator, and dot projector functionalities) first to a smaller pill-shaped hole and then to a tiny punch-hole. It implies a shift from 940nm to 13xx nm or 15xx nm wavelengths which are OLED transmissive, and therefore from GaAs to InP sensors

3D laser scanner in a commercialized car. This sensor, combined with cameras and radars, is gradually leading the driving experience to the highest levels of autonomy and safety.

There are at least two reasons why InP-based lasers are considered a premium choice for LiDAR. First, their capacity to accurately map the vehicle's environment at a longer range (> 200m) than conventional lasers. Second, they are eye safe: with mid-IR wavelengths, power for long-range detection can be increased without risking pedestrian eye injuries.

Its penetration into LiDAR remains very limited because of the cost of the InP lasers and the continuous development of the well-established GaAs lasers. So far, it is only being promoted by Luminar, which uses a 1550nm fiber-coupled laser and InP-based InGaAs photodetectors to manufacture its system. It could, however, be boosted by the adoption of a different ranging approach. Indeed, current LiDAR technologies are 100% based on the time-of-flight (ToF) method using narrow light pulses to detect the distance and direction of objects. With future LiDAR (SiPh/InP laser) generations employing a frequency-modulated continuous wave (FMCW) approach, velocity could also be measured, increasing accuracy and, therefore, safety.



Global view of marketplace projections and business opportunities

According to the Compound Semiconductor Monitor Module III Q3 2022, at Yole Intelligence we expect the InP bare die market to grow from US$2.5bn in 2021 to about US$5.6bn in 2027, with a CAGR of 14%. The growth is mainly driven by datacom and telecom applications, for which InP seems to be the best material to achieve the high data transmission rates and longer distances required in data centers and 5G base stations and to provide high-bandwidth, low-latency, low-power fiber communications in data-center interconnects (DCI). The consumer sensing market, at US$31m in 2022, is predicted to reach US$151m in 2027, with a 37% CAGR, due to the evolution of the iPhone's under-display sensor configuration. With a modest US$33m in 2021, the consumer-wearable sensing market should grow steadily thanks to current and future models of Apple's AirPods. A jump is forecasted from 2025 with the possible adoption of InP in smartwatches, bringing the market to US$159m in 2027 with a CAGR2021–2027 of 30%. Because of high competition with GaAs, InP is not expected to penetrate the automotive LiDAR market before the take-up of FMCW systems planned in 2026–2027.

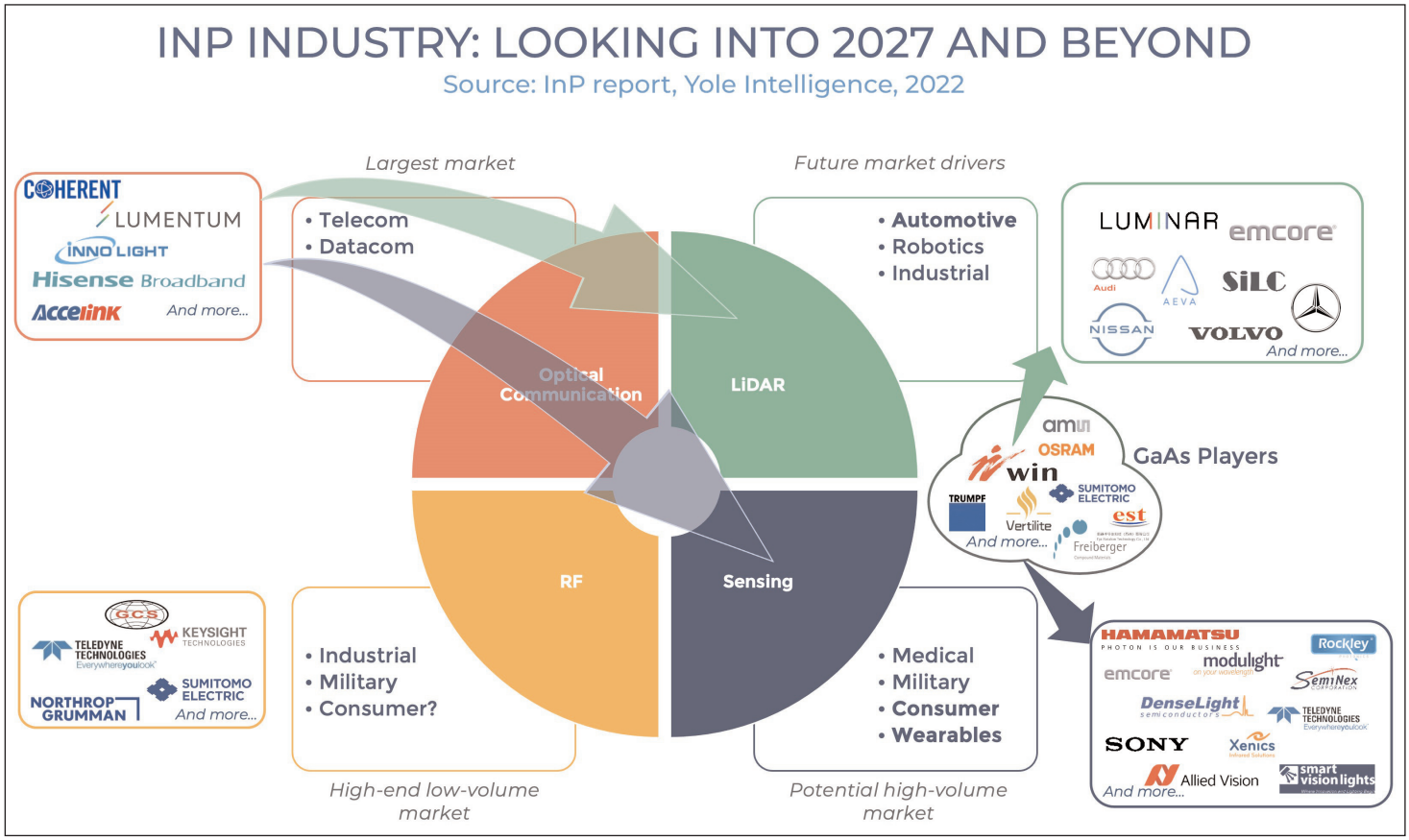
In terms of business opportunities, the established datacom-telecom players – including Lumentum, Coherent Corp (formerly II-VI Inc), Accelink, and Hisense – endowed with InP know-how and manufacturing equipment, may be tempted to enter consumer markets. As InP and GaAs share the same epitaxy process and equipment, GaAs VCSEL/EEL companies such as Trumpf and ams OSRAM could also find an interest in moving towards the LiDAR and sensing markets. A few other players, like the foundry WIN Semiconductors, already has a foot in the door. This is just a small sample of the companies that could contribute to the changing of the InP industry landscape once the green light is given.

Considering alternative scenarios

The story (and the numbers above) could be rewritten if one considers InP's limitations for entering a mass market and the potential competition from another III–V semiconductor that could slow down InP's penetration.

Cost: the sinews of war

Despite its superior electrical properties compared with silicon and GaAs, semiconductor players keep in mind that the industry is cost driven. And therein lies the rub: InP costs more not only in terms of wafers (3–4 times the price of GaAs) but also in terms of device manufacturing. InP laser manufacturing suffers from low yield, which in turn significantly increases the cost of the die. The trend for advanced laser technologies for longer reach and higher speed in telecoms and datacoms will amplify the issue: the electro-absorption modulated laser (EML) technology needed to fulfill these requirements involves extra epitaxial growth steps and a higher probability of generating an even lower yield. In addition, the InP technology platform is currently 2", 3" or 4" in diameter, whereas GaAs is 4" or 6" and silicon is 8" or 12". With InP's potential to penetrate the consumer market, the industry will need to move to larger wafer sizes, which is not anticipated before 2024–2025.



InP versus GaAs: a fierce competition

New technology developments are being made to overcome GaAs' limited bandgap energy (9xx nm). For smartphone under-display 3D sensing, epiwafer foundry IQE is currently working on a very promising new laser technology based on dilute-nitride GaAs, targeting a 13xx nm wavelength. However, this technology could take a few years to enter the market, leaving InP enough time to establish itself comfortably in this field. The competition between InP and GaAs also extends to LiDAR. Lumentum and Hesai have designed GaAs multi-junction VCSEL (905nm) arrays based on the ToF approach which, when powered with very short pulses, reach extremely high peak power with no danger to the eye. This makes them an ideal solution for long-range LiDAR systems with a range of up to 200m. Thanks to the use of a new generation of components like VCSELs and ultra-sensitive silicon photomultiplier (SiPM) detectors, ToF LIDARs increased their performance and should still be used for several years. In parallel, FMCW InP-based LiDARs are in the development phase and are expected on the horizon 2026–2027.

Lumentum and Hesai have designed GaAs multi-junction VCSEL (905nm) arrays based on the time-of-flight approach which, when powered with very short pulses, reach extremely high peak power with no danger to the eye. This makes them an ideal solution for long-range LiDAR systems with a range of up to 200m... In parallel, FMCW InP-based LiDARs are in the development phase and are expected on the horizon 2026–2027

And the final word goes to...

Relegated to niche applications until now because of cost and technology control difficulties, will InP's performance opportunities for consumer and automotive use offset these disadvantages? The answer is Apple. Apple's interest in InP-based solutions has begun to spread throughout the whole supply chain, which is now taking a closer look at this industry. Whether InP moves into a position of prominence in the marketplace depends on Apple's strategy, which will obviously take into account cost, performance and supply chain security. ■

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Author: Ali Jaffal Ph.D. is a technology & market analyst specialized in Compound Semiconductors and Emerging Substrates at Yole Intelligence. As part of the Power & Wireless team, he is deeply engaged in the development of a dedicated collection of compound semiconductors market & technology reports and monitors.

Sources:

InP report, Yole Intelligence, 2022
Compound Semiconductor Monitor Module III Q3 2022, Yole Intelligence

Room-temperature CW InGaAs 980nm laser diodes on on-axis silicon

Progress towards light emitters directly integrated on a silicon OEIC platform.

China's Beijing University of Posts and Telecommunications has demonstrated room-temperature continuous wave (RT-CW) operation of 980nm indium gallium arsenide (InGaAs) quantum well (QW) laser diodes (LDs) directly grown on on-axis silicon (Si) (001) [Chen Jiang et al, Appl. Phys. Lett., v121, p061102, 2022].

The team comments: "RT-CW operation of silicon-based GaAs-buffered III–V QW lasers directly grown on on-axis Si (001) substrates has not been realized until now."

It is hoped that such directly integrated devices could reduce the costs of optoelectronic integrated circuits (OEICs) fabricated on silicon platforms through eased mass production, compared with using external light sources or wafer bonding of III–V light emitters.

Barriers to heteroepitaxy of III–V materials on silicon include crystal defects such as threading dislocations (TDs), antiphase domains (APDs), and micro-cracks. These defects tend to seriously reduce the opto-electronic performance of III-V structures.

One way to reduce the impact of TDs on performance is to use quantum dots rather than QWs. However, the implementation of QWs on silicon is attractive since it would allow the transfer of the vast engineering knowledge from commercial light-emitting devices grown on III–V substrates to the silicon platform.

The 420nm GaAs template (Figure 1) was grown by metal-organic chemical vapor deposition (MOCVD) on on-axis Si (001). The precursors were trimethylgallium and arsine (AsH_3). The silicon substrate was subjected to an annealing treatment in hydrogen to avoid anti-phase domain formation.

The remainder of the device was grown using solid-source molecular beam epitaxy (MBE). The template had a root-mean-square roughness of 0.91nm.

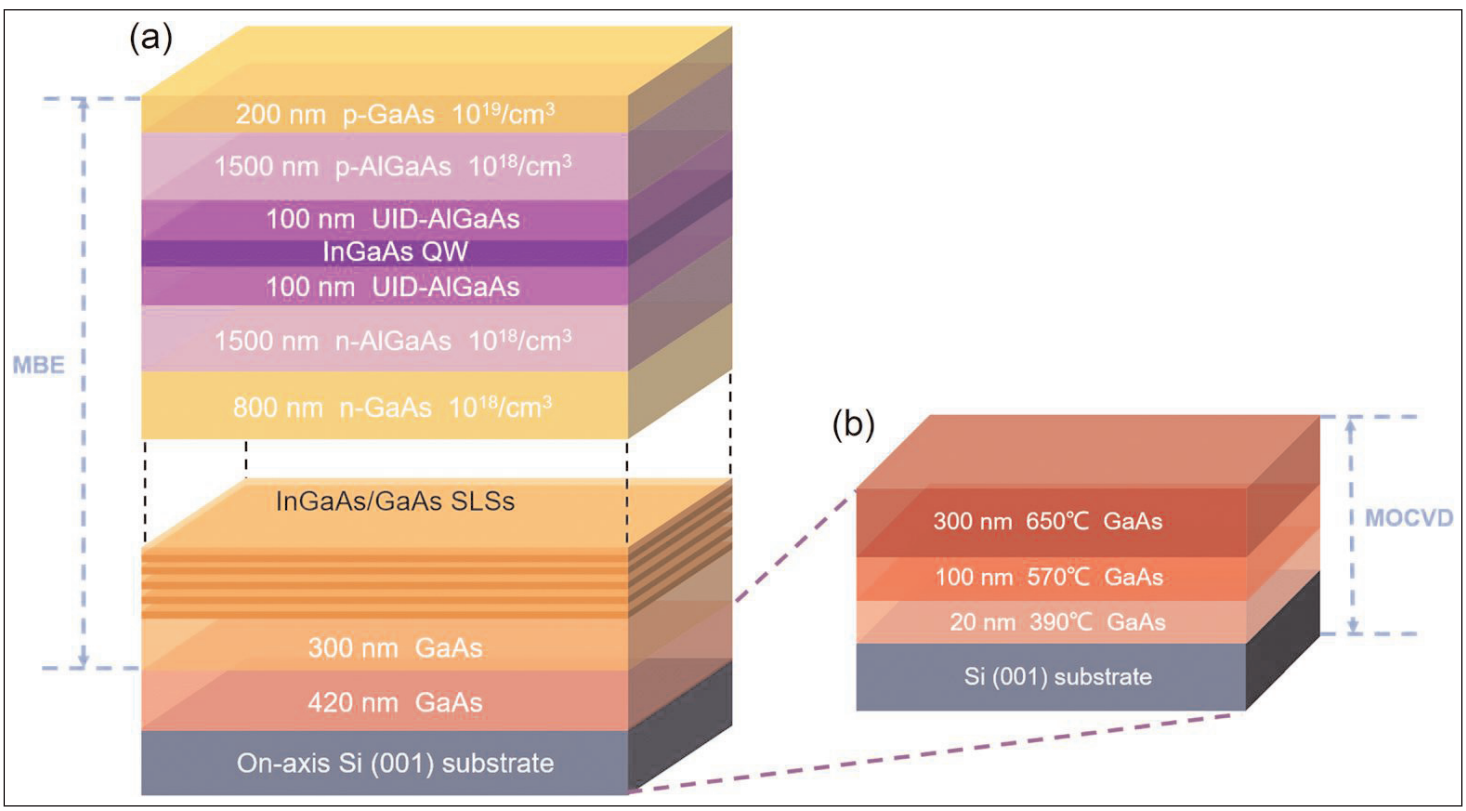

Figure 1. (a) Schematic of QW laser directly grown on on-axis Si (001). (b) MOCVD scheme for initial 420nm GaAs/Si (001) template layers.

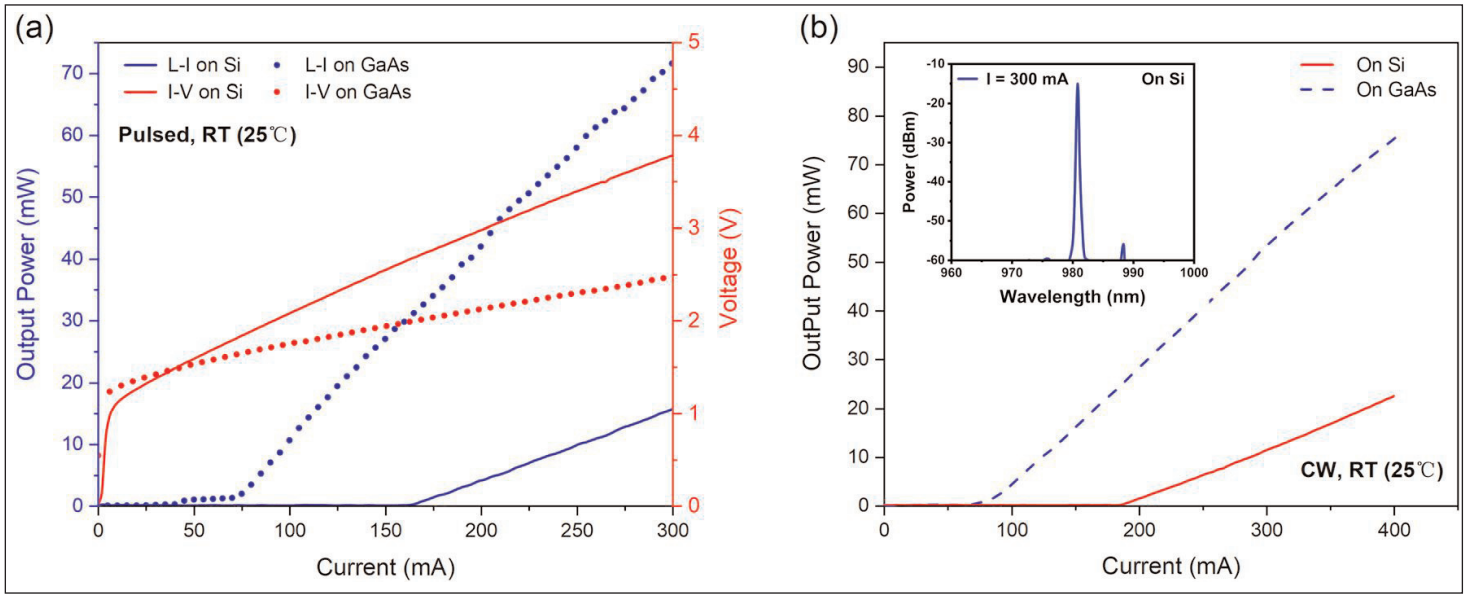

Figure 2. Room-temperature performance of laser diodes on GaAs and Si substrates in (a) pulsed and (b) CW operation at room temperature. Inset: lasing spectrum of Si-based laser at 300mA.

The first 300nm GaAs buffer layer flattened the growth surface further. Rough surfaces have been found to lead to non-radiative recombination via exciton generation, sapping laser performance. Four sets of 5x(10nm/10nm) strained-layer superlattices (SLSs) separated by 300nm GaAs spacers filtered out dislocations. The threading dislocation density (TDD) at the n-GaAs contact surface was $4.9x10^7/cm^3$.

The active 8nm InGaAs QW was embedded in an unintentionally doped (UID) aluminium gallium arsenide (AlGaAs) waveguide structure of two 100nm layers. The doped cladding layers were 1500nm. The bottom n-contact was 800nm; the top p-contact was 200nm. The n- and p-type doping were supplied by silicon (Si) and beryllium (Be), respectively. The laser layers were grown in an As_2 atmosphere.

A reference structure was also produced on a GaAs substrate.

The material was fabricated into stripe Fabry–Pérot laser diodes with 21.6μm x 1mm cavities. The mirror end facets were formed by wafer cleaving without any optical coatings being applied. The laser diode chips were mounted on copper heatsink in C-mount packages. The measurements were carried out at room temperature (25°C).

In 5% duty-cycle 50μs pulse operation the laser threshold current density was $328A/cm^2$ (70.5mA) for the device on GaAs substrate (Figure 2).

There is a long way to go to make the lifetime of these lasers comparable to that of the currently demonstrated Si-based QD lasers. The essential issue to fulfil this target should be dramatically further reducing the TDD of the heteroepitaxial GaAs virtual substrate

For the silicon substrate laser diode the density was more than twice that at $768A/cm^2$ (165.1mA). While one wants the threshold to approach that of GaAs-based devices, the team points out that all previous reports of InGaAs laser diodes on on-axis Si (001) have had higher thresholds still.

The slope efficiency of the laser diode on silicon was 0.113W/A, and the single-facet output power 15.5mW at 300mA. The power at that point showed no sign of attenuation, according to the team.

The threshold current density increased in CW operation to $381A/cm^2$ (81.9mA) and $867A/cm^2$ (186.4mA) for the GaAs- and Si-based laser diodes, respectively. The corresponding output powers at 400mA were 75.6mW and 22.5mW. The slope efficiencies were 0.24W/A on GaAs substrate, and 0.097W/A on silicon.

The researchers attribute the poorer performance under CW operation to thermal effects from heat accumulation, which is avoided in pulsed mode. Lower thresholds on silicon have been achieved on misoriented Si ($331A/cm^2$), but on-axis Si is preferred in the context of integration with mainstream silicon electronics.

CW operation of Si-based laser diodes at 300mA injection resulted in a laser peak at 980.8nm wavelength. The lifetime of the initial devices was 90s, but the team was able to optimise the devices to give a longer 12 minute life at 23°C.

The team admits that there is "a long way to go to make the lifetime of these lasers comparable to that of the currently demonstrated Si-based QD lasers", adding: "The essential issue to fulfil this target should be dramatically further reducing the TDD of the heteroepitaxial GaAs virtual substrate." ■

https://doi.org/10.1063/5.0098264

Author: Mike Cooke

Pocketing benefits for QD lasers on 300mm silicon

Researchers at UCSB claim the first electrically pumped in-pocket MBE 1300nm laser diodes with continuous-wave operation to 60°C.

University of California Santa Barbara, USA, reports "the first electrically pumped in-pocket Fabry–Perot quantum dot lasers grown by MBE emitting around 1300nm with cleaved facets, sustaining lasing characteristics up to 60°C with a wall-plug efficiency of 8.6%" [Chen Shang et al, Light: Science & Applications v11,p 299, 2022]. The team also included researchers from IQE Inc and RF SUNY Polytechnic Institute in the USA and NAsPIII/V GmbH in Germany.

It is hoped that the in-pocket laser diodes (LDs) will be easier to integrate into silicon (Si) and silicon-on-insulator (SOI) photonic structures than light-emitting devices applied by wafer bonding or direct epitaxial growth using blanket deposition techniques. In particular, in-pocket lasers can be butt-coupled on a level with silicon nitride (SiN) or SOI waveguide cores, rather than evanescent coupling, which is used with wafer bonding, and difficult to achieve with epitaxial structures with the light-absorbing thick buffer layers needed to reduce defect formation and propagation into the device layers. The use of an indium arsenide (InAs) quantum dot (QD) active region also promises to be less affected by any defects that remain.

The team comments: "With additional lithography and etching steps and/or alternative layout designs, a variety of active components such as semiconductor optical amplifiers, mode-locked lasers, or distributed-feedback lasers can also be fabricated from the same chip. This fabrication process can be used in integrating complex photonic circuits on 300mm-diameter SOI wafers."

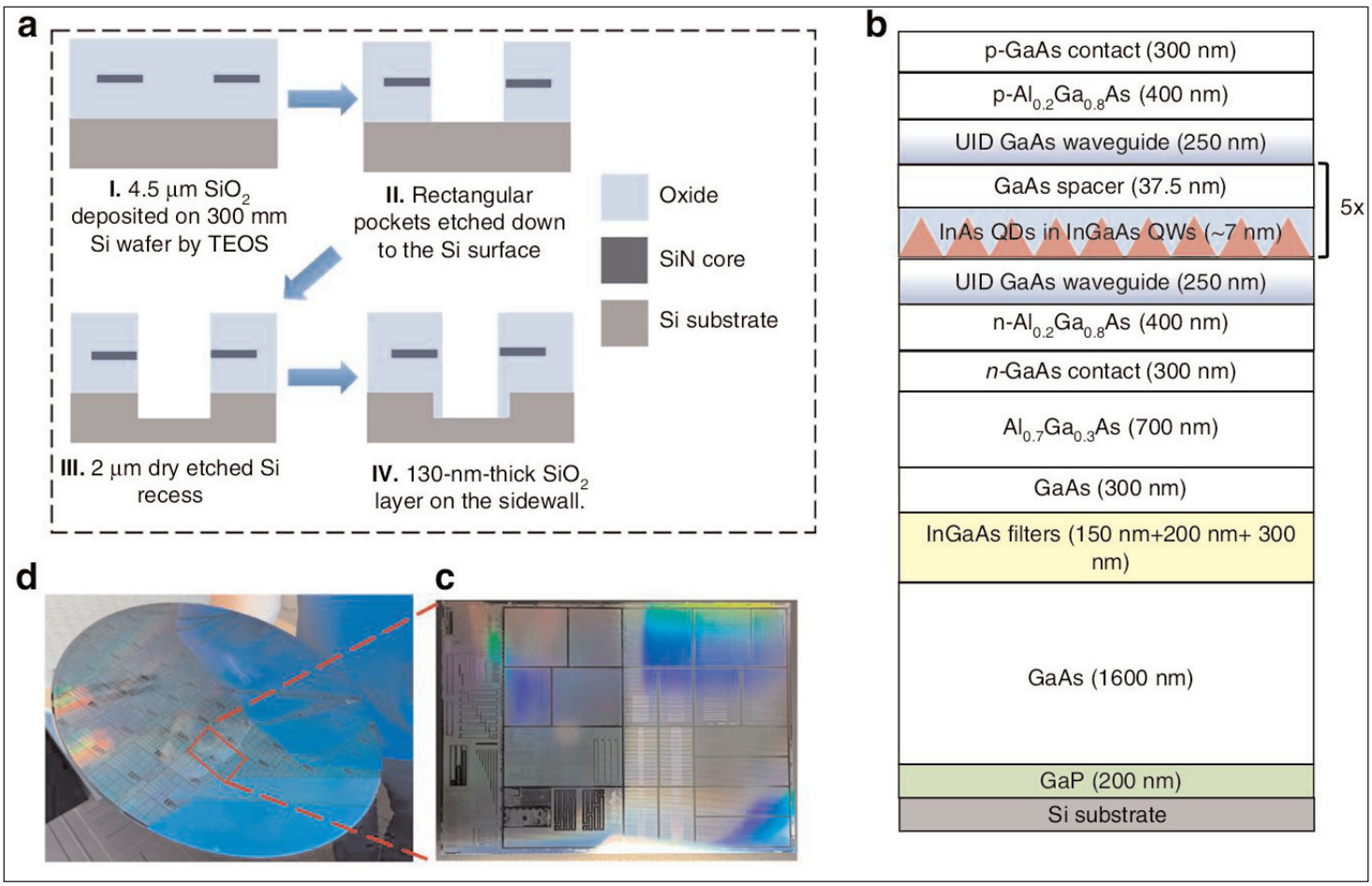

Figure 1. (a) Pattern formation process before III–V deposition. (b) Simplified III–V laser stack. (c) Diced coupon from as-patterned 300mm silicon wafer for growth condition investigation. (d) As-patterned 300mm silicon wafer.

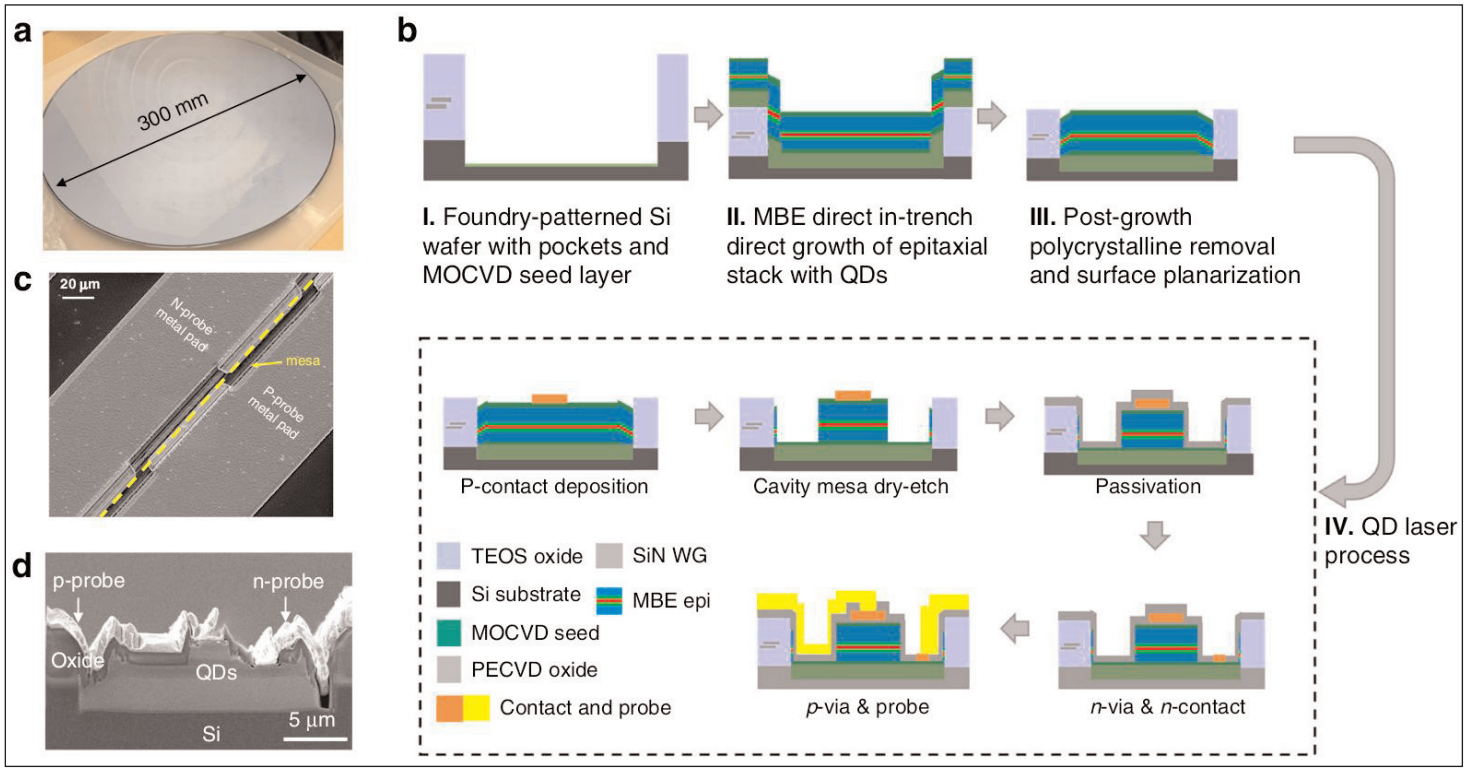

Figure 2. (a) As-grown 300mm wafer from IQE, covered with polycrystalline III–V material. (b) Simplified fabrication flow for laser fabrication, not drawn to scale. (c) Top-down view of as-fabricated device. (d) Cross-section scanning electron micrograph (SEM) of as-cleaved in-pocket laser.

The pocket LDs were fabricated on a 300mm silicon photonic template with tetraethoxysilane (TEOS) oxide patterning (Figure 1).

One challenge of the pocket structure was to obtain suitable temperature control in the molecular beam epitaxy (MBE) used for the device layers. This was critical due to the very narrow window (±2.5°C) for the InAs QD nucleation in the indium gallium arsenide (InGaAs) multiple quantum well (MQW) layers. Unfortunately, unlike in blanket MBE, reflective high-energy electron diffraction (RHEED) in-situ monitoring of the growth process was not possible due to interfering signals from the non-pocket regions, so the researchers had to depend on pyrometer readings calibrated from separate experiments on diced coupons of material.

It was found that the temperature in the pocket regions were possibly 45°C higher than the non-pocket regions. The higher temperature evaporated indium from the growth front, inhibiting QD formation.

Further work showed that a 30°C reduction in growth temperature was needed for QD formation with a ground-state photoluminescence peak around 1300nm wavelength. The full width at half maximum was 32meV, and the ground-to-excited-state peak separation 70meV; "comparable to typical values for blanket silicon substrates," the team adds.

Growth of the structure on a 300mm wafer was then carried out using the derived conditions. The seed layers of 200nm gallium phosphide (GaP) and 500nm GaAs were applied at NAsPIII/V, using metal-organic chemical vapor deposition (MOCVD). The devices layers were applied at IQE by MBE.

The wafer was diced into rectangular coupons for fabrication into laser diodes at UCSB's Nanofab (Figure 2). The QD laser fabrication was eased by the previous removal of polycrystalline residue from the growth process by wet etch and planarization. The team comments: "The removal of surface polycrystal enables easier handling with a more planarized sample surface and better focus calibration in the photolithography steps."

The resulting laser diodes had a ridge waveguide of 3.5µm width in a 20µm-width pocket. The maximum double-sided laser output power was 126.6mW continuous wave (CW) at 20°C. The laser threshold was at 47.5mA. The researchers say that the performance is comparable to devices grown on blanket silicon substrate with similar threading dislocation density (TDD). The maximum double-sided wall-plug efficiency was 8.6% at 214mA. CW lasing continued up to 60°C, and pulsed lasing to 70°C.

It is hoped that thermal management concerns of the pocket structure can be overcome through template quality, growth condition, device design and other optimizations. Aging experiments showed about a 10% increase in bias current needed for 10mW output power after 350 hours, comparable to devices on blanket silicon.

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Author: Mike Cooke

Optically pumped yellow InGaN edge-emitting laser

A stepping stone towards electrical pumping shows material quality that is competent for future development.

University of California Santa Barbara (UCSB) in the USA claims the first report of optically pumped 568nm yellow lasing from a high-crystal-quality indium gallium nitride (InGaN) quantum well (QW) edge-emitting structure grown on bulk GaN substrate [Panpan Li et al, Appl. Phys. Lett., v121, p071103, 2022].

The researchers comment: "Even though, in practice, electrically injected laser diodes have broader applications and impacts, an optically pumped device is undoubtedly a good indicator that the material quality is competent for future development and can be well regarded as a precursor to electrically injected laser diodes."

Yellow lasing is quite difficult in general, depending on frequency conversion in gas, ion or dye media. Such methods tend to be bulky, expensive and inefficient. Use for yellow laser light has been found in advanced biology and astrophysics/astronomy studies.

The problems for generating yellow light from InGaN include the large lattice mismatch between GaN and high-indium-content InGaN and inconvenient electric fields arising from differing charge polarization of the various III–nitride bonds. In laser structures, there is the additional problem of arranging suitable confinement of the optical mode to enable stimulated emission. The UCSB team points to the aluminium gallium nitride (AlGaN) cladding that is often used being problematic in the yellow range due to the thickness required going beyond the critical thickness, after which the material relaxes by cracking.

The laser material was grown by atmospheric-pressure metal-organic chemical vapor deposition on c-plane bulk GaN (Figure 1). The yellow light was generated by high-indium-content InGaN multiple QWs (MQWs) separated by AlGaN/GaN barriers.

The researchers were keen to have a very flat surface to increase the optical pumping efficiency. Atomic force microscopy gave a 0.3nm root-mean-square roughness over a 5μmx5μm field. The threading dislocation density was estimated to be $5x10^7/cm^2$ through analysis of cathodoluminescence images. The substrate threading

Cap	GaN		10nm
Waveguide	5x($In_{0.12}Ga_{0.88}N$/GaN)	920°C	5x(1.5nm/3nm)
Yellow MQW	**6x($In_{0.3}Ga_{0.7}N$/AlGaN/GaN)**	**760°C**	**6x(2nm/2nm/9nm)**
Waveguide	20x($In_{0.12}Ga_{0.88}N$/GaN)	920°C	20x(1.5nm/3nm)
Cladding	n-$Al_{0.06}Ga_{0.94}N$	960°C	1.5μm
Buffer	GaN		3μm
Substrate	Bulk c-plane GaN		

Figure 1. Epitaxial structure.

dislocation density was of order ~10^6/cm^2. The team points to the low-temperature growth of the lattice-mismatched MQW as the main source of the extra threading dislocations.

The normal top cladding was replaced by a quarter-wavelength layer of titanium dioxide (TiO_2). "Compared with traditional epitaxial InGaN waveguiding and AlGaN cladding, the use of the high refractive index of TiO_2 (near 2.6 at 580nm) on the top of the active regions greatly improves the confinement in the vertical direction by attracting the mode upward, although such structure will not be valid for electrical injection of laser diodes," the team explains.

The TiO_2 does have the drawback of absorbing the pump wavelength of 355nm, but the coefficient is less than that of high-indium-content InGaN. The 51nm quarter-wavelength TiO_2 cladding was deposited on a 38nm tantalum oxide (Ta_2O_5) top waveguide layer. On the basis of simulations, the team suggests that "the combined use of Ta_2O_5 and TiO_2 layers can enhance the confinement factor by nearly 25% while keeping the internal loss and single-pass absorption of the pumping source still at the same level." These top layers were applied by ion-beam deposition.

The laser bars were formed by reactive ion etch of 20–50μm ridges. The material thickness was reduced to 75μm by polishing. The bars were cleaved to give mirror facets, and then mounted on copper heatsinks.

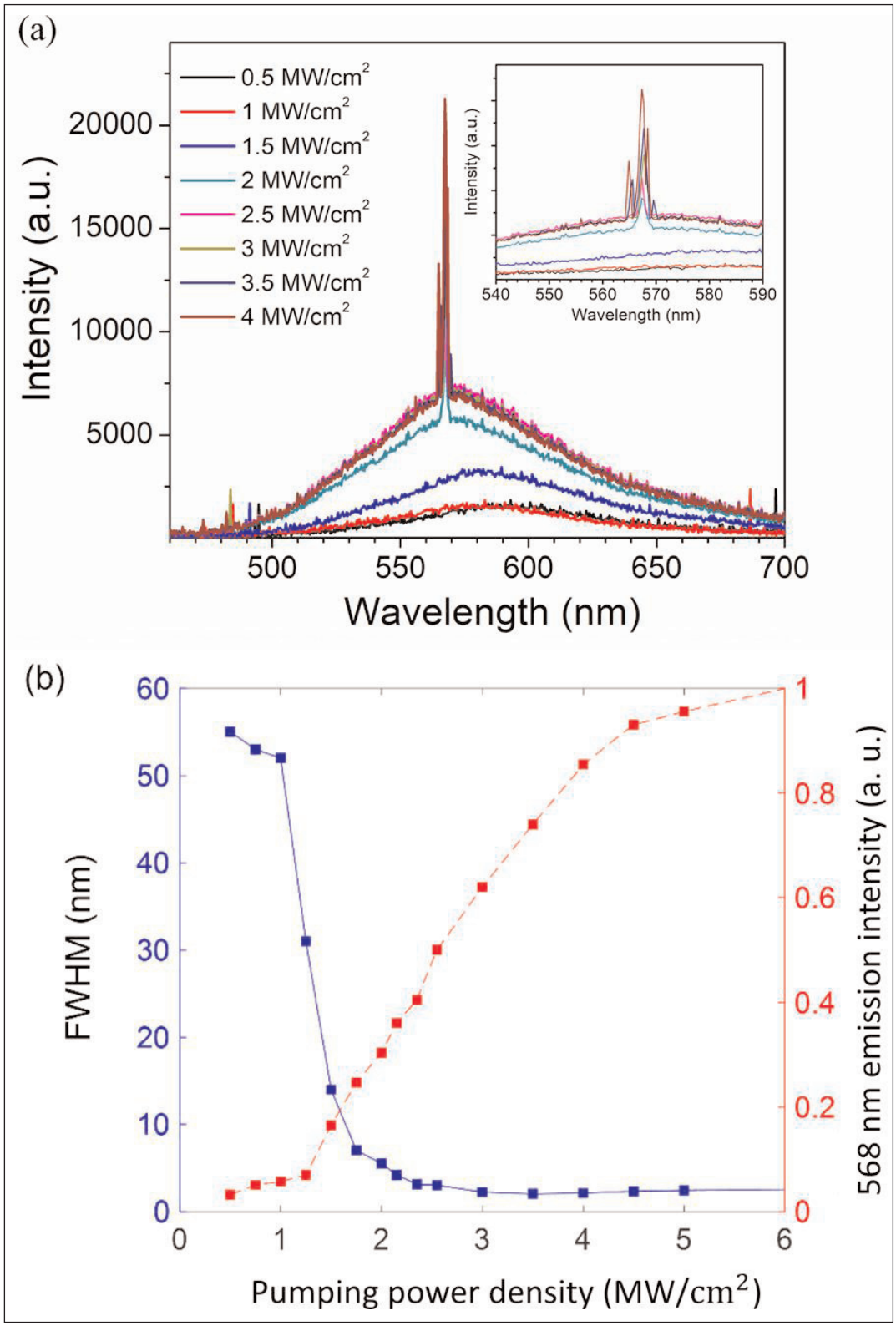

Figure 2. (a) Spectra collected at laser facet at various pumping power densities. Inset: close-up of stimulated emission wavelength. (b) Full-width at half maximum (FWHM) and intensity of simulated emission versus pumping power density.

The peak emission for a 1.4mmx50μm laser bar was at 568nm under 10Hz 30ps pulsed pumping (Figure 2). As the pumping passed through the 1.5MW/cm^2 pump power threshold the line-width reduced from 50nm to less than 2nm. The polarization of the laser light was found to be more than 90% transverse electric, as expected from simulations. ■

https://doi.org/10.1063/5.0093264

Author: Mike Cooke

Boron nitride pulsed laser deposition

Ultrawide bandgap could lead to optoelectronic and high-power applications.

Researchers in the USA report on pulsed laser deposition of hexagonal boron nitride (h-BN) on gallium nitride (GaN) with a view to optoelectronics and high-power electronics [Abhijit Biswas et al, Appl. Phys. Lett., v121, p092105, 2022]. The bandgap of h-BN is ~5.9eV, considered an ultra-wide bandgap (UWBG) relative to WBG GaN at ~3.4eV.

The team from Rice University, Oak Ridge National Laboratory and DEVCOM Army Research Laboratory found the h-BN/GaN to be second-harmonic generation active, and Schottky diodes formed from the material had a higher reverse-bias breakdown voltage, compared with Schottky diodes fabricated on GaN.

The researchers comment: "WBG and UWBG semiconductors including GaN, SiC, Al(Ga)N, diamond, Ga_2O_3 and BN are expected to revolutionize next-generation electronic device platforms because of their capabilities of realizing lower power loss, smaller system volume, higher operating voltage and temperature, and superior radiation hardness as compared to conventional semiconductors such as silicon and GaAs."

The team also suggests: "As BN and GaN are both III–nitrides, the heterojunctions made of BN/GaN can modify and/or improve the GaN-based device performances and could play an important role in high-power electronics and radio frequency (RF) applications, up to subterahertz regimes."

The PLD h-BN was grown on an unintentionally doped (UID) (0001) GaN on sapphire substrate produced through metal-organic chemical vapor deposition (MOCVD). The PLD growth temperature was 800°C. The laser source was a krypton fluoride (KrF) excimer laser emitting light of 248nm wavelength in the deep ultraviolet in 25ns pulses at 5kHz. The atmosphere was 100mTorr nitrogen. The laser ablation target was high-purity h-BN about 50mm away from the substrate.

The researchers see the advantages of PLD as including accurate stoichiometry transfer and uniform growth of films from dense poly- or single-crystalline targets with "enhanced adsorbate surface mobility endowed by high-energy radicals (both ionized and neutral; B^+, N^+, N*, N_2, N_2^+ and BN) that are accelerated from the

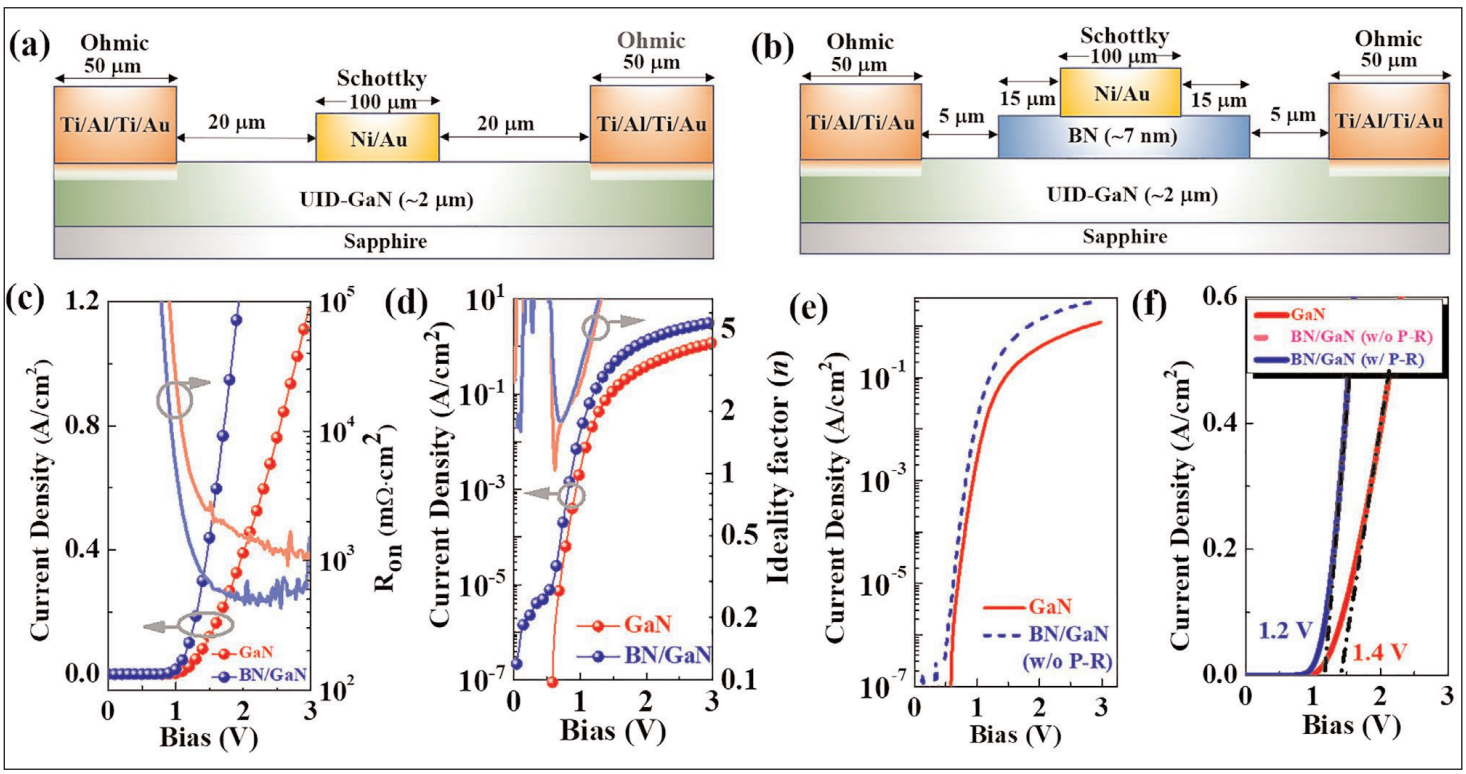

Figure 1. Schematics of (a) GaN and (b) BN/GaN Schottky diodes. Comparison of current density versus forward bias in (c) linear scale and (d) semi-log scale. (e) Comparison after removing the parallel resistance in BN/GaN diode. (f) Turn-on voltages from linear extrapolation.

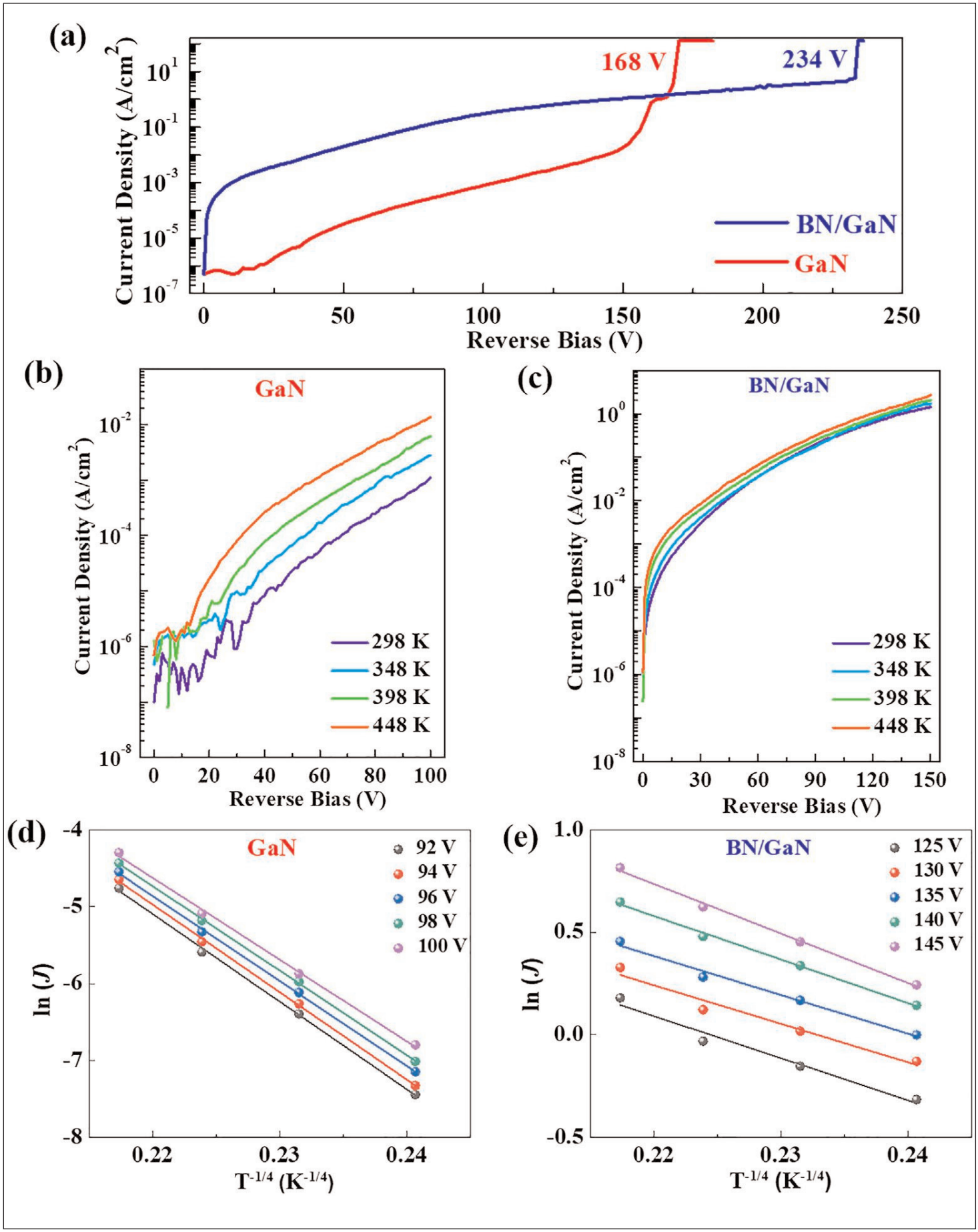

Figure 2. (a) Breakdown curves at room temperature. Reverse current density versus bias at different temperatures for (b) GaN and (c) BN/GaN Schottky diodes. VRH model plots for (d) GaN and (e) BN/GaN reverse leakage before breakdown.

target in the form of laser-ablated plasma." Also the growth temperature is relatively low, compared with MOCVD.

The 7nm BN layer resulted from 500 laser shots. After deposition, the sample was cooled at a rate of 20°C/min.

The BN layer was analysed using x-ray photoelectron spectroscopy (XPS). The analysis showed a main signal of B–N bonding, but there were also traces of bonds of B with oxygen and other B atoms. The N spectrum also showed the presence of some bonds with carbon impurities. Fourier-transform infrared (FTIR) and Raman spectroscopy studies, along with high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) were also performed. Atomic force microscopy showed a surface roughness of 0.267nm, compared with 0.183nm for the substrate.

The atomic structure was found to be disordered in the Raman and HAADF-STEM analyses. The disorder was due to mismatching between the "a" lattice parameters: 2.50Å for BN and 3.18Å for GaN. The a-ratio of 3:4 is considered to be best for a hexagonal on wurtzite structure such as GaN. Since 3/4 of 3.18Å is 2.385Å, the BN lattice would need to be highly compressed with around 4.6% strain to obtain this ratio.

Instead, the researchers describe their BN layer as being "disordered, amorphous-like". Even so, such material "was recently found to be applicable for ultraviolet (UV) photo-detection and high-performance electronics."

Another potential opportunity could come from its optical second-harmonic generation (SHG). Since BN is transparent in the visible wavelength range, this could open the way to visible-range nonlinear optoelectronics. The SHG signal from the BN layer was found to be 2.2x that of the GaN substrate. The laser input was 800nm wavelength and the SHG response was at 400nm from the scanned surface. The SHG response was found to be uniform across the surface.

The electrical performance was studied through fabricating nickel/gold Schottky diodes with and without the BN layer (Figure 1). The Ohmic metal contacts were titanium/aluminium/titanium/gold. The fabrication was performed at Rice University's Nanofab Cleanroom facility.

The team comments: "It can be seen that the forward current of the BN/GaN device is higher than the GaN device, which suggests that the BN layer does not block the current compared with what an insulating layer does in a conventional metal–insulator–semiconductor diode."

The BN/GaN device shows some leakage in the low-bias region, compared with the pure GaN diode. This can be modelled as a parallel resistance. Even removing this extra current, the BN/GaN device continues to show a higher current density for a given bias than the GaN diode.

The researchers extracted Schottky barrier heights of 1.3 and 1.1eV for the GaN and BN/GaN diodes, respectively. The respective idealities were 1.04 and 1.41.

The team writes: "The relatively lowered Schottky height of the BN/GaN diode not only leads to the increased forward current as compared with the GaN diode but also causes the increased reverse leakage current."

Despite the high reverse-bias leakage, the BN/GaN diode had a higher breakdown voltage of 234V, compared with 168V for the GaN diode (Figure 2). The temperature variation of the performance was found to be consistent with the 3D variable range hopping (VRH) model, which predicts the current density at a given bias varying as J_exp(−(T_c/T)¼). Such behavior would be seen as a straight line on plot of the logarithm of current density (ln(J)) versus the inverse fourth root of temperature ($T^{-¼}$). The characteristic parameters Tc were extracted from the slopes of the straight lines: $1.5x10^8$K for GaN and $3.4x10^5$K for BN/GaN.

The researchers suggest the higher breakdown of the BN/GaN devices could be due to the higher critical field in BN, allowing high electric fields at the electrode edge where breakdown often occurs. Higher critical fields are expected in materials with wider bandgaps, although low purity and/or crystallinity can hamper this effect. ■

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First inverted gallium oxide DI-MOS transistor

Novel Crystal Technology has reported a β-Ga_2O_3 inverted double-implanted MOS transistor that achieves 1kV breakdown voltage and 6V threshold voltage.

At the 83rd Japan Society of Applied Physics Autumn Meeting Symposium on 21 September, Novel Crystal Technology Inc of Sayama City, Saitama Prefecture, Japan reported what it claims is the first basic operation of a gallium oxide (β-Ga_2O_3) inverted double-implanted MOS transistor (DI-MOS-FET) with a high breakdown voltage (1kV) and a sufficiently high threshold voltage (6V). The firm has been aiming to commercialize the β-Ga_2O_3 transistor since 2019 by participating in the 'Research and Development of Inverted MOS Channel Type Gallium Oxide Transistor' program of the National Security Technology Research Promotion Fund (JP004596) of the Acquisition, Technology & Logistics Agency.

The latest achievement is expected to greatly advance the development of medium-to-high-voltage (0.6–10kV) gallium oxide transistors, in turn leading to lower prices and higher performance in power electronics. Moreover, it can contribute to the efficient use of electric energy in vehicles by improving the efficiency and downsizing of power electronics equipment such as power converters for solar power generation, general-purpose inverters for industrial use, and power supplies.

Compared with silicon carbide (SiC) and gallium nitride (GaN) as high-performance materials for replacing silicon, gallium oxide has superior material properties, and low-loss, low-cost power devices can be made with it by using a low-cost crystal growth method. β-Ga_2O_3 is expected to be useful in various power electronics equipment, such as home appliances, electric vehicles, railway vehicles, industrial equipment, solar power generators, and wind power generators. In addition, domestic and foreign companies and research institutes are accelerating their R&D on β-Ga_2O_3 because they see the material as a way to reduce the size and improve the efficiency of installed electrical equipment.

Results

Until now, normally-off β-Ga_2O_3 transistors have used a fin structure that does not require a p-type layer, because p-type conductive layer technology has not yet been established. However, the fin must have a fine structure of 0.4μm or less with good dimensional control. It has been difficult to fabricate devices such as this with a chip size of several millimeters square with good yield.

In response to this problem, Novel Crystal Technology has been developing an inverted MOS channel structure that can be manufactured with high yield even using conventional stepper exposure equipment and dry etching equipment. Instead of relying on developing the technically challenging β-Ga_2O_3 p-type conductive layer, the current development uses a high-resistance β-Ga_2O_3 layer doped (through ion implantation) with

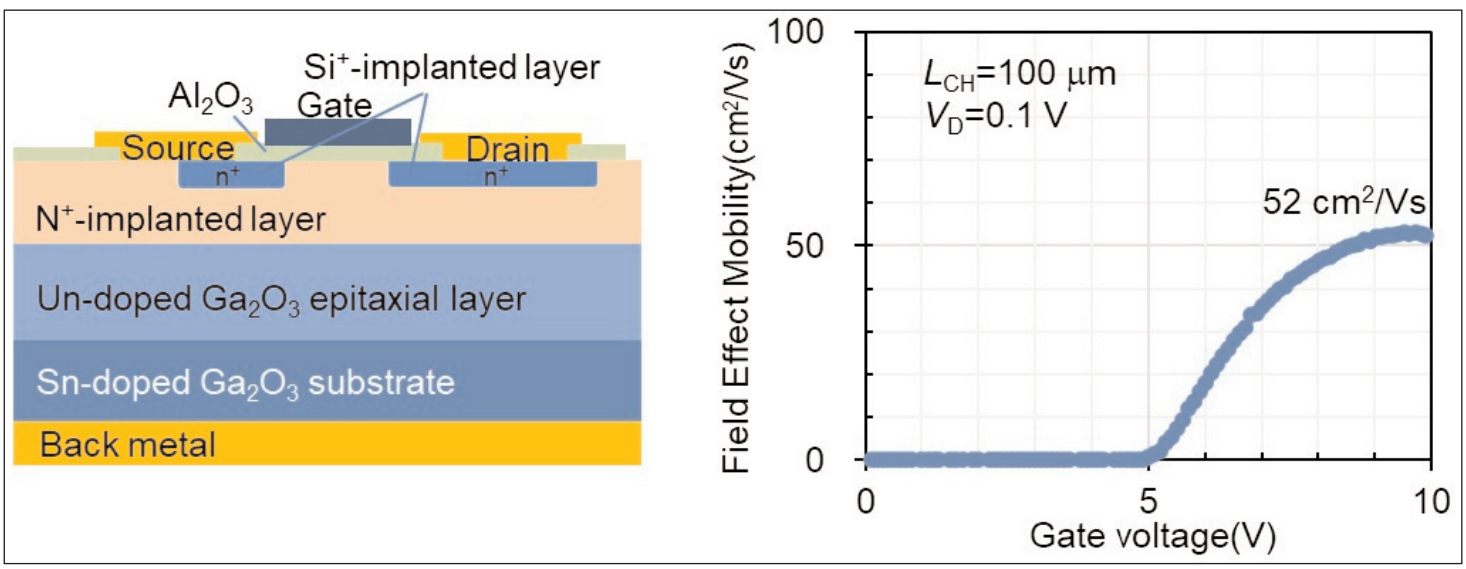

Figure 1: Cross section (left) and channel mobility (right) of long-channel lateral transistor.

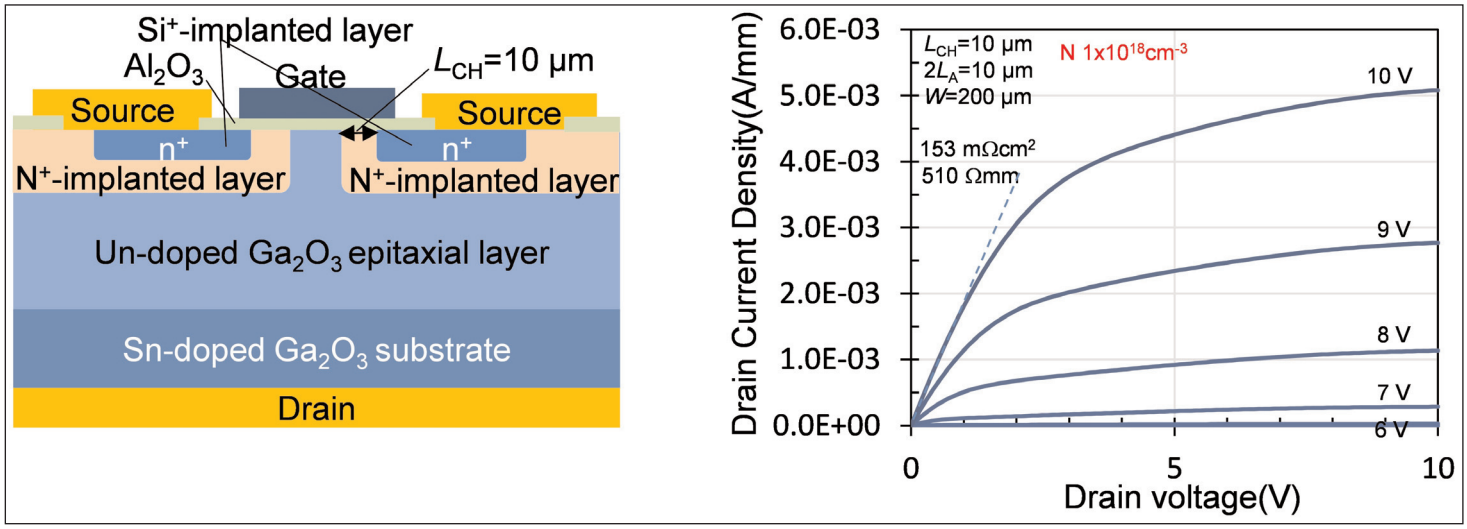

Figure 2: Cross section (left) and static characteristics (right) of β-Ga_2O_3 DI-MOS transistor.

nitrogen (N) as an acceptor impurity, and a well layer is made through an activation heat treatment.

In a mobility evaluation, the fabricated long-channel (L_{CH}=100μm) lateral transistor exhibited a high threshold voltage of 6.2V (which could not be achieved with a fin structure) and a higher MOS channel mobility (52cm^2/Vs) than that of a device made from silicon carbide (Figure 1).

Furthermore, an inverted DI-MOS transistor (Figure 2) fabricated using this process had a threshold voltage of 6.6V at an N^+ ion implantation concentration of 1x$10^{18}cm^{-3}$ and an off-stage voltage of 1.1kV at an N^+ ion implantation concentration of 3x$10^{18}cm^{-3}$ or higher (Figure 3). Novel Crystal Technology found that the N^+ ion-implanted high-resistance β-Ga_2O_3 layer works as a threshold voltage control layer and a current-blocking layer in the same way as a p-type conductive layer. The researchers believe that the channel length of the prototype DI-MOSFET was as long as 10μm, and the on-resistance was as high as 153mΩcm^2. The newly developed DI-MOSFET device and process should enable large devices to be fabricated on 4–6 inch wafer mass-production lines, and significant progress is expected in the development of low-loss β-Ga_2O_3 power transistors.

Future plans

Novel Crystal Technology says that it will analyze the characteristics of the N-doped β-Ga_2O_3 high-resistance layer in the prototype inverted MOS transistor as part of the project commissioned by the Acquisition, Technology & Logistics Agency. In addition, it aims to conduct trial production on a 4-inch mass-production foundry line, improve the device characteristics, and ensure reliability. It will also proceed with the development of a full β-Ga_2O_3 power module combined with a gallium oxide Schottky barrier diode (SBD) that is now being commercialized.

According to a Fuji Keizai report '2022 Current Status and Future Prospects of the Next Generation Power Devices & Power Electronics Related Equipment Market', the market for medium- and high-voltage high-speed transistors and high-speed diodes is expected to grow to 7.9bn yen in 2025 and 47bn yen by 2030. Novel Crystal Technology says that it will enter this market with β-Ga_2O_3 transistors, SBDs, and full β-Ga_2O_3 modules. ■

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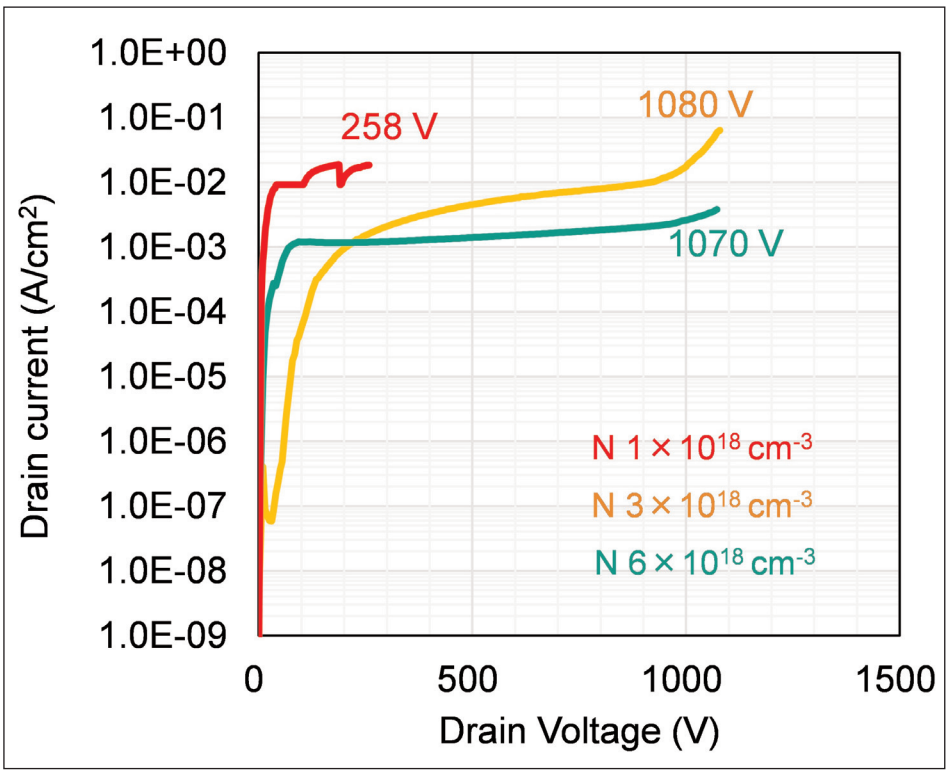

Figure 3: Breakdown voltage waveform of β-Ga_2O_3 DI-MOS transistor.

InGaAs biristor for high-density DRAM

Researchers demonstrate device with high reliability, scalability and endurance with 3D prospects.

Researchers in Korea have demonstrated capacitor-less $4F^2$ 2-terminal indium gallium arsenide (InGaAs) npn junction dynamic random access memory (DRAM) [Joon Pyo Kim et al, IEEE Electron Device Letters, published online 5 September 2022] with a view to highly compact 3D structures.

Standard DRAM cells tend to have areas 6–8F2 relative to the process feature size (F) that incorporate 1 transistor and 1 capacitor (1T1C). By removing the need for capacitor storage of the memory state, the cell area can be reduced. The device designed and fabricated by Korea Advanced Institute of Science and Technology (KAIST) and Korea Advanced Nano Fab Center (KANC) used a bistable resistor (biristor) structure (1R0C).

Although $4F^2$ capacitor-less transistor memory structures (1T0C) have been reported, they suffer from reliability problems due to hot carriers degrading the gate dielectric during operation. Birisitors produced in silicon need relatively high voltages of more than 4V to operate.

The higher mobility of III–V materials such as InGaAs enables lower voltages for a given current, and hence reduced biristor operating voltages.

The KAIST/KANC InGaAs epitaxial structure (Figure 1) was grown on indium phosphide (InP) substrate using metal-organic vapor phase epitaxy. It is hoped that present advances in integrating InGaAs on 300mm silicon substrates will lead to high-volume, low-cost deployment in future.

The n^+ layer was achieved using tellurium (Te) doping with diethyl-tellurium precursor. Tellurium gives far higher activation levels of electron charge carrier concentration (N_D), at more than $5x10^{19}/cm^3$, compared with conventional silicon doping for n-InGaAs.

The high N_D was needed for low operation voltage for the InGaAs biristor DRAM, according to design simulations. The researchers optimized the growth process to allow the use of Te doping, since compressive strains make it difficult to grow high-quality layers. X-ray analysis showed negligible lattice mismatch with the InP substrate.

The 400nm base region of the device was p-doped with zinc. The thickness of this layer controlled the operation voltage of the memory. For stable latch operation, this thickness would need to be carefully constrained in production across a memory chip, especially in the thinner layers that would result in lower operation voltage.

The fabricated devices were formed from mesas measuring 10μmx10μm. The cell area was, of course, larger. The hafnium dioxide (HfO_2) surface passivation was 20nm thick. The contact metals were 20nm/70nm molybdenum/gold (Mo/Au).

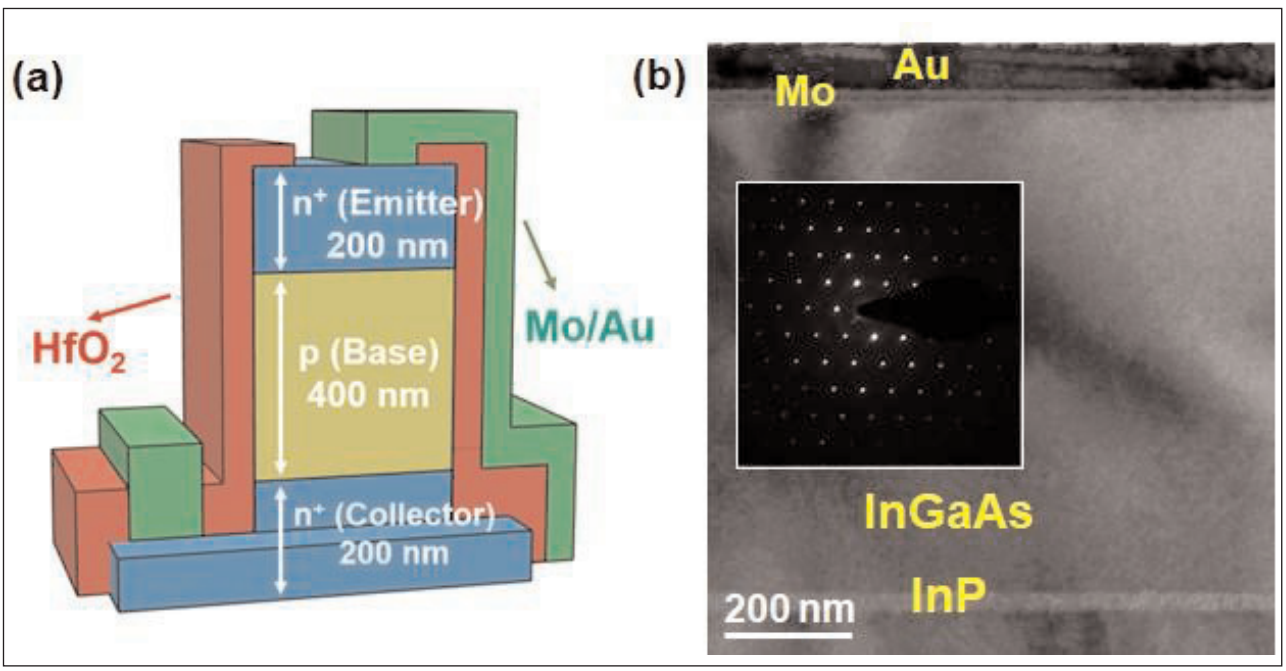

Figure 1. (a) 3D schematic structure and (b) cross-sectional transmission electron microscope image of fabricated vertical InGaAs biristor. Inset: electron diffraction image of InGaAs material.

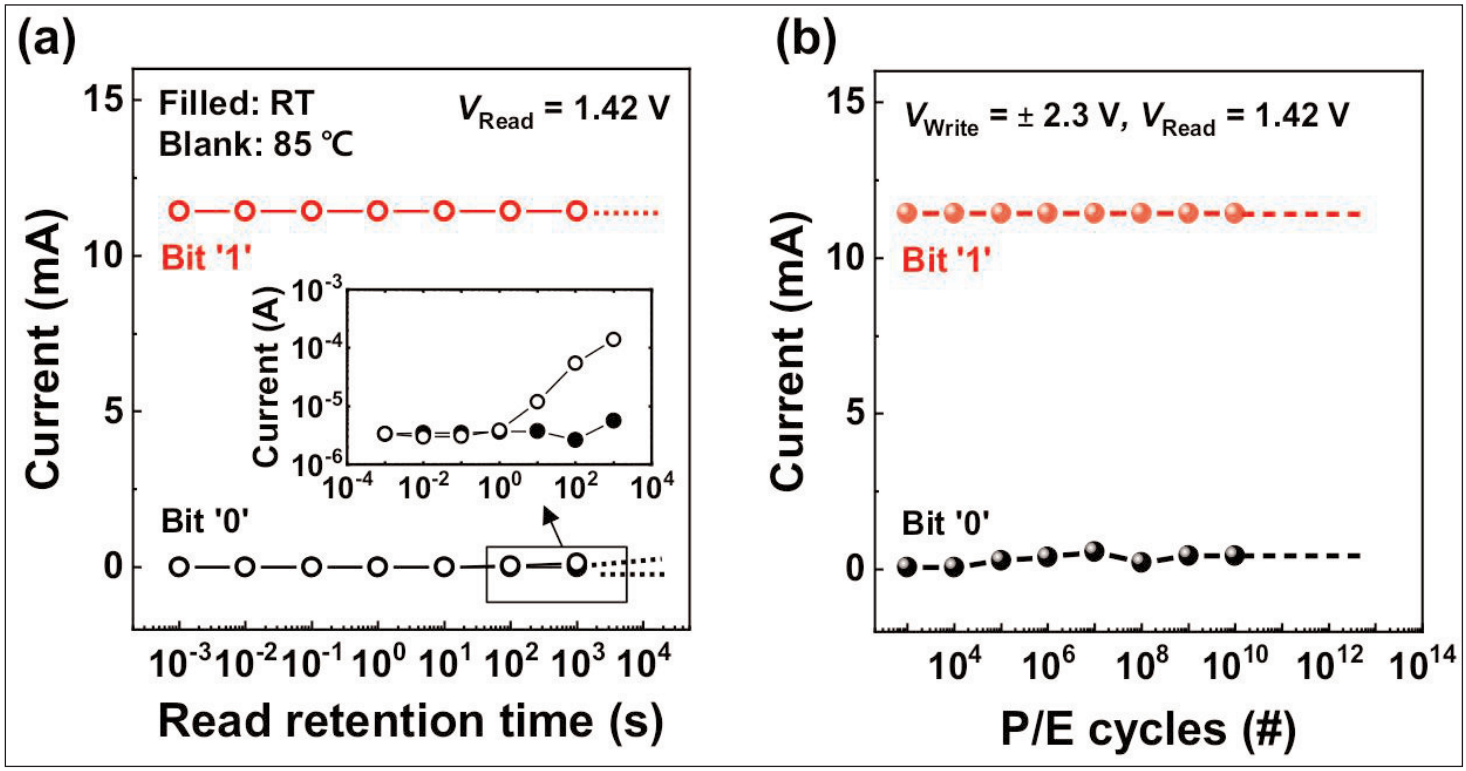

Figure 2. (a) Retention characteristics of InGaAs biristor at room temperature and 85°C. (b) Endurance characteristics.

The current–voltage behavior of the devices showed hysteresis with two current levels between latch-up (V_{LU}) and latch-down (V_{LD}) voltages. These current levels are used to represent the memory state. The latch-up state is caused by impact ionization at the base–collector junction, enabling higher current flow. As the voltage is reduced through latch-down the impact ionization stops, reducing current flow. The hysteresis behavior was only weakly dependent on temperature up to 100°C.

The team comments: "Once the biristor is latched up, the programmed state is not disturbed because of positive feedback with adequate V_{Read}. As the device is biased with the V_{Read} during the retention, quite large static power seems to be consumed during retention. However, it can be further reduced by decreasing the current level through device scaling."

The researchers used program/erase (P/E) voltages of ±2.3V with write times as low as 20ns. The P/E voltage was low enough to avoid device breakdown.

The data retention reached more than 1000s for measurements at room temperature and 85°C (Figure 2). The endurance of the device reached to at least 10^{10} P/E cycles, the point at which the test was stopped. The endurance performance was attributed to the low operation voltage along with the gateless structure.

Added to the advantages of high device reliability and scalability, the KAIST/KANC team points to the low back-end-of-line (BEOL) fabrication process temperature of 250°C as enabling of 3D device stacking for even greater concentration of memory in a small volume. ■

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Author: Mike Cooke

Table 1. Benchmarks with various devices reported as capacitor-less DRAM. First column: KAIST/KANC device; second column: 1T1C DRAM comparison/reference, others capacitor-less.

Characteristic	1R0C InGaAs biristor	1T1C Si DRAM	1R0C Si biristor	1T0C InGaAs transistor	1R0C n-i-p-i-n Si biristor
Cell area	$4F^2$	$6–8F^2$	$4F^2$	$4F^2$	$4F^2$
V_{Write}(V)	2.3	~3.0	6.5	1	<1
Write time	20ns	~10ns	5ns	>30µs	<30ns
V_{Read}(V)	1.42	—	5	1	<1
Current sensing margin	>11.4mA (114µA/µm^2)	—	0.42mA	<20µA/µm	—
Retention	≥10^3s	~64ms	10s	<10^{2s}	>1µs
Endurance (cycles)	≥10^{10}	≥10^{10}	10^{11}	<10^{10}	>10^7
BEOL compatibility	O (250°C)	X	X	O (—)	X

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Tel: +1 518 271 7375
Fax: +1 518 271 7394
www.crystal-is.com

CS Microelectronics Co Ltd (Vital Materials subsidiary)
Gaofeng Park,
Wanzhou Economic-Technological Development Area,
Chongqing,
China 404040
Tel: +86 023-58879888
E-mail: csm_sales@vitalchem.com
www.cs-micro.com
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Freiberger Compound Materials
Am Junger Loewe Schacht 5,
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Germany
Tel: +49 3731 280 0
Fax: +49 3731 280 106
www.fcm-germany.com

Kyma Technologies Inc
8829 Midway West Road,
Raleigh, NC, USA
Tel: +1 919 789 8880
Fax: +1 919 789 8881
www.kymatech.com

MARUWA CO LTD
3-83, Minamihonjigahara-cho,
Owariasahi, Aichi 488-0044, Japan
Tel: +81 572 52 2317
www.maruwa-g.com/e/products/ceramic

sp3 Diamond Technologies
2220 Martin Avenue,
Santa Clara, CA 95050, USA
Tel: +1 877 773 9940
Fax: +1 408 492 0633
www.sp3inc.com

Sumitomo Electric Semiconductor Materials Inc
7230 NW Evergreen Parkway,
Hillsboro, OR 97124, USA
Tel: +1 503 693 3100 x207
Fax: +1 503 693 8275
www.sesmi.com

The Fox Group Inc
200 Voyageur Drive, Montreal,
Quebec H9R 6A8, Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

III/V-Reclaim
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Germany
Tel: +49 8728 911 093
Fax: +49 8728 911 156
www.35reclaim.de

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Santa Clara, CA 95054 , USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
Contact Person: Cathy W. Hung
E-mail: sales@tecdia.com
www.tecdia.com

Wafer Technology Ltd
34 Maryland Road, Tongwell,
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Fax: +44 (0)1908 210443
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Fax: +1-561-842-2677
www.waferworld.com

4 Epiwafer foundry

Albemarle Cambridge Chemical Ltd
Unit 5 Chesterton Mills,
French's Road, Cambridge CB4 3NP,
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.camchem.co.uk

Intelligent Epitaxy Technology Inc
1250 E Collins Blvd,
Richardson, TX 75081-2401,
USA
Tel: +1 972 234 0068
Fax: +1 972 234 0069
www.intelliepi.com

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Fax: +1 514 630 0227
www.thefoxgroupinc.com

5 Deposition materials

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

Matheson Tri-Gas
6775 Central Avenue,
Newark, CA 94560,
USA
Tel: +1 510 793 2559
Fax: +1 510 790 6241
www.mathesontrigas.com

Nouryon Functional Chemicals B.V.
Zutphenseweg 10, 7418 AJ
Deventer,
The Netherlands
Tel. +31 652 478554
https://hpmo.nouryon.com

Praxair Electronics
542 Route 303,
Orangeburg, NY 10962,
USA
Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

Vital Thin Film Materials (Guangdong) Co Ltd (Vital Materials subsidiary)
18G, 18th Floor, Shenzhen Free
Trade Centre, No.111 Taizi Road,
Nanshan District,
Shenzhen, Guangdong, China 518067
Tel: (+86) 0755-21651348
sales@vitaltfm.com

www.vitaltfm.com
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

6 Deposition equipment

AIXTRON SE
Dornkaulstr. 2,
52134 Herzogenrath,
Germany
Tel: +49 2407 9030 0
Fax: +49 2407 9030 40
www.aixtron.com

ETC (LPE subsidiary)
Via Falzarego, 820021 Baranzate (Mi),
Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

FHR Anlagenbau Gmbh
(Vital Materials subsidiary)
Am Hügel 2, D-01458
Ottendorf-Okrilla,
Germany
Tel: +49 35205 520-0
E-mail: sales@fhr.de
E-mail: sales@vitalchem.com
www.fhr.biz
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

LPE S.p.A.
Via Falzarego, 8
20021 Baranzate (Mi), Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

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

Plasma-Therm LLC
10050 16th Street North,
St. Petersburg, FL 33716,
USA
Tel: +1 727 577 4999
Fax: +1 727 577 7035
www.plasmatherm.com

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95873 Bezons Cedex,
France
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Fax: +33 (0) 1 39 47 45 62
www.riber.com

SVT Associates Inc
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Fax: +1 952 934 2737
www.svta.com

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
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USA
Tel: +1 925 245 5817
Fax: +1 925 449-4096
www.temescal.net

Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797,
USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

Kayaku Advanced Materials Inc
200 Flanders Road,
Westborough, MA 01581,
USA
Tel: +1 617 965 5511
www.kayakuam.com

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

EV Group
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Fax: +43 7712 5311 4600
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Fax: +44 (0) 1389 879 042
www.logitech.uk.com

Plasma-Therm LLC
(see section 6 for full contact details)

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Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

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Wales, UK
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Fax: +44 (0)1633 414141
www.spts.com

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85748 Garching, Germany
Tel: +49 89 32007 0
Fax: +49 89 32007 162
www.suss.com

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1024 Ecublens,
Switzerland
Tel +41 21 694 35 00
Fax +41 21 694 35 01
www.synova.ch

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054 ,
USA
Tel: +1-408-748-0100
Fax: +1-408-748-0111
Contact Person: Cathy W. Hung
Email: sales@tecdia.com
www.tecdia.com

Veeco Instruments Inc
(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd
Ermine Business Park, Huntingdon,
Cambridgeshire PE29 6WR, UK
Tel: +44 (0) 1480 424800
Fax: +44 (0) 1480 424900
www.goodfellow.com

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

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

10 Gas and liquid handling equipment

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

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Ismaning, 85737,
Germany
Tel: +49 89 96 24000
Fax: +49 89 96 2400122
www.csclean.com

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

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

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

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

11 Process monitoring and control

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

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

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

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Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald,
Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

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

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

13 Characterization equipment

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Fax: +1 402 477 8214
www.jawoollam.com

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

CST Global Ltd
4 Stanley Boulevard,
Hamilton International
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Tel: +44 (0) 1698 722072
www.cstglobal.uk

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

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

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Fax: +1 508-832-0506
www.pi.ws
www.pi-usa.us

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Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

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Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

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4 Stanley Boulevard, Hamilton International Technology Park,
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UK
Tel: +44 (0) 1698 722072
www.cstglobal.uk

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

19 Facility equipment

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

Vacuum Barrier Corporation
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USA
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20 Facility consumables

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

21 Computer hardware & software

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

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

22 Used equipment

Brumley South Inc
422 North Broad Street,
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www.ClassOneEquipment.com

23 Services

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TECDIA Inc
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Fax: +1-408-748-0111
Contact Person: Cathy W. Hung
www.tecdia.com

24 Resources

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www.alshuktz.com

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USA
Tel: +1 408 943 6900
www.semi.org

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

event calendar

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3–7 December 2022
68th annual IEEE International Electron Devices Meeting (IEDM 2022)
Hilton San Francisco Union Square hotel,
San Francisco, CA, USA
E-mail: iedm-info@ieee.org
www.ieee-iedm.org

7–9 December 2022
LASER World of PHOTONICS INDIA
Bombay Exhibition Centre,
Mumbai, India
E-mail: info@world-of-photonics-india.com
www.world-of-photonics-india.com/en

14–16 December 2022
SEMICON Japan 2022
Tokyo Big Sight,
Tokyo, Japan
E-mail: jcustomer@semi.org
www.semiconjapan.org/en

1–3 February 2023
SEMICON Korea 2023
COEX, Seoul,
South Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org/en

19–23 February 2023
2023 IEEE International Solid- State Circuits Conference (ISSCC 2023)
San Francisco, CA USA
E-mail: Issccinfo@yesevents.com
www.isscc.org

5–9 March 2023
Optical Fiber Communication Conference and Exhibition (OFC 2023)
San Diego Convention Center,
San Diego, CA, USA
E-mail: custserv@optica.org
www.ofcconference.org

17–21 March 2023
4th International Congress on Advanced Materials Sciences and Engineering (AMSE-2023)
Hilton Vienna Danube Waterfront,
Vienna, Austria
E-mail: eve@istci.org
www.istci.org/amse2023

19–23 March 2023
IEEE Applied Power Electronics Conference and Exposition (APEC 2023)
Orange County Convention Center,
Orlando, FL, USA
E-mail: apec@apec-conf.org
www.apec-conf.org

20–21 March 2023
China Semiconductor Technology International Conference (CSTIC) 2023, in conjunction with SEMICON China 2023
Shanghai, China
E-mail: cstic@semichina.org
www.semiconchina.org/en/5

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22–24 March 2023
SEMICON China and FPD China 2023
Shanghai New International Expo Centre, China
E-mail: semichina@semi.org
www.semiconchina.org/en

26–30 March 2023
2023 IEEE International Reliability Physics Symposium (IRPS)
Hyatt Regency, Monterey, CA, USA
E-mail: IRPSreg@ieee.org
www.irps.org

25–27 April 2023
26 Annual CMSE (Components for Military and Space Electronics) Conference and Exhibition (CMSE 2023)
Four Points by Sheraton (LAX), Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

7–12 May 2023
2023 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center,
San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

21–25 May 2023
LightFair 2023
Javits Center, New York, USA
E-mail: michellem@lightfair.com
www.lightfair.com

23–25 May 2023
SEMICON Southeast Asia (SEMICON SEA 2023)
Setia SPICE Convention Centre & Arena, Penang, Malaysia
E-mail: semiconsea@semi.org
www.semiconsea.org

Microwave Week

11–13 June 2023
2023 IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: support@mtt.org
www.rfic-ieee.org

11–16 June 2023
2023 IEEE/MTT-S International Microwave Symposium (IMS 2023)
San Diego Convention Center,
San Diego, CA, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/ims2023

11–16 June 2023
43rd Symposium on VLSI Technology & Circuits – 'Rebooting Technology & Circuits for a Sustainable Future'
Rihga Royal Hotel, Kyoto, Japan
E-mail: vlsisymp@jtbcom.co.jp (Asia and Japan) or vlsi@vlsisymposium.org (North America and Europe)
www.vlsisymposium.org

25–29 June 2023
World of PHOTONICS CONGRESS — International Congress on Photonics in Europe
ICM – Internationales Congress Center München,
Munich, Germany
E-mail: info@photonics-congress.com
www.photonics-congress.com/en

11–13 July 2023
SEMICON West 2023
Moscone Center, San Francisco, CA, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

6–8 September 2023
SEMICON Taiwan 2023
TaiNEX 1&2, Taipei, Taiwan
E-mail: semicontaiwan@semi.org
www.semicontaiwan.org

17–22 September 2023
26th European Microwave Week (EuMW 2023)
Berlin Messe, Germany
E-mail: eumwreg@itnint.com
www.eumweek.com

1–5 October 2023
European Conference on Optical Communication (ECOC 2023)
Glasgow, Scotland, UK
E-mail: postmaster@theiet.org
https://ecoc2023.theiet.org

14–18 October 2023
2023 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Monterey, CA, USA
E-mail: cs@cshawevent.com
www.bcicts.org

14–17 November 2023
SEMICON Europa 2023
Messe München, Munich, Germany
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