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semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

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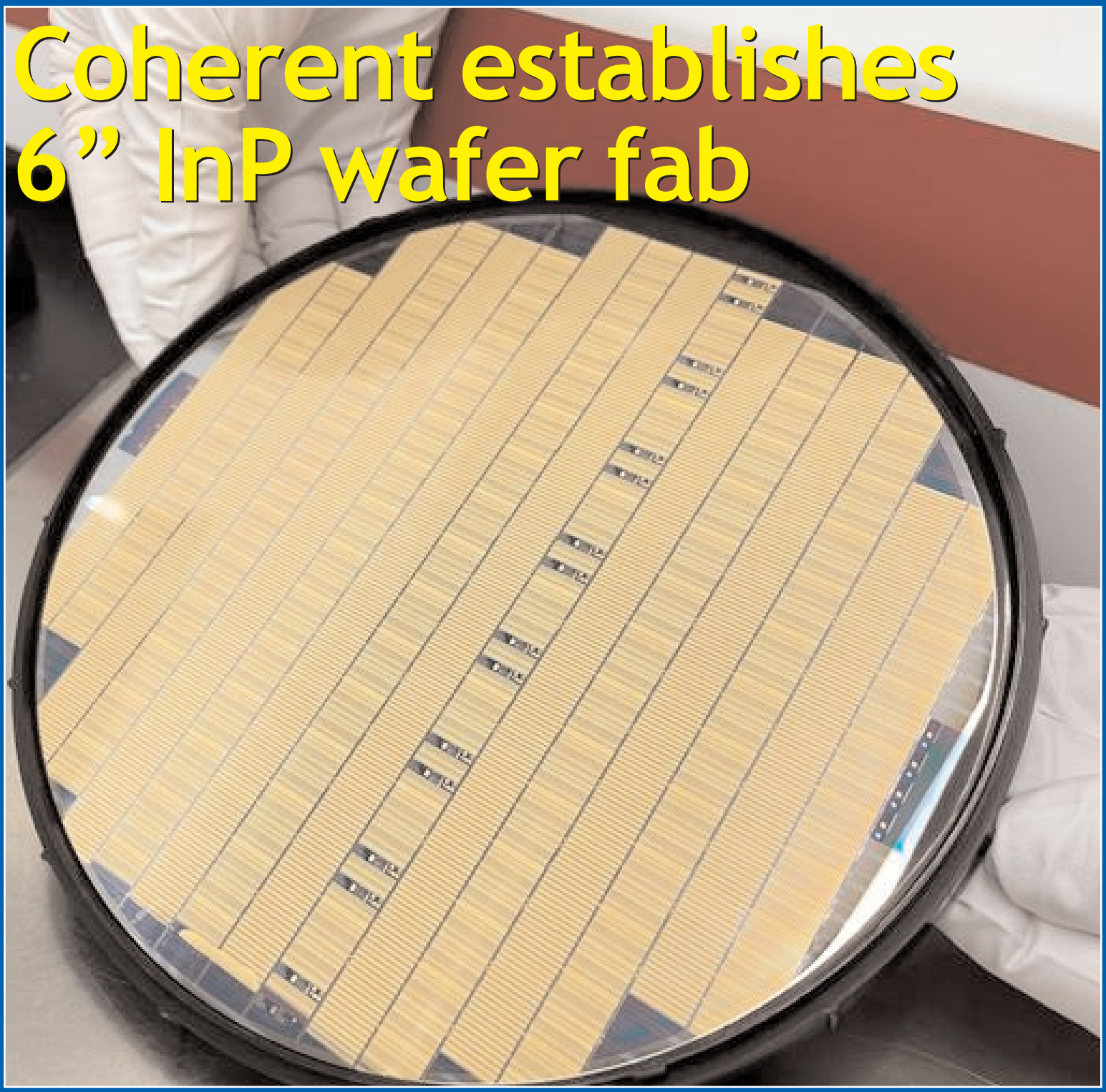
Coherent establishes 6” InP wafer fab



Odyssey sold for $9.52m • GaAs Labs sells Mission Microwave
Mersen gains €12m • ams OSRAM re-assessing micro-LED strategy

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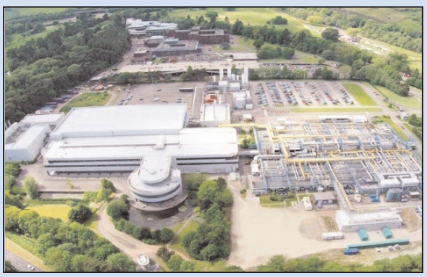
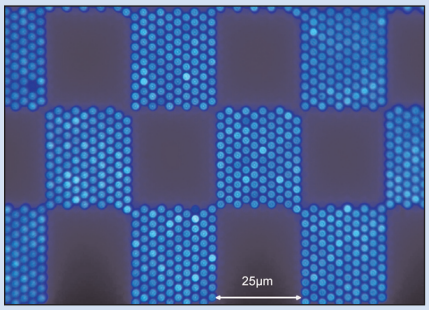
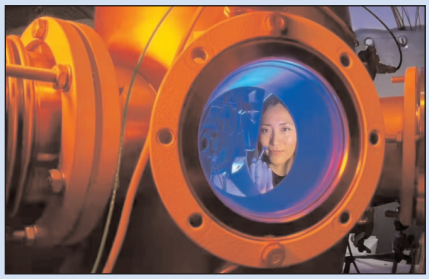


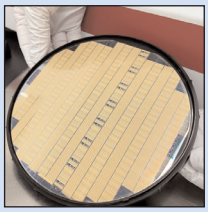
p12 Vishay has acquired Nexperia's Newport Wafer Fab following UK Government approval.



p39 MICLEDI Microdisplays has announced a first closing of its Series A funding round, brings total funding to date to nearly $30m.



p42 Friedrich Schiller University Jena and TU Braunschweig have launched a three-year BMBF-funded joint project OptoGaN, which focuses on porous gallium nitride.



Cover image: Coherent has established what it says is the world's first capability for 6-inch indium phosphide wafer fabrication, in its fabs in Sherman, Texas, and Järfälla, Sweden, increasing production capacity and lowering die costs for InP optoelectronic devices. **p50**

editorial

OSRAM's µLED fab loses core partner

On 28 February, Germany/Austria-based ams OSRAM announced the unexpected cancellation of a cornerstone project for its micro-LED program, although discussions with the related customer — assumed to concern the display module for the Apple Watch Ultra 3 — were ongoing (see page 38).

In April 2022, ams OSRAM announced plans to construct the 'Kulim 2' fab for 8-inch LED wafers at its site in Malaysia (for ramp-up in late 2023) and in November 2022 it said a strategic customer had agreed to make substantial pre-payment to reserve micro-LED manufacturing capacity.

Up to now, ams OSRAM has invested about €1.3bn in the project (including about €1m in capital expenditure). However, the ramp-up schedule slipped first to 2024, then 2025. ams OSRAM was said to be on track with process development and qualifications but Apple reportedly struggled to achieve satisfactory yields in pilot lines for downstream manufacturing processes such as mass transfer. The first Apple Watch with a micro-LED display was originally scheduled for release in 2026, but slipped to 2027 or even later. In the meantime, the cost of the existing Apple Watch Ultra 2's OLED display module has fallen to less than $40 versus the likely $85 cost for Apple's micro-LED display in its first year, estimates market analyst firm Yole Group.

Amid its ongoing elevated capital expenditure and delay in significant revenue generation to 2026, ams OSRAM last October agreed a $420m sale-and-lease-back deal for the Kulim 2 building, with an option to buy it back in ten years (meanwhile retaining ownership of the equipment).

ams OSRAM now expects to record non-cash impairment charges on micro-LED-related assets and goodwill of €600–900m in first-quarter 2024, as it re-assesses its micro-LED strategy and future use of Kulim 2. Nevertheless, the project cancellation is expected to improve ams OSRAM's cash flow in the next 24 months, due partly to reduced CapEx.

ams Osram has cut its 'mid-term' (2026) forecast for compound annual revenue growth, but only from 6–10% to 6–8%, due to its confidence in its core markets such as automotive LEDs and strengthening in the industrial and medical sectors.

In addition, Yole notes that, after acquiring expertise in designing and manufacturing micro-LED chips (especially sub-10µm, needed for high-volume consumer products) and perhaps freed from restrictions imposed by Apple on serving competitors and adjacent applications, ams OSRAM can further promote its foundry services to micro-LED companies as well as releasing its own standard micro-LED die products.

However, Yole reckons that demand could be served from ams OSRAM's existing 150mm-wafer Regensburg and Kulim 1 fabs or the 200mm micro-LED pilot line in Regensburg, Germany. So, disposal of Kulim 2 is possible.

Since ams OSRAM was Apple's sole micro-LED chip supplier, there was speculation that Apple is discontinuing micro-LED display development, after spending more than $2.6bn (plus $420m to acquire Luxvue in 2014). However, despite laying off most staff, Apple retained a team working on an AR-related micro-LED project, said Yole. According to TrendForce, Apple is seeking alternative chip suppliers. Candidates in Taiwan include Innolux/Foxconn or Ennostar/PlayNitride/AU Optronics (the latter of which recently began mass production of micro-LED watch display panels, and is a pre-existing supplier for Apple MacBook Pro LCD screens).

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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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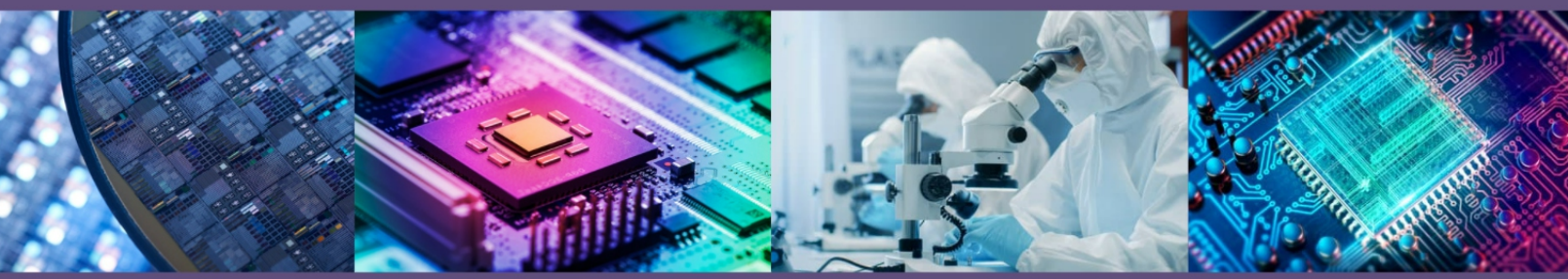

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Silicon carbide power device market to grow to $5.33bn in 2026

TrendForce surveys capacity expansions in silicon carbide substrate and device production

Benefitting from robust demand from downstream applications, market research firm TrendForce forecasts that the silicon carbide (SiC) power device market will grow to $5.33bn by 2026, with mainstream applications still highly reliant on electric vehicles and renewable energy sources.

Recently, the SiC market has seen new developments involving companies such as Mitsubishi Electric, Mersen, and Ascen Power.

Mitsubishi Electric beginning construction of SiC fab in April

In March 2023, Japan's Mitsubishi Electric announced plans to invest about JPY100bn (CNY4.856bn) over five years to construct an 8-inch SiC fab and enhance related production facilities. According to the latest reports from Nikkei, construction of the fab in Kumamoto Prefecture, will begin in April, with operations scheduled to start in April 2026.

Spanning six floors with a total area of about 42,000m^2, the new fab will primarily handle front-end processes for 8-inch SiC wafers, incorporating an automated transport system across all processes to create a highly efficient production line. The firm plans to gradually increase SiC production capacity by five times by fiscal-year 2026 (compared with fiscal 2022).

In May 2023, Mitsubishi Electric signed a memorandum of understanding (MoU) for US-based Coherent to supply 8-inch n-type 4H-SiC wafers for the new factory. Both parties are committed to expanding the production scale of 8-inch SiC devices.

Ascen Power accelerates phase one capacity ramp-up of SiC chip manufacturing project

Ascen Power's SiC chip manufacturing project is a major project under Guangdong's 'Strengthening Chip Technology Project', with a total investment of CNY7.5bn, covering an area of 150 acres.

The first phase involves an investment of CNY3.5bn to build a production line that is currently ramping up capacity to produce 240,000 6-inch automotive-grade SiC chips annually by the end of 2024, according to the fab's plant manager Shao Yonghua. The second phase focuses on establishing an adjacent, reserved production line capable of producing 240,000 8-inch automotive-grade SiC chips annually. The products include insulated-gate bipolar transistors (IGBTs), SiC Schottky barrier diodes (SBDs)/junction barrier Schottkys (JBS) and SiC metal–oxide–semiconductor field-effect transistors (MOSFETs), targeting applications including electric vehicles, photovoltaics, and smart grids.

In November 2022, the project's cleanroom officially began operation, achieving a monthly production capacity of 10,000 pieces. Its automotive-grade and industrial-grade chips have been mass-produced and sampled, and these are about to complete automotive verification. To date, Ascen Power has signed agreements with more than 40 customers and achieved tape-out, covering most SiC chip design companies nationwide.

In May 2023, Mitsubishi Electric signed an MoU for US-based Coherent to supply 8-inch n-type 4H-SiC wafers for the new factory. Both parties are committed to expanding the production scale of 8-inch silicon carbide devices

Mersen to rev up SiC wafer production

On 12 March, European graphite materials and SiC wafer supplier Mersen announced that it has received investment from the French government to expand the capacity of its SiC wafer project. The subsidy may exceed €12m (about CNY94m), sourced from the 'France 2023 Plan' — a significant joint interest project in microelectronics and communication technology in Europe.

Mersen says that it intends to use the funds to advance the research and industrial production of p-SiC low-resistivity polycrystalline SiC wafers.

Mersen expects to invest €85m (about CNY670m) between 2023 and 2025 (employing 80–100 staff), promoting capacity construction at the Gennevilliers plant in France, and achieving a potential manufacturing capacity of 400,000 150mm-diameter wafers by 2027.

Additionally, Mersen will supply SiC wafers to engineered substrate maker Soitec of Bernin, France. In November 2021, the two concerns entered into a strategic partnership to jointly develop polycrystalline SiC wafers with extremely low resistivity for SiC power electronic components based on Soitec's SmartSiC technology, leveraging their respective expertise in substrates and materials.

www.trendforce.com

Quarterly smartphone production jumps 12.1% in Q4/2023

Annual total falls 2.1% to 1.166 billion units in 2023

Third-quarter 2023 saw a significant rebound in global smartphone production, marking the end of an eight-quarter slump, according to market research firm TrendForce. In a strategic year-end surge, brands amped up production to capture more market share, propelling fourth-quarter smartphone output up 12.1% to 337 million units. Despite this final-quarter growth, 2023 rounded off with a slight 2.1% dip in annual production — totaling 1.166 billion units.

The outlook for 2024 hints at a brighter future, free from the inventory pressures of the previous year, says TrendForce. However, the pace of market recovery remains under scrutiny. The spotlight is on artificial intelligence (AI) applications, with industry giants joining forces to usher in the next wave of AI-powered smartphones.

Brands ramp up production targets in response to year-end shopping season and market share consolidation

Thanks to the buzz around its iPhone 15 series, Apple stole the show in Q4/2023 with a staggering 58.6% production surge, cementing its lead with about 78.5 million units produced. But, despite leading the pack, Apple experienced a 4.2% fall in annual production, dropping to 223 million units and securing second place. With Huawei's resurgence, Apple is expected to encounter heightened competition in China's premium market segment, where both brands vie for the same high-end consumer base.

Top 6 Smartphone Brands by Production and Market Share in 4Q23 (Million Units)

Ranking	Company	Production	QoQ	Market Share
1	Apple	78.5	58.6%	23.3%
2	Samsung	53.5	-11.0%	15.9%
3	Xiaomi	43.1	0.7%	12.8%
4	Oppo	40.0	3.4%	11.9%
5	Transsion	29.5	11.3%	8.8%
6	Vivo	25.5	4.1%	7.6%

Samsung navigated through a transitional phase in Q4/2023, seeing an 11% decline in production to about 53.5 million units, yet still holding firm at second place for the quarter. Meanwhile, its yearly production took an 11.3% hit, slipping to 229 million units and narrowing its lead over Apple to a mere 0.5%.

Xiaomi (including Xiaomi, Redmi, and POCO) slightly grew its Q4 production by 0.7%, reaching 43.1 million units and maintaining third position despite a 6.1% annual decrease to 147 million units. Oppo (including Oppo, Realme, and OnePlus) followed closely with a 3.4% quarterly increase, rounding off the year with a 4.1% dip to 139 million units. Vivo (including Vivo and iQoo) managed 4.1% growth in Q4, ending full-year 2023 on a 2.9% decrease to 93.5 million units and sliding to sixth place in global production. Smartphone brands with a significant stake in the Chinese market are bracing for heightened competition amid a downturn in China's consumer spending and Huawei's aggressive market return.

Transsion climbs to fifth place globally as it expands in India and South America

Standout performer Transsion, (including TECNO, Infinix, and itel) not only achieved robust 11.3% growth in Q4/2023 but also made history by breaking the 90 million annual production barrier — marking a 46.3% year-on-year increase. This propelled Transsion to fifth place globally, which TrendForce attributes to the replenishment of channel inventory, moving beyond entry-level products to more diverse offerings, and successful expansion into new markets such as India and South America.

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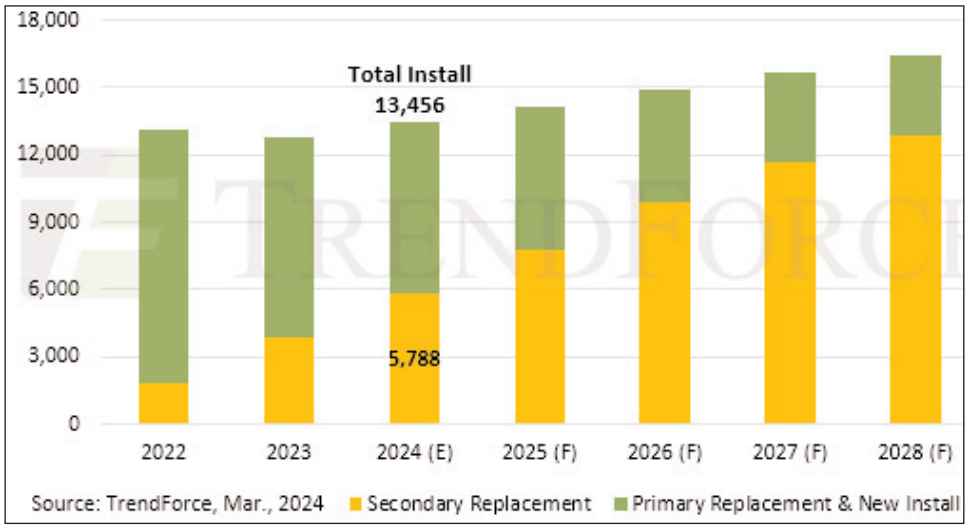
LED lighting industry to see 5.8 billion units of secondary replacement demand for lamps and luminaires in 2024

Secondary replacement to be 78% of LED lighting demand by 2028

Market research firm TrendForce's latest reports indicate a significant turning point for the LED lighting market in 2024, as an estimated quantity of 5.8 billion LED lamps and luminaires reach the end of their lifespan. This is set to trigger a substantial wave of secondary replacements, breathing new life into the market and boosting total LED lighting demand to 13.4 billion units, the firm adds.

Currently, LED lamps and luminaries account for about 70% of all lighting solutions in use worldwide, narrowing the scope for replacing traditional fixtures with LED alternatives. Only specific, unique applications continue to rely on non-LED lighting, making the cost of transition increasingly expensive and suggesting that the first wave of replacement may have largely concluded. Despite a dip in shipments of LED lighting products in 2023, the decline has not been drastic, thanks to the rising tide of secondary replacement demand, which has now become the LED market's key driver.



LED lighting installation and replacement forecast, 2022–2028, millions of units.

Secondary replacement demand for LED lighting to peak between 2025 and 2028

LEDs are generally designed to last 25,000–40,000 hours, translating to a real-world service life of 7–10 years. TrendForce posits that LED lamps and luminaires installed between 2014 and 2016 have begun to hit their lifespan limit from 2023, propelling demand for secondary replacement year after year. This trend is expected to fuel the lighting market's growth over the next five years, making secondary replacement the dominant force by 2025, and by 2028 they are projected to account for as much as 78% of LED lighting demand.

However, the road to realizing the potential of secondary replacement demand is fraught with challenges, notes TrendForce. Many households lack awareness about the need for replacements, with concepts like health-conscious lighting and environmental considerations not yet mainstream. Some potential users are hesitant, adopting a wait-and-see approach. Additionally, a general lack of understanding about the science of lighting and its commercial and artistic value persists in some regions, preventing full appreciation of what modern lighting technology can offer, the firm adds.

Last but not least, product quality varies in the market, and presently consumers often prioritize price over quality. In future, the LED lighting market will progressively step into a more stable, cyclically developing period. In this evolving landscape, brand significance is increasingly highlighted as a key factor in attracting consumer interest in repeat purchases.

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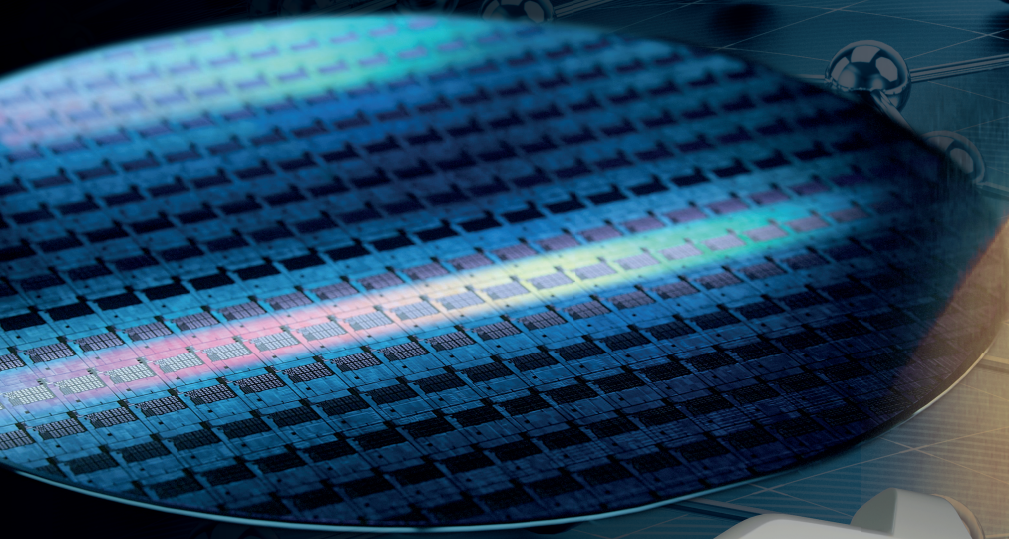

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UK becomes participating state in EU's Chips Joint Undertaking, accessing €1.3bn Horizon Europe collaborative research funding

Semiconductor researchers and businesses to gain up to £35m in UK Government backing

The UK has joined the European Union's 'Chips Joint Undertaking' as a participating state, giving British semiconductor researchers and businesses enhanced access to a €1.3bn fund set aside from Horizon Europe (the European Union's scientific research initiative) to support research in semiconductor technologies over 2021-2027.

Access to the one of the Chips Joint Undertaking's funds is being backed by an initial £5m this year from the UK Government's Department for Science, Innovation and Technology (DSIT), and delivered by the agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation). An additional £30m is due to support UK participation in further research between 2025 and 2027.

"Our membership of the Chips Joint Undertaking will boost Britain's strengths in semiconductor science and research to secure our position in the global chip supply chain," said Saqib Bhatti MP, Parliamentary Under-Secretary of State for Tech and the Digital Economy in the DSIT, while announcing the move at the Global Semiconductor Alliance (GSA) International Semiconductor Conference in London (13–14 March).

This follows the UK joining Horizon Europe through a bespoke new agreement with the EU last year. The program is giving UK companies and research institutions opportunities to lead global work to develop new technologies and research projects, in areas from health to artificial intelligence (AI). Tens of thousands of UK companies are now eligible for Horizon Europe grants, which are worth £450,000 to a business, on average.

"We are looking forward to working with the UK partners to develop the European industrial ecosystem in microelectronics and its applications, contributing to the continent's scientific excellence and innovation leadership in semiconductor technologies and related fields," says Chips JU executive director Jari Kinaret.

It is reckoned that, this year, the Chips Joint Undertaking fund is well aligned to UK research expertise. In 2024, it includes two focused calls for funding bids on semiconductors for cars and other vehicles as well as RISC-V, an open-source architecture that aims to accelerate semiconductor innovation by lowering the cost of chip design. It also provides more open opportunities for scientists and firms to bid for research support.

"UK Semiconductor startups have a rich history of collaboration with the European Union. Our semiconductor research base is the fourth largest in the world," notes Sean Redmond, managing partner at Silicon-Catalyst. "Commercializing these inventions with the help of the EU Chips Joint Undertaking will significantly increase their probability of success, mitigating risks by local collaborations that provide a clear path from lab to fab," he adds.

Commercializing these inventions with the help of the EU Chips Joint Undertaking will significantly increase their probability of success, mitigating risks by local collaborations that provide a clear path from lab to fab

Joining the Chips Joint Undertaking initiative as a 'participating state' allows the UK to collaborate more closely with European partners on semiconductor innovation, with a role in setting research priorities and funding decisions as the fund evolves in the years ahead. This includes the opportunity for the UK to be a part of a new funding opportunity with the Republic of Korea to research ways to combine semiconductor chips to improve performance through advanced packaging — which the UK–Republic of Korea Semiconductor Framework, signed in November 2023.

British research has elsewhere pushed semiconductor technology forward in fields like silicon photonics and compound semiconductors.

Participation in the EU Chips Joint Undertaking will "enable us to work with key EU partners to advance and commercialize high-voltage power electronics we develop within the IKC [Innovation and Knowledge Centre] REWIRE, as well as high-power, high-frequency RF technology we develop within UK, US and European Space Agency (ESA) programs," says Martin Kuball, chair of the Royal Academy of Engineering in Emerging Technologies, professor in physics at the UK's University of Bristol, and director of the Centre for Device Thermography and Reliability.

This follows DSIT and UK Research and Innovation investing £22m in two Innovation and Knowledge Centres in Southampton and Bristol, aimed at reinforcing these key areas of British research. These centers are dedicated to advancing chip technologies

such as silicon photonics and compound semiconductors toward commercialization.

"CSconnected, the organization representing the South Wales Compound Semiconductor sector, warmly welcomes the news that the UK is to join the EU Chips Joint Undertaking," comments CSconnected's director Chris Meadows. "Collaboration is at the very heart of our fast-growing and rapidly evolving semiconductor sector that underpins technologies of today and is key to enabling our future connected world, AI, robotics and in meeting global net-zero ambitions," he adds.

Joining the EU Chips Joint Undertaking "opens up opportunities for UK companies to compete with our European peers on a more level playing field," believes Jen Walls, CEO of Scotland-based Clas-SiC Wafer Fab Ltd. "The UK has a lot to offer in this sector and we are grateful as this will foster a more supportive environment for innovation," she adds.

"Semiconductors are critical to the UK's economic and national security. They underpin crucial technologies such as advancement in AI," says Vaysh Kewada, founder & CEO of Salience Labs. "The UK produces world-leading research in silicon photonics, compound semiconductors and others. This government support is a good step forward to foster growth and to ensure that the UK remains relevant in the critical technologies of tomorrow," she adds.

"This is an excellent opportunity for UK researchers and businesses to strengthen links with our EU partners and collaborate on cutting-edge semiconductor projects of national importance," believes Martin McHugh, CEO at CSA Catapult. "Access to the Horizon Europe funds will enable the UK to partner on projects where we have mutual and significant strengths, such as design, advanced packaging and compound semiconductors," he adds.

"Semiconductors are at the base of core technologies that can solve important societal challenges, among which net-zero and electrification, and significant advancements in the field can be achieved only thanks to collaborative efforts and government support," concludes Dr Giorgia Longobardi, founder & CEO of Cambridge GaN Devices.

The deadline for Phase 1 applications this year is 14 May.

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onsemi realigns its business groups to expand product portfolio and accelerate growth

Analog and Mixed-Signal Group formed for automotive, industrial and cloud end-markets Simon Keeton promoted to group president of Power Solutions Group

Intelligent power and sensing technology firm onsemi of Scottsdale, AZ, USA has formed an Analog and Mixed-Signal Group (AMG) that will be led by newly appointed group president Sudhir Gopalswamy. The group will be focused on expanding onsemi's portfolio of power management and sensor interface devices to unlock an additional $19.3bn total addressable market and accelerate the firm's growth in the automotive, industrial and cloud-end markets.

AMG combines the former Advanced Solutions Group (ASG) and Integrated Circuits Division (ICD), previously a part of the Power Solutions Group (PSG). Gopalswamy will oversee both AMG and the Intelligent Sensing Group (ISG), which together drove nearly $4bn in revenue for the company last year.

Additionally, Simon Keeton has been promoted to group president of the Power Solutions Group. His leadership has been instrumental in delivering more than $4bn in total revenue last year, while ramping a profitable silicon carbide business that achieved over $800m in revenue in 2023, says onsemi.

"This organizational alignment builds on our strength in delivering highly differentiated and optimized solutions focused on customer needs," says president & CEO Hassane El-Khoury. "With Simon and Sudhir's industry expertise and proven track records, we are setting the foundation for further growth and leadership in intelligent power and sensing technologies," he adds.

AMG specializes in the development of a range of power management ICs and high-precision, low-power sensor interfaces and communications products. Onsemi says that it positions it to become a full-suite provider of high-efficiency power tree solutions with an expanded portfolio of gate drivers, DC–DC converters, multi-phase controllers, eFuses and more. The group will continue to extend its range of automotive- and industrial-focused sensor interface and communication solutions such as inductive, ultrasonic and medical sensing, as well as single-pair Ethernet and Bluetooth Low Energy (Bluetooth LE) solutions.

Onsemi reckons that the strategic reorganization will add more system value for customers by powering every architecture with analog and mixed-signal technologies that enable advanced functionality, higher performance and faster time to market.

www.onsemi.com

Vishay completes acquisition of Nexperia's Newport Wafer Fab following UK Government approval

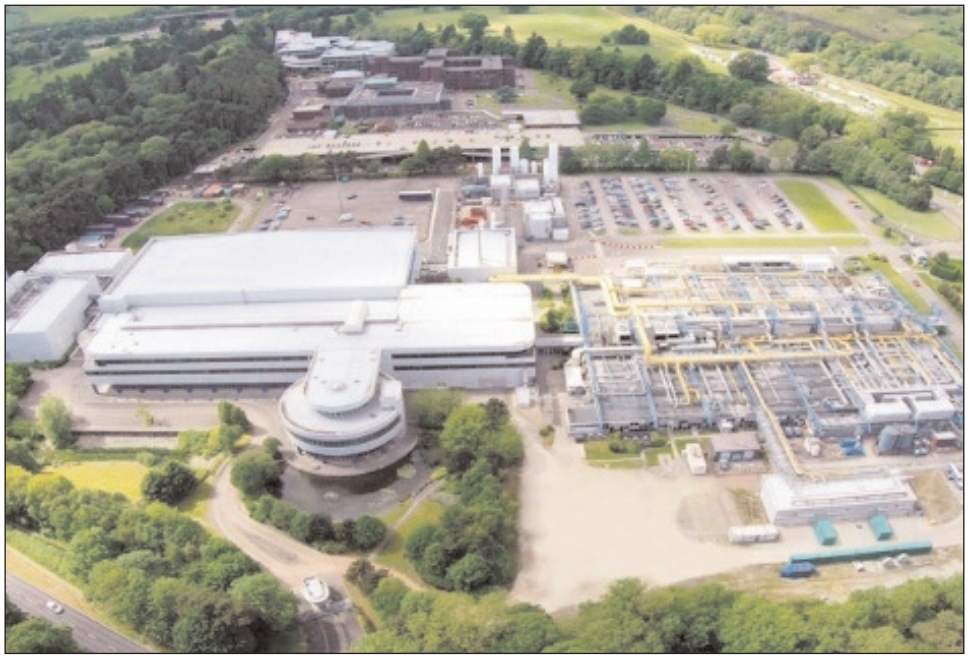
Vishay to expand Newport's capacity and accelerate SiC and GaN production and technology development

Discrete semiconductor and passive electronic component maker Vishay Intertechnology Inc of Malvern, PA, USA has completed its acquisition of the wafer fabrication facility and operations in Newport, South Wales, UK of Netherlands-based Nexperia B.V. for about $177m in cash on hand (net of cash acquired).

Located on 28 acres and with the capacity to produce more than 30,000 200mm-diameter wafers per month, the automotive-certified facility is the UK's largest semiconductor fab, with a long history of supplying components to the automotive and industrial markets. Vishay aims to position the facility as a "manufacturing excellence center focusing on net-zero transformation of decarbonization and electrification". As a new member of the Compound Semiconductor Cluster in South Wales, Vishay plans to collaborate with local universities and others in the UK to enhance its R&D on power compound semiconductors.

"The acquisition of Newport aligns with the strategic shift the board envisioned with its decision to appoint new leadership [in early 2023]," says Vishay's executive chairman Marc Zandman.

"Vishay set an ambitious goal of investing approximately $1.2bn in capacity over a three-year period in order to position the company to seize the opportunities created by the megatrends of e-mobility and sustainability needed for a Net Zero economy," said president & CEO Joel Smejkal on 8 November, when Vishay announced the acquisition. "While this transaction is supplemental to our capex investment strategy, adding Newport Wafer Fab to our manufacturing footprint will be instrumental to achieving our goal of expanding capacity for our customers and to accelerating our SiC [silicon carbide] strategy," he added at the time. "Our goal is to safeguard the positions of the highly skilled and dedicated employees and to invest the necessary capital to set up production for our SiC trench MOSFETs and diodes. With its solid balance sheet and ample liquidity, Vishay will immediately bring stability and its reliable cash flow generation to ensure the facility becomes a fully operational and profitable fab," he reckoned.



"Vishay is making this shift, investing in technologies and incremental capacity to drive faster growth and enhance returns to stockholders. The goal is to prepare Vishay to capitalize on the megatrends of e-mobility, sustainability and connectivity," says Zandman.

With a Vishay-owned fab to qualify and scale our silicon carbide portfolio, we are accelerating our participation in the SiC MOSFETs and diodes marketplace

"With a Vishay-owned fab to qualify and scale our SiC portfolio, we are accelerating our participation in the SiC MOSFETs and diodes marketplace, as desired by our customers," says Smejkal. "In late 2022, the MaxPower acquisition advanced our SiC intellectual property and MOSFETs product technology. We are excited to further develop our SiC and GaN [gallium nitride] technology as a new member of the Compound Semiconductor Cluster in South Wales," he adds.

"Vishay is committed to investing in Newport to grow capacity, and to accelerate our SiC and GaN production and technology development," says Smejkal. "We are now preparing to share our plans for Newport at our upcoming Investor Day on 2 April."

To affect the transaction, Vishay bought the legal entity Neptune 6 Ltd and its operating subsidiary Nexperia Newport Ltd, which owns and operates the Newport facility. Neptune 6 Ltd is expected to be renamed Vishay UK Holdings Ltd and Nexperia Newport Ltd is expected to be renamed Vishay Newport Ltd.

UK government approves Vishay's acquisition of Newport

Completion of the acquisition comes after the UK Secretary of State in the Cabinet Office on 1 March made a final order under section 26 of the National Security and Investment Act 2021 regarding acquisitions of control over entities and assets in (or linked to) the UK that may pose national security risks. Netherlands-based Nexperia B.V. is a subsidiary of China-based Wingtech Technology Co Ltd.

Previously, on 5 July 2021, Nexperia had acquired an additional 86% of the shares of what was then Newport Wafer Fab (NWF), taking its stake to 100%. Nexperia was a customer of Newport Wafer Fab's foundry services and became its second largest shareholder in 2019. The Newport site complemented Nexperia's other European manufacturing operations in Hazel Grove, Manchester, UK, and Hamburg, Germany.

However, in November 2022 the UK Government's Secretary of State for Business, Energy and Industrial Strategy (BEIS) determined that the acquisition constituted a trigger event under section 8(2)(c) of the Act, as it presented 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.

A "necessary and proportionate" measure to mitigate the risk to national security required Nexperia to sell at least 86% of Nexperia Newport Ltd.

The final order allowing completion of the acquisition of the former Newport Wafer Fab from Nexperia is subject to the condition that Vishay, its subsidiary Siliconix or their subsidiaries must inform the Secretary of State in advance of completing any agreement to sell, transfer, grant a lease or licence any part of the Newport site to any third party. This is since the Secretary of State "reasonably considers that a risk to national security would arise should sensitive intellectual property, expertise and/or other sensitive information relating to compound semiconductor design, research and development or manufacturing at the Newport site, including their dual-use applications, become accessible to third parties".

www.newportvishay.co.uk
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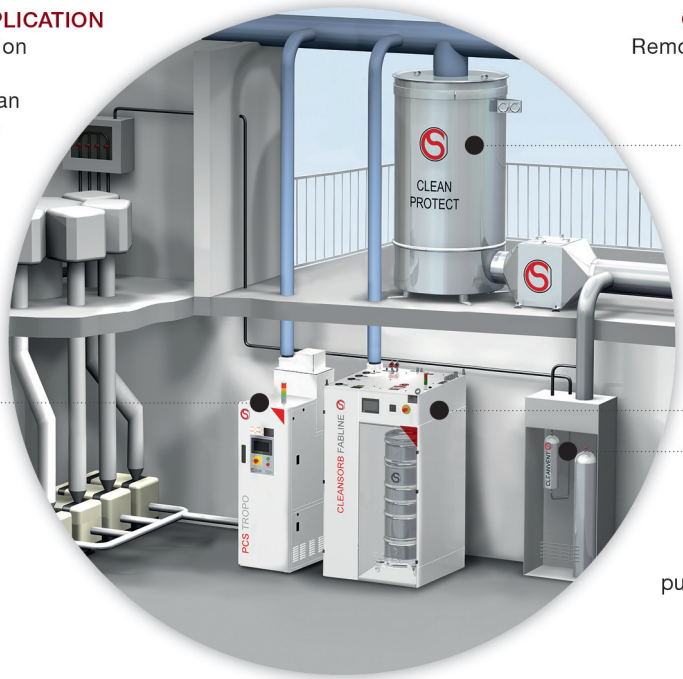

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Wolfspeed launches New York Semiconductor Registered Apprenticeship Program with support from National Institute of Innovation and Technology

First apprentice to support workforce development for Mohawk Valley

The National Institute for Innovation and Technology (NIIT) and the United States Department of Labor (USDOL) has applauded Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — for the establishment of its New York Registered Apprenticeship Program (RAP). As part of its role in the USA's semiconductor talent pipeline development, the Institute serves as the USDOL's national Intermediary responsible for expanding Registered Apprenticeships (RAs) throughout the semiconductor and nanotechnology industry supply chains.

Facilitated by the Manufacturers Association of Central New York (MACNY) through the Institute's Growing Apprenticeships in Nanotechnology and Semiconductor (GAINS) program, Wolfspeed's program will provide opportunities for workers that are looking to expand their skills and build a career in the semiconductor and advanced manufacturing industry.

"We commend Wolfspeed for championing domestic semiconductor manufacturing with the establishment of its Registered Apprenticeship at their Mohawk Valley Fab," says the Institute's president & CEO Mike Russo. "As the USDOL Intermediary dedicated to expanding Registered Apprenticeships throughout the semiconductor and nanotechnology-related supply chains, we're thrilled to offer technical support and subject-matter expertise to Wolfspeed through our GAINS program," he adds. "Registered Apprenticeships provide individuals from all backgrounds with the chance to obtain high-quality jobs and vital skills through a learn-and-earn framework, presenting a significant opportunity for Americans exploring career and educational pathways."

The GAINS Program equips individuals in Wolfspeed's RAP with crucial skills for career advancement. Employers and apprentices alike benefit from the Institute's resources, including the National Talent Hub — an interactive online platform facilitating skills assessments, educational and career planning, professional development support, training progress tracking, and program administration assistance. These initiatives align curriculum, cultivate regional talent pipelines and foster a dynamic workforce.

"Our GAINS program is scalable and extends to all participating employers' sites across the USA. However, we work closely with regional partners to implement our program effectively," says the Institute's national apprenticeship director Martha Ponge. "In New York specifically, I'd like to thank Mohawk Valley Community College (MVCC) for providing the Required Technical Instruction for the program and to MACNY for serving as a group sponsor."

Earlier in March, Wolfspeed celebrated the official signing of Aaron Albright as the first apprentice in the Mohawk Valley program. Albright has been with Wolfspeed for the past 18 months, initially starting on the materials handling team before advancing to the manufacturing technician team. In January, he transitioned into his current role as an equipment apprentice.

Albright and future Wolfspeed apprentices will complete a 16-month program for placement in the company's Equipment Technician career pathway in an industrial manufacturing technician role. The RAP involves 2700 hours of on-the-job training and 216 hours of college instruction provided by MVCC.

"We are committed to making the next generation aware of the incredible career opportunities in the semiconductor industry and broader STEM fields," says Wolfspeed's chief human resources officer Margaret Chadwick. "Our New York RAP will simultaneously train up-and-coming industry professionals while helping us develop our workforce and reach capacity expansion goals at our Mohawk Valley Fab," she adds. "We are excited to work with our apprentices, building out the semiconductor industry here in the USA, and we're grateful for collaborators like the Institute, MACNY and MVCC who help to make these advancements possible."

www.niit.org/apprenticeship-gains
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DOE launches $2.25m American-Made Silicon Carbide Packaging Prize

The US Department of Energy's (DOE) Office of Electricity (OE) has launched the $2.25m American-Made Silicon Carbide (SiC) Packaging Prize. This contest invites competitors to propose, design, build and test state-of-the-art SiC semiconductor packaging prototypes to enable these devices to work more effectively in high-voltage environments such as energy storage. The prize is part of the American-Made Challenges program, which fosters collaboration between the USA's entrepreneurs and innovators, DOE's National Labs, and the private sector.

"Silicon carbide has become a mature and widely used technology for systems requiring power delivery, particularly charging and discharging in energy storage applications like electric vehicle charging and solar systems with batteries," says Gene Rodrigues, assistant secretary for Electricity.

While silicon carbide material can withstand high voltage fluctuations and temperatures, conventional device packaging for them overheats, limiting performance in electronic equipment. Improved packaging can therefore enable greater SiC applications, advancing the transition to 'clean' energy.

To enable these devices to work most effectively and to advance storage of the generated renewable energy, SiC power modules need to be expanded to higher voltage and higher current ratings. The SiC Prize offers a total prize pool of $2.25m across three phases:

- *Phase 1 — Design Study:* Participants will describe their team, plan to make progress toward developing SiC semiconductor packaging and showcase any prototypes. As part of this phase, participants will show evidence of a design prototype that meets or exceeds Phase 2 metrics. Up to 10 winning teams will receive $50,000 each and will be eligible to compete in Phase 2. (Total prize pool: $500,000).
- *Phase 2 — Initial Demonstration:* Winning teams from Phase 1 will develop a physical prototype of their SiC packaging solution that meets Phase 2 metrics. Teams must send their prototypes to a national lab for testing to validate the metrics achieved. At the end of Phase 2, four winning teams will receive $250,000 each and become eligible to compete in Phase 3. (Total prize pool: $1m).
- *Phase 3 — Final Demonstration:* Teams will continue the development of their SiC packaging solution and showcase their working prototypes. They will work to achieve the high-voltage and high-current targets while continuing to innovate towards an improvement in packaging. One winning team will be named Grand Prize winner and be awarded $750,000. (Total prize pool: $750,000).

The competition is open only to private entities (for-profits and non-profits); non-federal government entities such as states, counties, tribes and municipalities, academic institutions; and individuals. Submissions are due by 30 August.

www.herox.com/SiCPackagingPrize

Qorvo launches four 1200V silicon carbide modules in compact E1B package

Qorvo Inc of Greensboro, NC, USA has launched four 1200V silicon carbide modules in a compact E1B package with low on-resistance $R_{DS(on)}$, namely the 19mΩ, 50A UHB50SC12E1BC3N and 9.4mΩ, 100A UHB100SC12E1BC3N half-bridge modules and the 70mΩ, 15A UFB15C12E1BC3N and 35mΩ, 25A UFB25SC12E1BC3N full-bridge modules.

The highly efficient SiC modules are suitable for electric vehicle (EV) charging stations, energy storage, industrial power supplies and solar power applications.

"The modules in this new family can replace as many as four discrete SiC FETs, thus simplifying thermo-mechanical design as well as assembly," says Ramanan Natarajan, director of product line marketing for Qorvo's SiC Power Products business. "Our cascode technology also allows higher switching frequency operation, further reducing solution size by using smaller external components," he adds. "For our customers, the high efficiency of these modules streamlines the power supply design process so they can focus on the design, layout, assembly, characterization and qualification of one module as opposed to numerous discrete components."

Led by the 9.4mΩ UHB100SC12E1BC3N, these four SiC modules leverage Qorvo's unique cascode configuration, which minimizes $R_{DS(on)}$ and switching losses to maximize efficiency, especially in soft-switching applications. Silver-sinter die attach reduces thermal resistance to as low as 0.23°C/W; when combined with the stacked die construction found in the 'SC' part numbers, power cycling performance is improved by 2x over comparable SiC power modules on the market, it is reckoned. Together, these characteristics contribute to superior thermal performance and reliability with the ease of use and power density of a highly integrated SiC power module, Qorvo adds.

www.qorvo.com

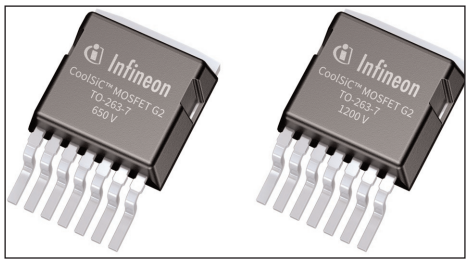
Infineon launches CoolSiC MOSFET Generation 2

Second-generation trench technology boosts performance by 20%

Infineon Technologies AG of Munich, Germany has introduced its next generation of silicon carbide (SiC) MOSFET trench technology. The new CoolSiC MOSFET 650V and 1200V Generation 2 is said to improve MOSFET key performance figures such as stored energies and charges by up to 20% compared with the prior generation without compromising quality and reliability levels, leading to higher overall energy efficiency.

CoolSiC MOSFET Generation 2 (G2) technology continues to leverage the performance capabilities of silicon carbide by enabling lower energy loss, yielding higher efficiency during power conversion and benefitting power semiconductor applications such as photovoltaics, energy storage, DC EV charging, motor drives and industrial power supplies.

A DC fast-charging station for electric vehicles that is equipped with CoolSiC G2 allows up to 10% less power loss compared with previous generations, while enabling higher charging capacity without compromising form factors. Traction inverters based on CoolSiC G2 devices can further increase EV ranges. In renewable energies, solar inverters designed with CoolSiC G2 make smaller sizes possible while maintaining a high power output, resulting in a lower cost per watt.



Infineon's CoolSiC MOSFET 650V and 1200V G2 devices.

"Megatrends call for new and efficient ways to generate, transmit and consume energy. With the CoolSiC MOSFET G2, Infineon brings silicon carbide performance to a new level," says Dr Peter Wawer, division president Green Industrial Power at Infineon. "This new generation of SiC technology enables the accelerated design of more cost-optimized, compact, reliable and highly efficient systems harvesting energy savings and reducing CO_2 for every watt installed in the field."

Infineon says that its CoolSiC MOSFET trench technology provides an optimized design trade-off, allowing higher efficiency and reliability compared with SiC MOSFET technology available so far. Combined with the .XT packaging technology, the firm is further increasing the potential of designs based on CoolSiC G2 with higher thermal conductivity, better assembly control and improved performance.

www.infineon.com/cms/en/product/power/mosfet/silicon-carbide/gen-2

Infineon adds 750V G1 CoolSiC MOSFET product family

Infineon Technologies AG of Munich, Germany has launched the 750V G1 discrete CoolSiC MOSFET to meet the increasing demand for higher efficiency and power density in industrial and automotive power applications.

The product family includes both industrial-grade and automotive-grade silicon carbide (SiC) MOSFETs that are optimized for totem-pole PFC, T-type, LLC/CLLC, dual active bridge (DAB), HERIC, buck/boost, and phase-shifted full-bridge (PSFB) topologies. The MOSFETs are suitable for use in both typical industrial applications, such as electric vehicle charging, industrial drives, solar and energy storage systems, solid state circuit breakers, UPS systems, servers/data centers, telecoms, and in the automotive sector, such as on-board chargers and DC–DC converters.

The CoolSiC MOSFET 750V G1 technology features what is claimed to be excellent $R_{DS(on)} \times Q_{fr}$ and superior $R_{DS(on)} \times Q_{oss}$ figures-of-merit (FOMs), resulting in ultra-high efficiency in hard-switching and soft-switching topologies, respectively. Its unique combination of high threshold voltage ($V_{GS(th)}$, typical of 4.3V) with low Q_{GD}/Q_{GS} ratio ensures high robustness against parasitic turn-on and enables unipolar gate driving, leading to increased power density and low cost of the systems.

All devices use Infineon's proprietary die-attach technology which delivers what is claimed to be outstanding thermal impedance for equivalent die sizes. The highly reliable gate oxide design — combined with Infineon's qualification standards — delivers robust and long-term performance.

With a granular portfolio ranging from 8mΩ to 140mΩ $RD_{S(on)}$ at 25°C, the new CoolSiC MOSFET 750V G1 product family addresses a wide range of needs. Its design is said to ensure lower conduction and switching losses, boosting overall system efficiency. Its packages minimize thermal resistance, facilitate improved heat dissipation, and optimize in-circuit power loop inductance, resulting in high power density and reduced system costs. The product family features the QDPAK top-side-cooled package.

The CoolSiC MOSFET 750V G1 for automotive applications comes in QDPAK TSC, D2PAK-7L and TO-247-4 packages, while for industrial applications QDPAK TSC and TO-247-4 packages are offered.

www.infineon.com/coolsic

CoolSiC MOSFET product family extended to 2000V

First discrete SiC devices with breakdown voltage of 2000V offers increased power density without compromising system reliability

Infineon Technologies has launched the CoolSiC MOSFETs 2000V in the TO-247PLUS-4-HCC package to meet designers' demand for increased power density without compromising system reliability even under demanding high-voltage and switching frequency conditions. The CoolSiC MOSFETs offer a higher DC link voltage so that the power can be increased without increasing the current. It is claimed to be the first discrete silicon carbide device with a breakdown voltage of 2000V on the market and comes in a TO-247PLUS-4-HCC package with a creepage distance of 14mm and clearance distance of 5.4mm. With low switching losses, the devices are suitable for solar (e.g. string inverters) as well as energy storage systems and EV charging applications.

The CoolSiC MOSFET 2000V product family is suitable for high DC link systems with up to $1500V_{DC}$. Compared with 1700V SiC MOSFETs, the devices also provide a sufficiently high overvoltage margin for $1500V_{DC}$ systems. The CoolSiC MOSFETs deliver a benchmark gate threshold voltage of 4.5V and are equipped with a robust body diode for hard commutation. Due to the .XT connection technology, the components offer what is said to be first-class thermal performance. They are also highly resistant to humidity.

In addition to the CoolSiC MOSFETs 2000V, Infineon will soon be launching the matching CoolSiC diodes: The first launch will be the 2000V diode portfolio in the TO-247PLUS 4-pin package in third-quarter 2024, followed by the 2000V CoolSiC diode portfolio in the TO-247-2 package in fourth-quarter 2024. These diodes are particularly suitable for solar applications. A matching gate driver portfolio is also available.

The CoolSiC MOSFET 2000V product family is available now. In addition, Infineon also offers a suitable evaluation board: the EVAL-COOL-SIC-2KVHCC. Developers can use the board as a precise universal test platform to evaluate all CoolSiC MOSFETs and diodes 2000V and the EiceDRIVER Compact Single Channel Isolated Gate Driver 1ED31xx product family through double pulse or continuous PWM operation.

www.infineon.com/coolsic-mosfet-discretes

Arrow and Infineon collaborate to help eInfochips accelerate EV charger development

30kW DC fast charger reference platform includes 1200V CoolSiC Easy power modules

Arrow Electronics Inc and its engineering services company eInfochips are working with Infineon Technologies of Munich, Germany to help eInfochips' customers accelerate the development of electric vehicle chargers.

Development of EV chargers, especially DC fast chargers, is becoming increasingly challenging to equipment manufacturers due to several factors, such as lack of prior experience, stringent functional safety and reliability requirements, and a fledgling support network. The collaboration between Arrow and Infineon aims to help innovators navigate these challenges while accelerating time-to-market.

As part of the collaboration, Arrow's High Power Center of Excellence has developed a 30kW DC fast charger reference platform. This includes Infineon's 1200V CoolSiC Easy power modules and also hardware design, embedded firmware, bi-directional charging support and energy metering functionality.

"Combining Arrow's strength in components, engineering and design services with Infineon's innovative products will help customers accelerate their design and speed to market in e-mobility applications," says Murdoch Fitzgerald, VP global engineering and design services at Arrow. "Customers can rely on this collaboration to deliver innovative and leading-edge DC faster chargers, accelerate and de-risk design cycles, and get access to a world-class support team enabling them to plan and manage their product roadmap and lifecycles," he adds.

"The joint 30kW DC fast-charger reference platform, which includes Infineon's latest power modules and devices, will help our customers bring more fast chargers to market as the future moves to electrical vehicles," says Shri Joshi, VP of Green Industrial Power, Infineon Technologies Americas. "We look forward to this ongoing collaboration to support our customer base."

The first reference design from this collaboration, a production-grade 30kW DC fast-charger reference development platform, was demonstrated at the Applied Power Electronics Conference 2024 in Long Beach, CA, USA (25–29 February).

www.arrow.com

Infineon files lawsuit in USA against Innoscience

Permanent injunction sought for infringement of GaN-related US patent

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

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

"The production of gallium nitride power transistors requires completely new semiconductor designs and processes," says Adam White, president of Infineon's Power & Sensor Systems Division. "We vigorously protect our intellectual property and thus act in the interest of all customers and end users," he adds. Infineon says that it has been investing in R&D, product development and the manufacturing expertise related to GaN technology for decades, and that it continues to defend its intellectual property and to protect its investments.

On 24 October 2023, Infineon announced the closing of the acquisition of GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications), expanding its position in power semiconductors. Infineon's GaN patent portfolio comprises about 350 patent families. Market analysts expect GaN revenue for power applications to rise at a compound annual growth rate (CAGR) of 49% to about US$2bn by 2028 (according to 'Power SiC and GaN Compound Semiconductor Market Monitor Q4 2023' from Yole).

www.innoscience.com
www.infineon.com

Worksport using Infineon's GaN power transistors in converters of its portable power stations

GaN to reduce battery system weight by 33% and system costs by 25%

Infineon has agreed a collaboration in which its GS-065-060-5-B-A gallium nitride power transistors will be used by Worksport Ltd of West Seneca, NY, USA in the converters for its portable power stations in order to increase their efficiency and power density. Enabled by Infineon GaN transistors, the power converters will be lighter and smaller in size with reduced system costs. In addition, Infineon will support Worksport in the optimization of circuits and layout design to further reduce size and increase power density.

"Infineon's high-quality standard and solid supply chain provide us with the best components to ensure power-dense converters for our COR system product line," comments Worksport's CEO Steven Rossi. The company's COR battery system can be integrated into a pickup truck or recharged by any solar panel or wall outlet. By replacing the former silicon switch in the power converter with Infineon's GaN power semiconductors and operating the transistors at higher switching frequency, Worksport will be able to reduce the battery system weight by 33% and system costs by up to 25%.

COR portable energy storage system.

It is reckoned that the working relationship with Infineon will also help Worksport to reduce CO_2 in the manufacturing process.

"To further drive electrification and decarbonization, the industry's power designs require innovation," says Johannes Schoiswohl, business line head GaN Systems of Infineon's Power & Sensor Systems Division. "With our GaN power semiconductors we enable Worksport to create the next-generation portable power stations that users require."

Available in a bottom-cooled, low-inductance GaNPX package, Infineon's GS-065-060-5-B-A is an automotive-grade 650V enhancement-mode GaN-on-silicon power transistor that offers very low junction-to-case thermal resistance for demanding high-power applications such as on-board chargers, industrial motor drives and solar inverters. Furthermore, it features simple gate drive requirements (0V to 6V) and a transient-tolerant gate drive (−20/+10V).

www.infineon.com/GaN

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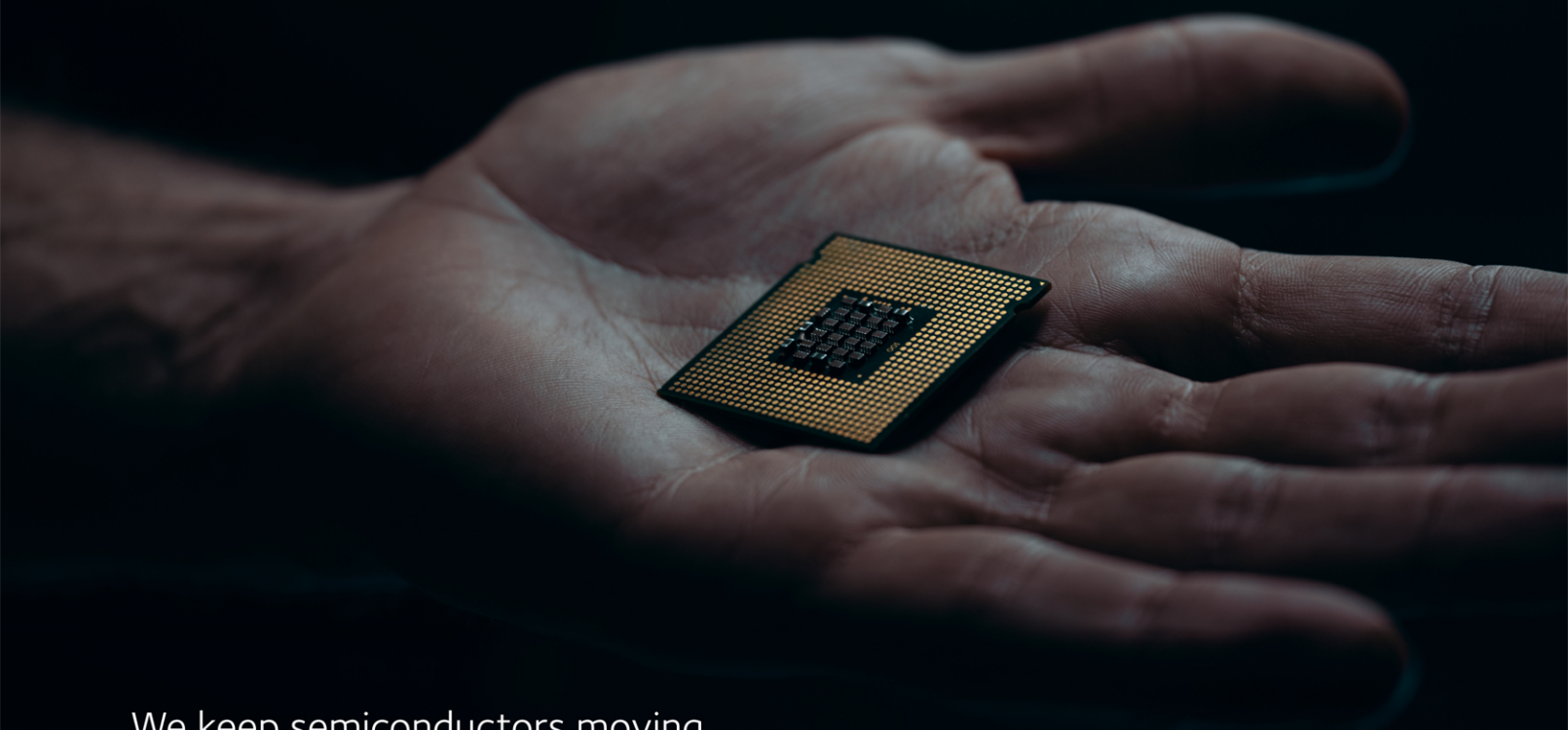

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DSV Global Transport and Logistics

MACOM awarded by Northrop Grumman for Supplier Excellence

MACOM recognized with Outstanding Quality Excellence and Top Large Business awards

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) has received two awards at US-based aerospace & defense technology company Northrop Grumman Corp's Supplier Excellence Awards.

"MACOM has helped to advance national security solutions and achieve mission success," comments Matt Bromberg, corporate VP, global operations, Northrop Grumman. "Northrop Grumman's supplier partners connect and protect the warfighter, defining what is possible in the battlespace."

Recognized for Outstanding Quality Excellence and Top Large Business awards, MACOM was said to be instrumental in aiding Northrop Grumman with manufacturing and distribution goals as the industry works to support Department of Defense customers and other commercial entities.

"Our team is committed to support Northrop Grumman's mission, and we stand ready to align our resources and technology to meet their current and future requirements," states MACOM's president & CEO Stephen G. Daly.

www.northropgrumman.com
www.macom.com

MACOM showcases latest products at SATELLITE 2024

Products include linearizer modules for SSPAs and TWTs, analog and photonics components for free-space optics, GaN MMICs and small-signal components and integrated hybrid assemblies

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) showcased its latest products for space and hi-reliability applications at the SATELLITE 2024 event in Washington DC, USA (19–21 March).

The portfolio includes a broad array of radio frequency (RF), microwave, millimeter-wave and optical products to support satellite communications links and ground-station infrastructure. These products include linearizer modules for solid state amplifiers (SSPAs) and traveling-wave tube amplifiers (TWTs), analog and photonics components for free-space optics (FSO), gallium nitride (GaN) monolithic microwave integrated circuits (MMICs) and various small-signal components and integrated hybrid assemblies for satellite payload and ground-station electronics.

Satellite 2024 demonstrations and new products announcements included:

- *V-band linearized GaN MMIC solutions:*
By combining proprietary analog linearization modules and GaN MMIC process technologies, MACOM can achieve higher linear output power and higher linear efficiency in SatCom transmitters. Linearization of SSPAs or TWTs enables systems to transmit higher levels of linear power, which improves link budget performance.
- *SatCom RF and microwave components:*
MACOM is expanding its single- and multi-function RF components to support Ku- and Ka-band SatCom applications. The portfolio includes gallium arsenide (GaAs) and GaN power amplifiers, gain blocks, and low-noise amplifiers (LNA), along with GaAs, silicon-on-insulator (SOI) and diode-based switches, mixers, attenuators and phase shifters.
- *Free-space optics:*
MACOM exhibited a wide range of components and capabilities for FSO systems, including lasers, laser drivers, various photodiodes, and transimpedance amplifiers (TIA). In addition, MACOM presented examples of various RF-over-fiber analog photonic subsystems used in high-performance SatCom applications.

www.satshow.com
www.macom.com

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Vertical GaN power device firm Odyssey sells for $9.52m

Deal subject to 20-calendar-day 'go shop' then shareholder vote in Q2

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA — which develops high-voltage vertical power switching components based on proprietary gallium nitride (GaN) processing technology — has entered into a definitive agreement to sell its assets for $9.52m in cash to "a large semiconductor company".

The buyer's name is being withheld as confidential during the 20-calendar-day 'go shop' period (expiring on 1 April), which permits Odyssey's board and its advisors Craig-Hallum Capital Group LLC to initiate and solicit alternative acquisition proposals from third parties. Odyssey's board has the right to terminate the agreement to accept a superior proposal.

"We have been afforded an opportunity to shop this purchase opportunity for 20 calendar days in an effort to ensure as many interested parties as possible can accurately gauge the potential value of our technology and assets at this point in time," notes CEO Rick Brown.

The asset sale, which was approved by Odyssey's board of directors, is expected to close early in third-quarter 2024 (on or around 1 July, but no later than 10 July) subject to customary closing conditions, including approval by Odyssey's shareholders.

Upon completion of the transaction, Odyssey's common stock will most likely cease to be listed on any and all public stock exchanges as soon as is practicable. The firm currently plans to wind down operations and hopes to pay out a liquidating dividend to the extent that funds are available at that time (currently estimated to be the end of 2024 at the earliest).

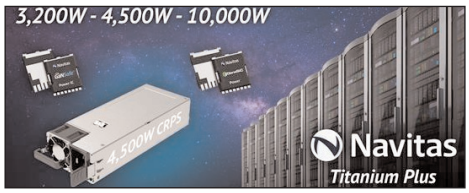
www.odysseysemi.com

Navitas unveils plans for 8–10kW power platform supporting 2025 AI power requirements

GaN and SiC technology roadmap addresses 3x increase in power demands of AI data centers in next 12–18 months

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA has announced its artificial intelligence (AI) data center technology roadmap for to up to 3x power increase to support similar exponential growth in AI power demands expected in just the next 12–18 months.

Traditional CPUs require typically only 300W and the data-center AC/DC power supplies would typically power the equivalent of 10 of these or 3000W (3kW). High-performance AI processors like NVIDIA's 'Grace Hopper' H100 are already demanding 700W each, with next-generation 'Blackwell' B100 and B200 chips expected to increase to 1000W or more by next year. To meet this exponential power increase, Navitas is developing server power platforms that rapidly increase from 3kW to up to 10kW. In August 2023, Navitas introduced a 3.2kW data-center power platform utilizing the latest GaN technology enabling over 100W/in^3 and over 96.5% efficiency.



Now, Navitas is releasing a 4.5kW platform enabled by a combination of GaN and SiC to push densities over 130W/in^3 and efficiencies over 97%. These two platforms have already generated significant market interest, says Navitas, with over 20 data-center customer projects in development expected to drive millions in GaN or SiC revenues, starting this year.

Now, Navitas is also announcing its plans to introduce an 8–10kW power platform by the end of 2024 to support 2025 AI power requirements. The platform will utilize newer GaN and SiC technologies and further advances in architecture to set all-new industry standards in power density, efficiency and time-to-market, the firm reckons. Navitas is already engaged with major data-center customers, with full platform launch anticipated in fourth-quarter 2024, completing this 3x increase in power demands in only 12–18 months.

Navitas says its unique data-center design center is creating these system designs to address the dramatic increases in AI data-center power requirements, and assist customers to deploy platforms quickly and effectively to meet the accelerated time-to-market demands of rapid AI advances. System designs include complete design collateral with fully tested hardware, schematics, bill-of-materials, layout, simulation and hardware test results to maximize first-time-right designs and fast revenue generation.

"Rapid development and deployment of artificial intelligence into global data centers has created a dramatic and unexpected power challenge for our entire industry," notes CEO & co-founder Gene Sheridan. "Our investment in leading-edge GaN and SiC technologies, combined with our unique data-center design center capabilities, have positioned us well," he reckons.

www.navitassemi.com

GaAs Labs sells Mission Microwave

GaN-based solid-state power amplifier and block upconverter firm bought by J.F. Lehman

California-based technology investment company GaAs Labs LLC has sold its portfolio company Mission Microwave Technologies LLC of Cypress, CA, USA — a provider of gallium nitride (GaN)-based solid-state power amplifiers (SSPAs) and block upconverters (BUCs) to the satellite communications market — to an investment affiliate of US-based J.F. Lehman Company (JFLCO).

The long-standing partnership between industry veterans John and Susan Ocampo of GaAs Labs and the Mission team saw the company grow significantly as it expanded its portfolio of microwave and millimeter-wave products to support critical ground-based, airborne, maritime and space-based applications for both government and commercial customers. Utilizing its unique power-combining technology and integrated systems design, Mission provides what is claimed to be the industry's most efficient, lightweight and compact high-power systems.

"Mission's commitment to its customers with innovative and differentiated product offerings has propelled its position as a market leader," says GaAs Labs' manager & co-founder Susan Ocampo. "We are committed to Mission's continued success as they embark on their next phase of growth," she adds.

"John Ocampo [who passed away in November] and GaAs Labs have been instrumental partners in helping Mission expand and evolve into a market leader," comments Mission's co-founder, president & CEO Francis Auricchio. "With the support of their deep technical expertise and operational experience, we have been able to accelerate our growth while advancing our products to serve the critical needs of our customer base," he adds. "We thank GaAs Labs for their partnership as we continue to expand our market position under JFLCO's sponsorship."

Phillips Lytle provided legal counsel and KippsDeSanto & Co served as financial advisor to GaAs Labs and Mission.

www.gaaslabs.com

Ancora's double-side-cooling GaN FET demonstrates robustness and long-term reliability

Performance meets demands of data-center, AI and high-performance computing power applications

Fabless design company Ancora Semiconductor Inc (an affiliate of Taiwan-headquartered power supply maker Delta Electronics Inc) recently passed a series of rigorous DMTBF (demonstrated mean time between failures) tests for its double-sided-cooling gallium nitride (GaN) field-effect transistor. These tests have verified that Ancora components can maintain superior performance over long periods (200,000 hours), highlighting the high reliability and dependability of its products. The product line has been incorporated into the XPG FUSION 1600W Titanium-grade power supply developed in collaboration with Delta Electronics and ADATA Technology Co Ltd.

Ancora says that its FET-E6007PD020 dual-sided heat dissipation component not only facilitates top-side heat dissipation applications but also features characteristics such as reduced electrical-thermal coupling risks and enhanced heat dissipation efficiency. Its patented dual-sided heat dissipation structure effectively separates electrical and thermal elements, further addressing heat conduction issues in high-power products.

Furthermore, its unique packaging structure reduces parasitic inductance, enhancing the efficiency of power products and demonstrating superior performance in high efficiency, high density, high frequency and temperature control, it is claimed. The product line's performance is said to meet the demands of advanced applications such as servers, AI (artificial intelligence), high-performance computing, medical and networking.

"Leveraging GaN's outstanding physical characteristics, we can achieve high efficiency and miniaturization," says general manager Dr TK Shing. "In addition to the FET-E6007PD020, a 650V dual-sided heat dissipation GaN device, Ancora Semiconductor will continue to expand its product line, offering a variety of GaN devices to meet different design requirements," he adds.

"The DMTBF test results demonstrate the reliability and stability of Ancora products, enabling higher power density and more robust energy-saving effects," comments Ares Chen, general manager of Delta Electronics' Power and System Business Group. "We look forward to Ancora launching more products and continuing to accelerate collaboration in high-power power supply units."

www.ancora-semi.com

Wise-integration raises €15m in Series B funding round

Funding to enable mass production and commercial deployment of WiseGan and WiseWare

Wise-integration of Hyeres, France — which was spun off from CEA-Leti in 2020 and designs and develops gallium nitride (GaN) integrated circuits and digital-control technologies for power supplies — has raised €15m in a Series B funding round led by imec.xpand and joined by Supernova Invest, BNP Paribas Developpement, Région Sud Investissement (RSI), Creazur, CASRA Capital and Angels for Greentech.

The round should fuel mass production and commercial deployment of the firm's flagship products, WiseGan and its digital-control technology WiseWare, and its support for clients globally as they adopt these solutions. The round included the five investors from the previous funding round plus three new investors.

"The €15m of new funding will accelerate the company's international expansion, ongoing R&D programs and the introduction of new products and solutions," says CEO Thierry Bouchet. "This funding will enable Wise-integration to accelerate our commercial development and product development and the launch of a new generation of high-performance GaN technology, which is designed to seamlessly integrate with digital controls and boost the efficiency and performance of power systems across various sectors," he adds. "A third roadmap focus will be to broaden our WiseWare product development, targeting high-value markets, such as industrial, telecom and automotive sectors."

Since its launch in 2020, the fabless company has built a portfolio of more than 10 patent families for power electronics. WiseGan encompasses GaN power integrated circuits designed to maximize the benefits of GaN technology, including higher power density, efficiency and reduced heat generation. WiseWare is a 32-bit, MCU-based, AC–DC digital controller optimized for GaN-based power supply architectures, offering simplified system design, a lower bill of materials and improved power density and efficiency.

This funding will enable Wise-integration to accelerate our commercial development and product development and the launch of a new generation of high-performance GaN technology, which is designed to seamlessly integrate with digital controls and boost the efficiency and performance of power systems across various sectors

Target markets include consumer electronics, from laptops to e-bikes, scooters and motorcycles, to industrial applications like robotics, as well as data centers and electric vehicles. All its solutions address the increasing demands for miniaturization, electrification and efficient power management.

Wise-integration has established a GaN supply chain to support its mass production and commercialization strategy, while ensuring what are claimed to be competitive costs in the market.

"Wise-integration's GaN technology can play a significant role in the global shift to electrification by enhancing the efficiency and performance of power systems across various sectors," comments imec.xpand partner Cyril Van_ura. "In the four years since its founding, this start-up has demonstrated the vision, drive, execution and technological knowhow to deliver game-changing power electronics solutions," he adds.

"We strongly believe in the huge potential of its WiseWare digital control technology and associated WiseGan components, anticipating a profound revolution in the power conversion market that propels GaN technology to replace legacy solutions even more rapidly," says Damien Bretegnier, investment director, Supernova Invest.

www.wise-integration.com

5N Plus commercializing its GaN-on-Si patents

Portfolio enables development of vertical GaN-on-Si power devices for 600–1200V high-power electronics, EVs and AI servers

Specialty semiconductor and performance materials producer 5N Plus Inc (5N+) of Montreal, Québec, Canada is officially launching the commercialization rights for its portfolio of gallium nitride on silicon (GaN-on-Si) patents which, it says, can enable the rapid prototype development and first-to-market commercialization of novel vertical GaN-on-Si power devices by firms operating in high-power electronics (HPE), electric vehicle (EV) and artificial intelligence (AI) server sectors.

Key patents enabling vertical GaN-on-Si devices

GaN is a mechanically stable, wide-bandgap semiconductor material with high heat capacity and thermal conductivity. Currently lateral GaN is mainly used in low-voltage (<400V) applications such as chargers, but novel vertical GaN-on-Si has the potential to replace silicon carbide (SiC), which is the current preferred material for medium- and high-voltage applications (i.e. EV inverters operating at 650V). SiC is expensive and not easily available, whereas GaN-on-Si is more efficient and cost-effective. Recent academic demonstrations utilizing key 5N+ patents have shown that vertical GaN-on-Si, as opposed to lateral GaN transistors showing destructive breakdown, offers soft breakdown with avalanche capability for safe, compact and more efficient devices.

"Our 54 patents have now been shown to be more high-performing and efficient than the current alternative through recent academic demonstrations," says president & CEO Gervais Jacques. "As such, our portfolio of patents is uniquely positioned to enable industry-leading HPE and EV firms to rapidly develop and commercialize first-to-market vertical GaN-on-Si power devices that will revolutionize high-voltage semiconductor applications," he adds.

5N+ GaN-on-Si patent portfolio

The commercial rights of the 54 granted patents owned by 5N+ include mandatory use of large-diameter thick silicon substrates (over 1mm), combined with masking layers to filter the dislocations. Increasing the thickness of large-diameter silicon substrates in vertical GaN-on-Si devices enables increased voltage capacity without increasing the chip size. Also included in this patent is the ability to remove the substrate to form the backside contacts once the GaN growth is complete. In addition, the firm holds lateral GaN-on-Si patents for radio frequency (RF) applications that will enable next-generation 5G and 6G wireless communication components. 5N+ holds these patents through its multi-junction solar cell subsidiary AZUR SPACE Solar Power GmbH.

www.azurspace.com
www.5nplus.com

ROHM's EcoGaN used in Innergie's 45W output USB-C charger C4 Duo

First model in Innergie's One for All Series adapters to use ROHM's GaN devices

Japan-based ROHM Semiconductor says its 650V GaN device (EcoGaN) has been adopted in the C4 Duo, a 45W output USB-C charger from Innergie, a brand of Taiwan-based power supply maker Delta Electronics.

ROHM began the mass production of 150V-withstand GaN HEMTs in 2022 and 650V-withstand GaN HEMTs in 2023 with what it claims is industry-leading device performance ($R_{DS(ON)} \times C_{iss}/R_{DS(ON)} \times C_{oss}$). Most recently, integrating an ESD protection element into the GNP1150TCA-Z improves ESD breakdown tolerance by about 75% over standard GaN HEMTs, it is reckoned, and has been evaluated to improve application reliability, ultimately leading to its adoption.

"The development of GaN power devices is a major focus in the global electronics industry, and therefore we have deepened our collaboration with ROHM over the past several years," notes Innergie's general manager Jason Chen. "Moreover, in 2022, we initiated a strategic partnership to jointly develop next-generation power semiconductors for power supply systems. This partnership has delivered ROHM's advanced 650V GaN (GNP1150TCA-Z) devices, which are now supporting Innergie's new products," he adds.

"The C4 Duo is the first model from Innergie's One for All Series adapters to use ROHM's GaN devices, and we expect more models to adopt this state-of-the-art technology… By strengthening our collaboration with ROHM, we will be able to provide customers adapters featuring higher power efficiency and capability but with much smaller product size."

www.deltaww.com/en-US/index
https://myinnergie.com/jp/product/c4-duo-45w-dual-usbc-power-adapter-fold
www.rohm.com/products/gan-power-devices/gan-hemt/gnp1150tca-z-product

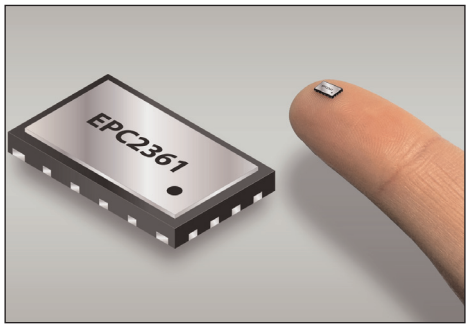
EPC launches first GaN FET with 1mΩ on-resistance

100V EPC2361 GaN FET supplied in compact 3mm x 5mm QFN package

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has launched the 100V, 1mΩ EPC2361, which is claimed to be the lowest on-resistance gallium nitride (GaN) field-effect transistor (FET) on the market, offering double the power density compared with EPC's prior-generation products.

The EPC2361 has a typical $R_{DS(on)}$ of just 1mΩ in a thermally enhanced QFN package with exposed top and a footprint of just 3mm x 5mm. The maximum $R_{DS(on)}$ x Area of the EPC2361 is 15mΩ*mm^2 — over five times smaller than comparable 100V silicon MOSFETs.

With its ultra-low on-resistance, the EPC2361 enables higher power



density and efficiency in power conversion systems, leading to reduced energy consumption and heat dissipation. This is particularly significant for applications such as high-power PSU AC–DC synchronous rectification, high-frequency DC–DC conversion for data centers, motor drives for eMobility, robotics, drones, and solar MPPT (maximum power point tracking).

"Our new 1mΩ GaN FET continues to push the boundaries of what is possible with GaN technology, empowering our customers to create more efficient, compact and reliable power electronics systems," says CEO & co-founder Alex Lidow.

The 2" x 2" (50.8mm x 50.8mm) EPC90156 development board is a half-bridge featuring the EPC2361 GaN FET. Designed for optimal switching performance, it contains all critical components for easy evaluation.

The EPC2361 is priced at $4.60 each in 3 Ku volumes. The EPC90156 development board is priced at $200 each.

www.epc-co.com

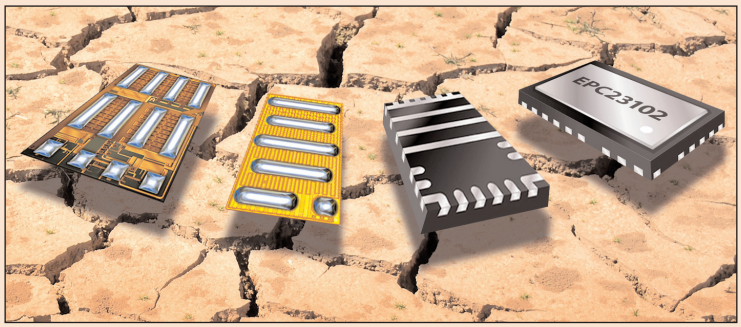
EPC issues Phase-16 Reliability Report

Expanded data and analysis includes overview of wear-out mechanisms and forecast of system reliability in realistic mission profiles

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 issued its Phase-16 Reliability Report, documenting continued work using test-to-fail methodology and adding specific guidelines for overvoltage specifications and improving thermo-mechanical reliability.

Compared with the Phase-15 Reliability Report, this version presents expanded data and analysis. It now includes a general overview of the wear-out mechanisms of primary concerns for a given application. New to this version of the report is a description of how to forecast the reliability of a system in a realistic mission profile that combines periods of substantial and minor stress.

Adding to the existing knowledge base, this report includes signifi-



cant new material on the thermo-mechanical wear-out mechanisms and overvoltage guidelines. Thermo-mechanical wear-out mechanisms include a study of the impact of die size and bump shape on temperature cycling (TC) reliability. This report also includes a study of overvoltage robustness for both the gate and the drain of GaN transistors.

The report is divided into the following sections:

- Section 1: Determining wear-out mechanisms using test-to-fail methodology;
- Section 2: Using test-to-fail results to predict device lifetime in a system;
- Section 3: Wear-out mechanisms;
- Section 4: Mission-specific reliability predictions including solar, DC–DC, and light detection & ranging (LiDAR) applications;
- Section 5: Summary and conclusions;
- Appendix: Solder stencil design rules for reliable assembly of PQFN packaged devices.

"The release of our Phase-16 report satisfies a critical need for ongoing research into GaN device reliability," says CEO & co-founder Dr Alex Lidow. "This report provides valuable insights on mission robustness, ensuring devices meet the demands of diverse applications."

www.epc-co.com/epc/design-support/gan-fet-reliability/reliability-report-phase-16

Finwave showcases performance improvements with GaN-on-Si technology at MWC Barcelona

3DGaN FinFETs enable higher power, speed and linearity for 5G/6G

At Mobile World Congress (MWC) Barcelona (26–29 February), Finwave Semiconductor Inc of Waltham, MA, USA hosted demonstrations of its latest technology and products, including unveiling the newest performance benchmarks with its gallium nitride on silicon (GaN-on-Si) technology and high-power switches targeting the infrastructure and handset markets.

Differentiated from conventional depletion-mode (Dmode) GaN technology, Finwave's says that its enhancement-mode (Emode) 200mm GaN-on-Si RF field-effect transistors (FETs) have less than 1Ω-mm on-resistance, low-knee voltage, >700mS/mm transconductance and negligible current collapse with power-added efficiency (PAE) as high as 60% and what is claimed to be excellent AM–PM performance for operating frequency ranging from 8GHz to 26GHz. The technology is capable of operating at a V_{dd} of 5V or lower, demonstrating its potential for efficient power amplifiers for 6G FR3 frequency band (7–24GHz) and FR2 mmWave-band infrastructure, CPEs and handset applications.

Furthermore, Finwave showcased its 3DGaN FinFET technology demonstrating its linearity improvement capability. Due to its three-dimensional gate geometry, Finwave's 3DGaN FinFET reduces transistor leakage current, current collapse and knee voltage while improving PAE and linearity over 10dB compared with conventional GaN transistors, it is reckoned. With higher linearity, better PAE and reduced memory effect, 3DGaN FinFET technology is suitable for applications such as massive MIMO with large arrays.

Finwave also unveiled its first family of high-power RF switch products. These feature 100ns fast switching and settling time, broadband operations up to 12GHz and high power handling up to 40W. The combination of broadband operation, fast switching and high power handling sets it apart from existing offerings, it is reckoned.

"Our technology has already demonstrated its ability to deliver extremely high performance in higher-frequency applications, and the implications of that are very exciting – for both infrastructure and handsets," says CEO Dr Pierre-Yves Lesaicherre. "Additionally, we are making strong progress in moving our patented GaN-on-Si technology from the MIT lab to high-volume production."

www.mobileworldcongress.com
www.finwavesemi.com

CGD showcases new reference designs & demos at APEC

ICeGaN technology addressing higher-power industrial applications

At the IEEE Applied Power Electronics Conference & Exposition (APEC 2024) in Long Beach, CA, USA (25–29 February), fabless company Cambridge GaN Devices Ltd (CGD) — which was spun out of the University of Cambridge in 2016 to design, develop and commercialize power transistors and ICs that use GaN-on-silicon substrates — addressed higher-power industrial applications with its ICeGaN technology by introducing new reference designs and showing demos that address the broad and diverse industrial market.

"We are acutely aware of the increasing power requirements of industrial applications, and the need for high efficiency" says chief commercial officer Andrea Bricconi. "For example, as the use of artificial intelligence (AI) proliferates, the power demanded by the exponential growth in power demanded by data centers is growing almost exponentially. Other applications, such as solar inverters, amplifiers, transport and smart mobility, process control and manufacturing are also interested in GaN and the feedback we have received is that they love the simplicity of our 'Drive it Like a MOSFET' approach."

With a high power density of 23W/in^3, GGD's 350W PFC/LLC reference design has an average efficiency of 93%, and a no-load power consumption of 150mW. The CrM totem-pole PFC + half-bridge LLC PSU has been realised using CGD's 650V, 55mΩ, H2 series ICeGaN technology, and delivers 20V/17.5A output.

The result of a partnership deal struck last year with Neways Electronics, a 3kW photovoltaic inverter is used to boost the DC solar voltage to a stable DC link voltage. With a maximum efficiency of 99.22% due to zero-current switching, it is an example of how CGD's GaN HEMT structure is simple for engineers to use, since it employs a standard silicon controller from Analog Devices Inc.

ICeGaN has been employed by AGD Productions in its compact AGD DUET amplifier, which is rated at 300W 4Ω. This is the first time that the firm has used a 100% GaN power transistor design for both the power stage and the amplifier.

Finally, the GaNext project, a consortium of 13 partners from three nations, has delivered compact 1kW intelligent power modules featuring integrated drive, voltage control and protection circuits using CGD's ICeGaN.

www.apec-conf.org
www.camgandevices.com

Mersen gains €12m in European funding to develop polycrystalline SiC substrate manufacturing

Funding follows strategic technical partnership in late 2021 with Soitec

Mersen of Courbevoie, France (which focuses on electrical power and advanced materials for high-tech industries) is to benefit from subsidies totaling over €12m under the European Commission's Important Project of Common European Interest program in MicroElectronics and Communication Technologies (IPCEI ME/CT).

The funding is provided by the French government as part of the 'France 2030' plan to develop industrial competitiveness and the technologies of the future. It covers both the R&D and industrial production phases of the p-SiC (polycrystalline silicon carbide) manufacturing process.

These polycrystalline silicon carbide substrates will be manufactured at Mersen's production plant in Gennevilliers, France, where the firm plans to invest about €85m between 2023 and 2025 and hire 80–100 staff. Already considered as part of Mersen's 2027 strategic plan (which was announced in March 2023), this agreement will enable the company to reach a potential manufacturing capacity of 400,000 wafers (150mm-equivalent) by 2027.

Combined with a monocrystalline silicon carbide active layer, the low-resistivity p-SiC polycrystalline silicon carbide substrate is used by manufacturers of SiC power semiconductors to improve production yields and transistor performance, leading to a smaller carbon footprint for the device.

Mersen says that the funding positions it as a major supplier of the new technology of engineered substrate manufacturer Soitec of Bernin, near Grenoble, France, as part of the strategic partnership signed between the two companies in 2021 to develop a new family of substrates for the electric vehicle market.

The funding "illustrates the importance of Mersen in the French semiconductor value chain ecosystem," says Mersen's CEO Luc Themelin. "Thanks to its expertise in advanced materials, the group is a key player in the manufacturing of silicon carbide semiconductors, one of the group's key growth drivers for its 2027 roadmap."

www.mersen.com

BelGaN qualifies its BEL1 650V eGaN platform for volume production with orders from several lead customers

GaN foundry ready to scale up to high volume after just two years

Automotive-qualified gallium nitride (GaN) open foundry BelGaN of Oudenaarde, Belgium has qualified its BEL1 first-generation 650V eGaN platform for volume production for several lead customers that placed orders. After achieving this milestone within just two years, BelGaN is now ready to scale up as a high-volume GaN foundry in Europe.

The fab in Oudenaarde started as MIETEC in 1983, was acquired by Alcatel in 1990 and then by AMI Semiconductor in 2002, and sold to ON Semiconductor in 2008. The team there started on GaN development in 2009. Established in September 2021, BelGaN acquired what was ON Semiconductor Belgium BV from onsemi in early 2022, the site in Oudenaarde has since been transforming from a silicon fab to a GaN fab.

"The GaN power device market is accelerating in unprecedented speed, proliferating from mobile consumer fast chargers to AI data-center, solar, industrial and automotive applications," says CEO Dr Alan Zhou, "We have engaged with over 30 global GaN customers, and received orders from several customers in our BEL1 650V eGaN platform. As GaN volume is ramping up, customers are looking for additional capacity for GaN manufacturing, and for securing sources in Europe in view of geo-political challenges. BelGaN is perfectly positioned to support this," he believes.

"Over the past years we have invested a lot in our research and development capabilities, doubling the team, leading to a cumulative GaN expertise of >300 man-years," says Dr Marnix Tack, chief technology officer & VP business development.

"In collaboration with our lead customers, we have extensively tested products built in the BEL1 technology, demonstrating at par performance to industry leaders in charger applications."

As part of the BEL1 release, BelGaN also offers several unique foundry services enabling a virtual IDM business model for its customers. These include quality services, technology development services and product design services: coming with the BEL1 platform, BelGaN is also releasing a library of reference products, with on-resistance R_{on} ranging over 70–1000mΩ, offered as bare die or in DFN 8x8 and 5x7 packages. These are available to BelGaN customers to accelerate the design of GaN products in the BEL1 platform, and for early testing of applications using those products.

www.belgan.com

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US Critical Materials announces discovery of gallium at Sheep Creek, Montana

Prime gallium claims average over 300ppm and go as high as 1370ppm

Private rare-earths exploration, development and process technology firm US Critical Materials Corp of Salt Lake City, Utah, has confirmed what it calls a "strategically significant" deposit of high-grade gallium on its 6700 acres of claims in Sheep Creek, Montana.

The Sheep Creek deposits are said to contain some of the highest grades of rare-earth minerals in the USA, including at least 13 of the currently listed 'critical' minerals.

Gallium is consistently listed as the number-one supply risk related to national security, as the USA is 100% dependent on imported gallium, primarily from China. The Chinese government recently embargoed the export of gallium, which is critical for national defense and other vital applications such as semiconductors, 5G technology, smartphones, satellite systems, critical photonics technologies, and especially current and next-generation defense systems.

The 2022 list of critical minerals identifies gallium as having the greatest US supply risk, a risk that has become a reality as a result of the recent export controls imposed by the People's Republic of China on gallium and other critical and rare-earth minerals.

In December 2023, US Critical Materials announced that it had signed an agreement with Idaho National Laboratories (INL) to develop new rare-earth processing methods including gallium separation. It is believed that technologies developed under this Cooperative Research and Development Agreement (CRADA) could potentially provide environmentally responsible mining and processing to mitigate environmental concerns.

"Not only is our gallium high grade, but we are also confident that we will be able to create a separation process that will be environmentally respectful," notes US Critical Materials' president James Hedrick, and a former rare-earth commodity specialist at the United States Geological Survey (USGS) and United States Bureau of Mines (USBM). "US Critical Materials' prime gallium claims average over 300ppm [parts per million] and go as high as 1370ppm. Gallium can be separated profitably at 50ppm," he adds. "US Critical Materials looks forward to being the primary gallium producer in the United States."

US Critical Materials says that, as it progresses in its mission to bolster national security and technological independence through domestic gallium production, it remains dedicated to fostering partnerships, advancing sustainable practices, and contributing to the economic vitality of local communities.

www.uscriticalmaterials.com

ESK-SIC and Kyocera to co-develop sustainable production of silicon carbide

By-products and end-of-life ceramics to be recycled using RECOSiC

ESK-SIC GmbH of Frechen near Cologne, Germany (which manufactures high-performance materials for industrial applications including electronics, the automotive industry, and power generation) and Kyocera (which manufactures technical ceramics and semiconductor technologies) have entered into a strategic partnership to develop solutions for the sustainable production of silicon carbide (SiC) and associated end-products.

By-products and end-of-life ceramics will be recycled using RECOSiC technology in order to produce raw materials that are specifically tailored to various end applications. Compared with currently available SiC raw materials on the market in terms of material science aspects, while minimizing the carbon footprint of the process the RECOSiC recycling technology is said to present a technological upgrade.

The partnership aims to improve the efficiency and sustainability of the entire silicon carbide value chain. This will involve developing new manufacturing technologies, optimizing production processes, researching innovative applications and establishing circular economy principles for the recycling of SiC materials.

"This collaboration with Kyocera will open up promising avenues for us to continue tapping into the potential of RECOSiC and create sustainable solutions for future challenges," says ESK's managing director Matthias Hausmann.

Kyocera brings its expertise in materials science, electronics and advanced manufacturing technologies to the partnership. "By combining our strengths, we will be able to drive the development of technologically advanced SiC products and offer solutions that meet the increasing demands for performance, efficiency and environmental compatibility," reckons Dr Nikolaos Katsikis, director R&D (CTO) at KYOCERA Fineceramics Europe GmbH in Selb, Germany.

www.esk-sic.de
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Veeco releases fifth sustainability report

Focus on hazardous substance policies, community philanthropy and engagement, employee health, commitment to company culture, and relationships with suppliers

Epitaxial deposition and process equipment maker Veeco Instruments of Plainview, NY, USA has released its fifth Sustainability Report highlighting its progress towards environmental, social and governance (ESG) initiatives. Reflecting 2023 data, this report demonstrates continued progress and commitment to executing a robust sustainability strategy, says the firm.

"Our commitment to environment, society and governance initiatives is as strong as ever," says CEO Bill Miller. "We strongly believe in reducing our carbon footprint, building a diverse and inclusive team, leveraging renewable energy sources, and being a responsible neighbor and corporate citizen."

Veeco's fifth Sustainability Report features detailed goals focused on hazardous substance policies, expanded community philanthropy and engagement, prioritized employee health, continued commitment to company culture, strong relationships with suppliers, and more.

www.veeco.com

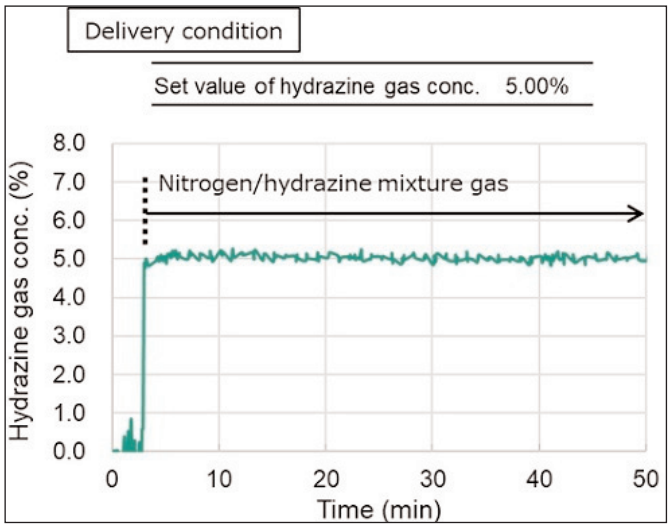
Taiyo Nippon Sanso develops high-purity hydrazine gas delivery system

System compatible with BRUTE Hydrazine of subsidiary RASIRC

Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan has developed a gas delivery system for high-purity hydrazine, compatible with the BRUTE Hydrazine of California-based subsidiary RASIRC Inc, which provides semiconductor processing materials and vapor-generation equipment.

In the electronic device manufacturing industry, hydrazine gas is favored for its superior reactivity over conventional nitriding sources, such as ammonia. This advantage facilitates the reduction of temperatures in the semiconductor manufacturing process, enhances film quality, and improves throughput. Such advancements are crucial for miniaturizing advanced logic semiconductors and increasing the storage capacity of memory chips.

TNSC offers RASIRC's BRUTE Hydrazine as a high-purity material specifically for semiconductor BRUTE Hydrazine, prepared by blending anhydrous hydrazine with a unique organic solvent stabilizer from RASIRC, which significantly boosts safety. While high-purity hydrazine gas has attracted attention as an emerging specialty gas for semiconductor manufacturing, a system that can deliver this gas via a concentrated and stable method has not been developed. Given the necessity for consistent delivery of such specialty gases in semiconductor production processes, the availability of a dedicated delivery system has become crucial, TNSC says.



Hydrazine gas concentration behavior using the delivery system.

So, leveraging its proprietary gas handling technology, TNSC has pioneered the development of a gas delivery system capable of safely and reliably delivering high-purity hydrazine gas tailored to semiconductor manufacturing processes. The high-purity hydrazine gas delivery system's features are as follows:

- A BRUTE Hydrazine vessel is securely housed within the gas delivery cabinet, facilitating the safe and stable delivery of a nitrogen/hydrazine gas mixture (see Figure).
- The system includes an integrated monitoring feature that continuously tracks the remaining amount of BRUTE Hydrazine gas, ensuring uninterrupted delivery. Vessel replacement is streamlined through an automated sequence, allowing for safe and easy maintenance without exposing the hydrazine gas.
- The interior of the gas delivery cabinet is maintained under continuous negative pressure to swiftly evacuate any potential gas leaks from the BRUTE Hydrazine cabinet or internal piping through the exhaust duct, preventing disasters.
- In case of hazardous conditions, the system is equipped with a safety feature that triggers an alarm and automatically ceases operation to ensure safety.

www.tn-sanso.co.jp

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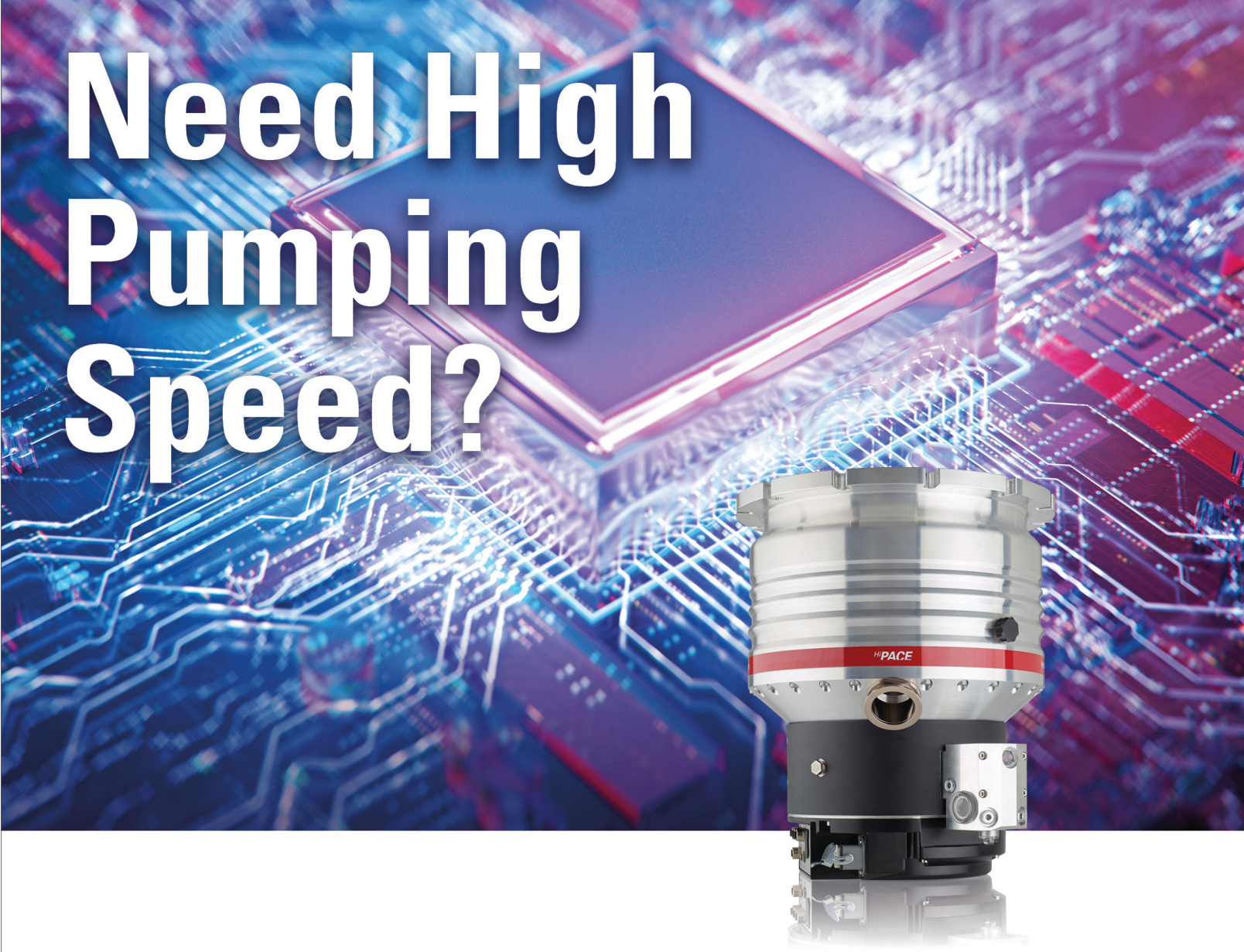

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Aixtron's Q4 revenue grows to record €214.2m, aiding full-year growth of 36%

Systems for SiC and GaN power electronics rise from 42% to 74% of equipment revenue during 2023

For fourth-quarter 2023, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported record revenue of €214.2m, up 30% on €165m last quarter and up 17% on €183.2m a year ago: This is also about three times first-quarter 2023's revenue of €77.2m, underlining Aixtron's flexibility in its supply chain and manufacturing.

Full-year revenue has hence grown by 36% from 2022's €463.2m to €629.9m in 2023.

On a geographic basis, Asia fell, from 68% to 50% of full-year revenue (due mainly to Taiwan dropping from €77.5m to €42.6m while Malaysia rocketed from €32.9m to €52m), while the Americas rose further from 18% to 20% (from €83.5m to €126.1m) and Europe rebounded from 14% to 30% (from €63.5m to €189.4m).

Of the annual revenue, equipment rose from 82% to 85% (€532.3m, up 40% on 2022's €380.4m). The remaining 18% (€97.6m) came from after-sales (consumables, spare parts and services).

Growth was driven mainly by systems for applications in silicon carbide (SiC)- and gallium nitride (GaN)-based power electronics booming from 42% to 74% of equipment revenue. Optoelectronics applications comprised 12% of equipment revenue and LEDs including micro-LEDs 11%.

Specifically, the business received a strong boost from the market launch of Aixtron's new metal-organic chemical vapor deposition (MOCVD) system types G10-AsP and G10-GaN in January and September 2023, respectively, completing the G10 system generation. After being recognized by a "leading global semiconductor company" for its "excellent performance", the G10-GaN is already seeing high demand shortly after its launch. Also, the G10-SiC chemical vapor deposition (CVD) systems accounted for about a third of Aixtron's system sales in full-year 2023, despite only being available since September 2022.

Full-year gross margin rises from 42% to 44%

In fourth-quarter 2023, gross margin was 46%, level with last quarter but up from 45% a year ago. Full-year gross margin rose from 2022's 42% to 44% in 2023.

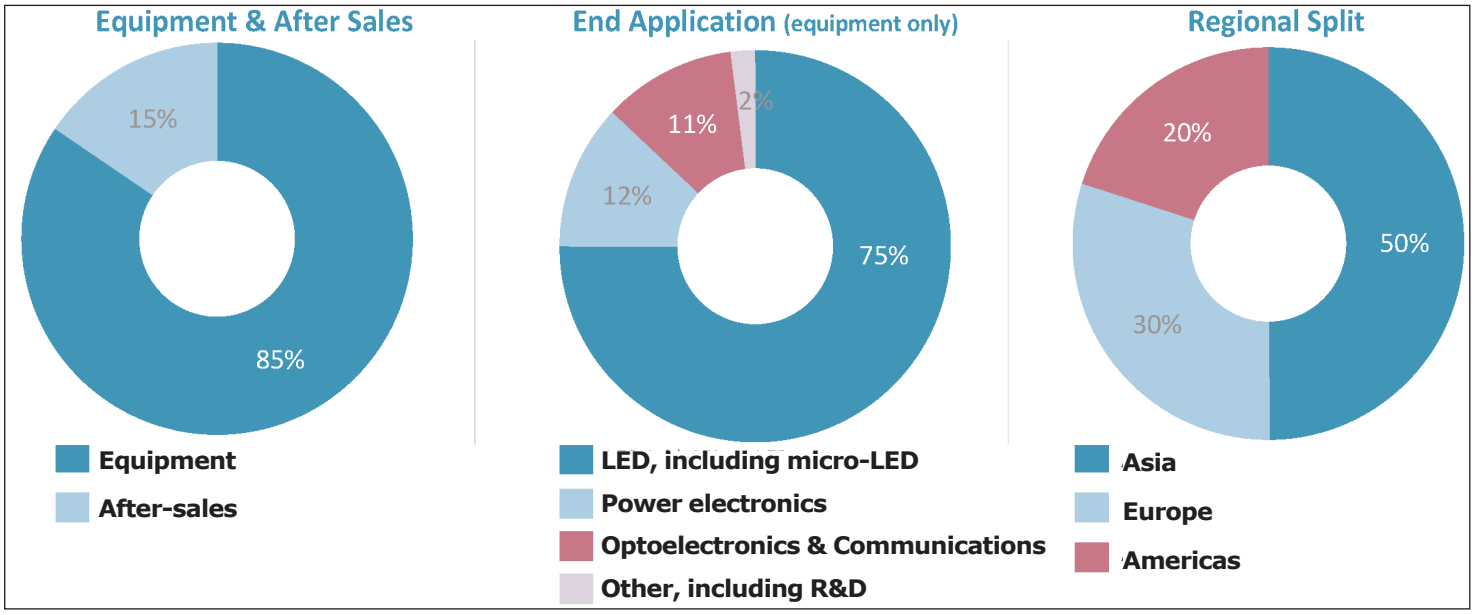
In 2023, Aixtron's launched the new Aixtron Innovation Center. The firm is investing about €100m on the site in a new cleanroom for the development and testing of the next generation of systems. Groundbreaking took place in Q4/2023, and the floor slab of the main building was completed by the end of the year. Work on the shell is underway and the project is on schedule.

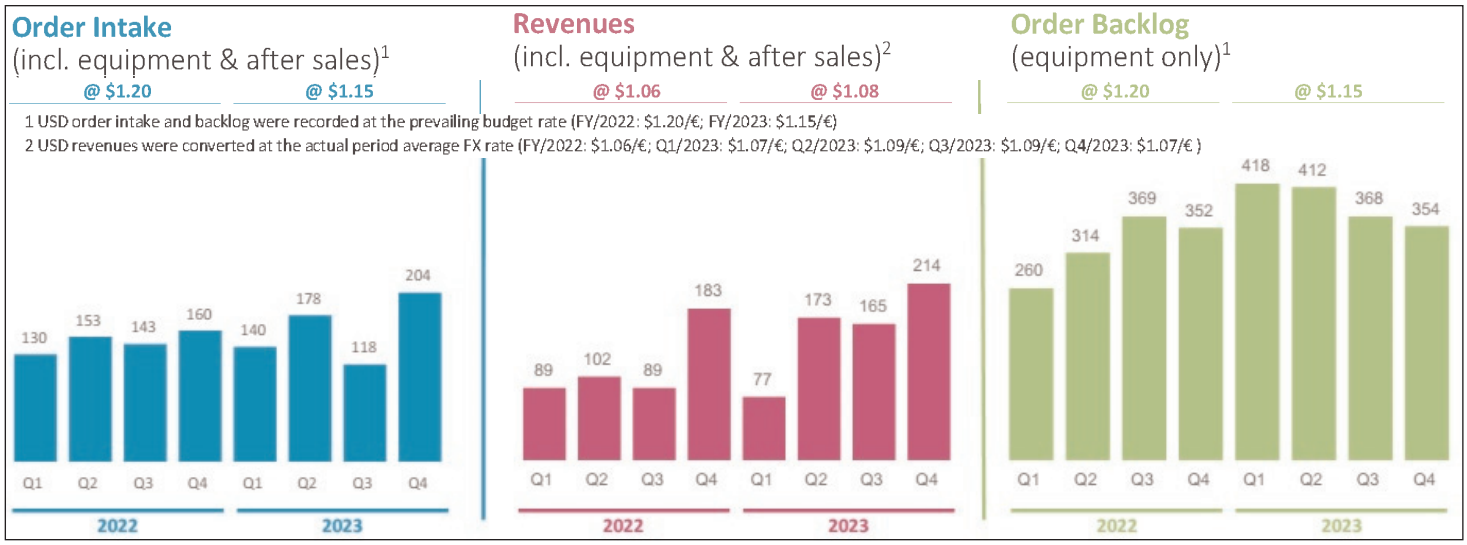
R&D spending has correspondingly further risen significantly in a targeted manner by 52% from 2022's already high level of €57.7m to €87.7m in 2023, including Q4 being up by 70% from €16.4m in 2022 to €27.9m in 2023. Total full-year operating expenses hence rose from €90.6m in 2022 to €122.3m in 2023.

Against the background of Aixtron's rapidly growing core business, full-time-equivalent staffing grew by 21% during 2023 from 895 to 1086, including R&D staffing rising from 254 to 366 (from 28% to 34% of the total workforce).

EBIT up 50%; net income up 45%

Fourth-quarter operating profit (earnings before interest and taxes,





EBIT) of €63.4m is up on €45.3m last quarter and €57.1m a year ago (although EBIT margin of 30% is down slightly from 31% a year ago). Full-year EBIT hence grew from 2022's €104.7m to €156.8m in 2023, with EBIT margin growing from 23% to 25%.

Quarterly operating cash flow was €18.4m, an improvement from –€0.1m a year previously. However, capital expenditure has almost quadrupled from €12.6m to €45.7m, driving full-year CapEx up from 2022's €29.5m to €62.4m for 2023. Quarterly free cash flow was hence –€27.4m, worsening from –€12.7m a year ago. Compared with +€7.7m in 2022, full-year free cash flow was –€109.7m in 2023, due mainly to the increased receivables (rising from €119.7m to €157.6m), investments in property, plant & equipment (in particular the new Aixtron Innovation Center) rising from €99m to €147.8m), and the build-up of inventories during 2023 (from €223.6m to €394.5m) in preparation for high planned sales in the coming quarters.

Cash, cash deposits and investments fell during 2023, from €325.2m at the end of 2022 to €209.9m at the end of Q3/2023 then €181.7m at the end of 2023.

However, underlining the firm's financial strength, the equity ratio of 75% at the end of 2023 is still up on 73% at the end of 2022.

Annual dividend rose by 29%

After the positive business development in the past year, Aixtron plans to again pay out a higher dividend. The Executive Board and Supervisory Board will therefore propose to the annual general meeting on 15 May a dividend payment of €0.40 per eligible share (up 29% from €0.31 per share in 2022).

Quarterly order intake up 28% year-on-year

As demand for efficient power electronics in particular remains strong, in fourth-quarter 2023 order intake rebounded from €118.5m last quarter to €204.5m, up 28% on €160.3m a year ago. Full-year order intake consequently grew by a record 9%, from 2022's €585.9m to €640.7m in 2023.

Equipment order backlog hence was up, albeit slightly, by 1% from 2022's €351.8m to €353.7m for 2023.

Growth to continue through 2024 and into 2025

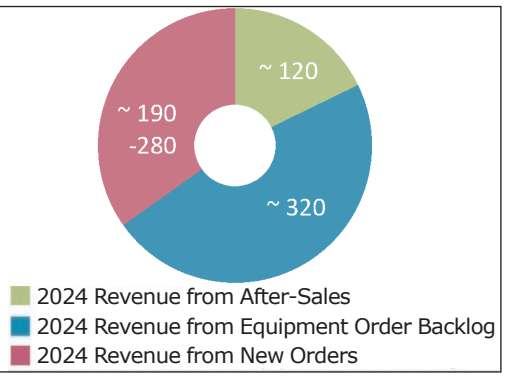
For first-quarter 2024, Aixtron expects revenue to fall back to €100–120m. However, it expects that the high demand for its systems will continue to increase and that revenue growth will continue during 2024.

Based on the equipment order backlog (convertible into 2024 revenue) of about €320m as of 1 January, joined by a forecasted €190–280m in new order intake that should be convertible into revenue in 2024, plus a forecasted €120m in after-sales revenue (all at a budget rate of $1.15/€), for full-year 2024 Aixtron forecasts revenue of €630–720m, gross margin of 43–45% and EBIT margin of 24–26%.

Also, Aixtron expects further strong sales growth in 2025, fueled by the next wave of growth in GaN and SiC power electronics, plus stable sales in the optoelectronics sector.

www.aixtron.com

Guidance € millions	Q1/2024	FY/2024
Revenues	EUR 100m – 120m	EUR 630m – 720m
Gross Margin (%)		43% – 45%
EBIT Margin (%)		24% – 26%



Aehr ships new high-power-configured FOX-XP system for wafer-level burn-in and stabilization of silicon photonics ICs

New capabilities and value through upgrade of existing system

Semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has shipped the first order from a major silicon photonics customer for a new high-power configuration of its FOX-XP system for volume production wafer-level burn-in and stabilization of next-generation silicon photonics integrated circuits (ICs).

The FOX-XP multi-wafer test and burn-in system is configured to enable cost-effective volume production test of wafers of next-generation photonic ICs, which can require up to 2–4 times as much power per wafer for test and burn-in and stabilization of the silicon photonics devices, and are targeted for use in the new optical I/O or co-packaged optics market.

"We were able to deliver these new capabilities and value through an upgrade of one of the customer's existing systems while maintaining backwards and forwards compatibility with all test programs, WaferPaks, and correlation results of previous lower-power wafers. This is a testament to our commitment to compatibility for our FOX platform," says president & CEO Gayn Erickson.

"We remain very enthusiastic about the silicon photonics market, which includes the current photonics transceiver market used in data and telecommunications, as well as the new application of silicon photonics integrated circuits for use in optical chip-to-chip communication that we see as a significant market opportunity for our products," he adds.

"This new FOX-XP system configuration and WaferPaks allow for testing up to 8192 high-power optical devices in parallel on each of nine wafers before they are singulated and placed into a fiber-optic transceiver for data-center and telecommunications infrastructure or for placement in co-packaged optics for optical chip-to-chip communication," Erickson continues. "Multiple companies including AMD, Nvidia, Intel, TSMC and GlobalFoundries have announced product roadmaps for devices using optical chip-to-chip communication."

The new FOX-XP system configuration with high-power WaferPaks enables production test of up to 3500W of power per wafer and up to nine full wafers in parallel. It also includes Aehr's latest chamber configuration, which has a smaller overall footprint and is compatible with Aehr's new WaferPak AutoAligner that the firm began shipping last year. This provides customers with fully automated material handling in a hands-free operation of 6–12" wafers using industry-standard wafer cassettes and front-opening unified pods (FOUPs) and can also support mobile robot and overhead transport of wafers in FOUPs.

The FOX-XP and FOX-NP systems and proprietary WaferPaks are capable of functional test and burn-in/cycling of silicon carbide and gallium nitride power semiconductors, silicon photonics integrated circuits as well as other optical devices, 2D and 3D sensors, flash memories, magnetic sensors, micro-controllers, and other leading-edge ICs in either wafer form factor before they are assembled into single- or multi-die stacked packages, or in singulated die or module form factor.

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IQE expands portfolio of epiwafers for high-speed optical connectivity

Addressing demands for AI, cloud, carrier & data-intensive workloads

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK is strengthening its portfolio of high-speed optical connectivity epiwafers to address increasing demands for artificial intelligence (AI), cloud, carrier and data-intensive workloads.

The products are designed to meet the demands of AI and data centers now and in the future, while also increasing energy efficiency. The new offerings are:

- the industry's first foundry epitaxy service for 1310nm quantum dot lasers (QDL), available on both gallium arsenide (GaAs) and silicon, with photonic integrated circuit (PIC) and CMOS platform compatibility to enable customers to develop next-generation high-data-payload optical transceivers for greater performance and energy efficiency within data centers;
- launch of a 56G 850nm vertical-cavity surface-emitting laser (VCSEL) reference design for pulsed amplitude modulation (PAM-4) optical transmission in data center and enterprise short-reach multi-mode fiber (MMF) applications;
- release of a 6-inch-diameter indium phosphide (InP)-based PIN photodetector platform, complementing the firm's 6" InP Fabry–Perot (FP), distributed feedback (DFB) and electro-absorption-modulated laser (EML) signal laser offering, for customers prototyping photonics devices at disruptive larger wafer diameters, enabling the industry to scale and meet the future demands of datacom whilst driving economies of scale.

"Datacom is undergoing a rapid transformation as it needs to meet the demands of generative AI and its high-speed data processing," notes Mark Furlong, executive VP, business development. "Our strengthened portfolio is at the forefront of an industry drive for faster, more efficient and cost-effective data connectivity solutions," he adds. "We are enabling our customers to develop a competitive advantage to transform optical networks at the heart of AI engines and next-gen compute while also generating economies of scale and supporting the need for more sustainable solutions."

www.iqep.com

ams OSRAM re-assessing micro-LED strategy after Apple project cancelled

Non-cash impairment charges of €600–900m; usage of new 8-inch LED facility in Malaysia to be reviewed

After having been informed of the unexpected cancellation of a cornerstone project for its micro-LED program, ams OSRAM GmbH of Premstätten, Austria and Munich, Germany says that it is re-assessing its micro-LED strategy. Discussions with the related customer — reported to be Apple — are ongoing.

Specifically, ams OSRAM will revisit the future use of its assets related to its micro-LED strategy, particularly the new 8-inch LED facility in Kulim, Malaysia.

Based on a first, preliminary estimation, ams OSRAM consequently expects to record non-cash impairment charges on micro-LED-related assets and goodwill of €600–900m in fiscal first-quarter 2024.

The firm also expects a slightly revised mid-term revenue compound annual growth rate (CAGR) of 6–8% on a like-for-like basis (without the non-core portfolio in semiconductors of €300–400m in 2023 and the divestments in the Lamps & Systems segment in Q1/2023) as volume sales from its 8" LED facility in Kulim can no longer be assumed in that time frame.

Changes to the capitalization of R&D investments into micro-LEDs and reduced subsidies from public funding schemes will impact ams OSRAM's operational profitability (adjusted EBIT) for fiscal year 2024 by €30–50m. The firm is considering additional cost improvements on top of its known 'Re-Establish-the-Base' program to further balance this negative impact on fiscal year profitability.

Nevertheless, ams OSRAM notes that its underlying business performance is on track and it continues to expect first-quarter revenue to improve year-over-year on a comparable basis to €800–900m. Adjusted EBIT is expected to still be 4–7% of revenue but will be burdened by the changes to capitalization of R&D and reduced subsidies within that range.

The cancellation of the cornerstone project is expected to improve the firm's cash flow profile in the next 24 months, due partly to reduced capital expenditure (CapEx).

Cancelled collaboration casts doubt on 2026 launch of micro-LED version of Apple Watch, says TrendForce

Reporting that the cancelled collaboration was with Apple, market research firm TrendForce notes that this casts uncertainty on the launch of the micro-LED version of the Apple Watch as ams OSRAM was the sole supplier for the micro-LED vertical chips, along with South Korean panel manufacturer LG Display supplying the glass driving backplane and mass transfer processes. With the partnership dissolved, the 2026 debut seems increasingly out of reach, comments TrendForce.

For the micro-LED Apple Watch, supply chain scarcity is pushing micro-LED panel costs potentially 2.5–3 times higher than similarly sized OLED panels. Secondly, ams OSRAM's smaller micro-LED vertical chips — while cost-saving and beneficial for redundancy design — demand higher transfer precision, posing another critical bottleneck for mass production. Thirdly, micro-LEDs still lacks a dedicated driving architecture, leaving micro IC or TFT solutions unresolved.

This casts uncertainty on the launch of the micro-LED version of the Apple Watch as ams OSRAM was the sole supplier for the micro-LED vertical chips, along with South Korean panel manufacturer LG Display supplying the glass driving backplane and mass transfer processes

However, TrendForce remains optimistic about Apple's venture into micro-LED technology. Taiwan and South Korea boast a robust line-up of manufacturers for micro-LED chips, backplanes, and related transfer processes, who are ready to fill the gap and offer Apple an opportunity to seek new supply chain partners.

Secondly, Apple's commitment to micro-LED innovation is evident in its extensive patent portfolio, which ranges from integrated display and sensor elements and flexible displays built on micro-LEDs. Abandoning these innovations could contradict Apple's consistently emphasized values, says TrendForce. Lastly, as a new display technology in the spotlight, the potential of micro-LEDs extends beyond watches to applications in head-mounted augmented reality (AR) devices, remaining an innovative new technology for Apple's medium- to long-term product diversification strategy.

TrendForce emphasizes that micro-LED technology is at an early stage of development. The involvement of industry giants like Apple significantly contributes to driving positive advancements across the sector. Notably, the integration of micro-LEDs into products such as watches could emerge as a flagship application within the next 2–3 years. With potential shipments reaching millions of units, this development is poised to play a crucial role in shaping the future of the industry, believes TrendForce.

www.trendforce.com
www.ams-osram.com

MICLEDI raises Series A funding to expand team, design and build active backplane ASIC, and create micro-LED display module for AR glasses

Cumulative funding rises to nearly $30m

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 — has announced a first closing of its Series A funding round with participation from imec.xpand, PMV, imec, KBC and SFPIM, demonstrating support for the firm's commercial and technological progress achieved in the seed round. The seed round award plus additional non-dilutive funding in the form of grants and other vehicles from VLAIO brings total funding to date to nearly $30m.

"Our door is open to engagements with some of the world's largest and most innovative electronic product manufacturing companies, most of whom are working on their own internal development projects for augmented reality displays in such diverse use-cases as smart wearable devices and automotive HUDs," says CEO Sean Lord. "This level of total funding to date is almost unheard of for a four-year-old startup."

MICLEDI used the seed round to validate a unique 300mm wafer manufacturing methodology, which is claimed to be the first in the world at 300mm. Seed funding also enabled the firm to prove best-in-class blue and green gallium nitride (GaN)-based micro-LED arrays with pixel-by-pixel micro-lenses in its unique 300mm flow. The company also demonstrated solid red performance using red GaN material with early proof of superior performance based on red aluminium indium gallium phosphide (AlInGaP). All three colors (R, G, B) were demonstrated to large audiences at the Consumer Electronics Show (CES) and SPIE AR-VR-MR 2024.

"This newest round of funding will be used to expand the team, design and build an active backplane ASIC, and create a fully functional micro-LED display module that can be used in glasses for AR displays," says Lord. "In addition, the new funds will help support collaboration agreements with customers and ensure that we keep pace with the growing demand for increasingly immersive video applications from tier-1 customers and partners in the rapidly growing AR market."

Industry experts agree that GaN-based material technology is the only pathway to RGB micro-LED displays that are bright enough to meet the demands of AR as well as other related applications of micro-displays. In conjunction with key customers, MICLEDI has launched specialty displays to serve these applications while continuing its primary focus on AR for consumer applications. MICLEDI and GlobalFoundries (GF) have agreed to transfer the company's unique micro-LED manufacturing flow into GF's CMOS fab in conjunction with backplane ASICs designed in GF's advanced CMOS process nodes, which is also reckoned to be a first in the micro-LED industry as part of the enablement of cost and volume demands of the burgeoning AR market.

In 2024, MICLEDI will have available full-color modules with an active backplane, and the firm is developing configurations of all three basic intrinsic color arrays with quantum dot filtering on already brilliant green and blue arrays. In addition, in the first half of second-quarter 2024 MICLEDI will introduce its first demo glasses.

www.micledi.com

Linköping spin-off Polar Light Technologies appoints CEO

Polar Light Technologies (PLT) — which stems from research by founder professor Per-Olof Holtz and his team at Sweden's Linköping University — has appointed Oskar Fajerson as CEO to lead it through the final stages of research and into commercialization of its micro-LED technology.

After recently making several advancements, Polar Light Technologies is increasing its efforts to finalize research and go to market. Whereas existing LED manufacturing technology results in an uneven surface with many defects and poor efficiency, Polar Light Technologies says that it has developed a way to fabricate micro-LEDs in small pyramids using controlled crystal growth, atomic layer by atomic layer. The result is claimed to be unmatched pixel size, brightness and energy efficiency.

"Polar Light Technologies is a world-leading company developing the next generation of micro-LEDs," comments Fajerson.

"Oskar has the right background to take PLT onwards to product launch," believes outgoing CEO Peter Nilsson. Fajerson has a background in product management, sales and marketing and a degree in material physics from KTH Royal Institute of Technology in Stockholm. His previous experience includes senior positions at a wide range of high-tech companies during their growth phases, including eye-tracking company Tobii.

www.polar-light-technologies.com

Feit files second white LED filament patent lawsuit

Injunction sought to bar importation and sale, claiming damages and attorney fees for infringement

California-based global lighting and smart home brand Feit Electronic Company Inc has commenced a second white LED filament patent enforcement action against Savant Technologies LLC doing business as GE Lighting in the United States District Court for the Northern District of Ohio. Feit Electric says that, despite being warned, Savant imported and then sold white LED filament light bulbs marketed under the GE brand.

Feit Electric introduced light bulbs with white LED filaments in August 2022 as an alternative to the traditional yellow filament. Anticipating that other light bulb suppliers might copy them, Feit Electric announced that it owns a set of patents directed to covering the yellow material used on LED filaments.

"Not only did we widely announce to the industry that Feit Electric owns a set of patents directed to covering the yellow material used on LED filaments, but we also specifically and directly informed Savant as well as retailers and other manufacturers," says president Alan Feit._"Despite those warnings, Savant went forward with infringing white LED filament products."

Feit Electric is seeking an injunction to bar the further importation and sale of infringing white LED filament light bulbs, for damages, and for enhanced damages and attorney fees for willful infringement.

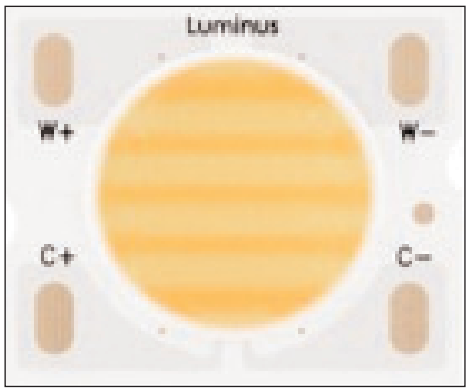
www.feit.com

Luminus expands range of Gen 2 CCT tunable COBs

Existing 6mm, 9mm and 14mm versions joined by 18mm and 22mm

Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — has expanded its Gen 2 CCT tunable chip-on-board (COB) LED portfolio with the introduction of the CTM-18 and CTM-22. Both feature the same 6500K to 2700K color combination of the exiting CTM-6, CTM-9 and CTM-14, along with two additional CCT (correlated color temperature) ranges: 4000K to 1800K and high-melanopic 5000K Salud to 2200K. The Gen 2 CCT tunable COBs are now available in three CCT ranges and five sizes, with the light-emitting surface (LES) diameters of 6mm, 9mm, 14mm, 18mm and 22mm. Each provides what is claimed to be industry-leading efficacy (lumens/Watt) and flux density, enabling customers to drive at higher currents to enable longer throws and more 'punch' in their spotlights.

The Gen 2 COBs boast two independent channels, offering warm



and cool white with over 90 CRI (color-rendering index). Engineered with a multi-stripe design, they ensure what is claimed to be excellent color mixing and high flux density, suitable for directional lighting applications. With the ability to achieve system beam angles ranging from 10° to 40° using standard secondary optics, customers can enjoy uniform color output and exceptional light quality, the firm adds. The three available CCT range options, coupled with consistent white light <3SDCM (standard deviation of color matching), make the COBs suitable for a range of applications, including commercial, residential, offices, human-centric lighting, museums, healthcare, retail stores, hospitality venues, and circadian lighting setups.

A wide array of optics, holders and connectors is compatible with the industry-standard footprints commonly used for two-channel COBs.

"The industry-leading efficacy and flux density of these Gen 2 products are meeting the growing demand for tunable CCTs to provide healthy lighting environments with adaptable tones," says David Davito, senior director of global product marketing, Illumination. "The quality of light is equally impressive, as these COBs enable the creation of narrow beams with smoother color mixing, providing a seamless dynamic directional lighting solution."

All Luminus color-tuning products are now available through Luminus' authorized distributors.

www.luminus.com/products/dynamic-cob/cct-tunable

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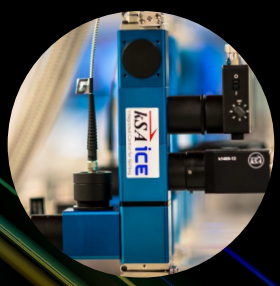

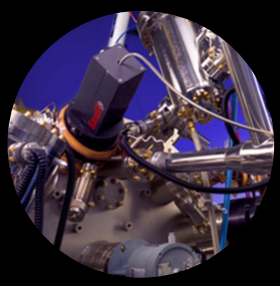
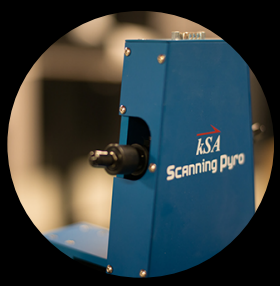

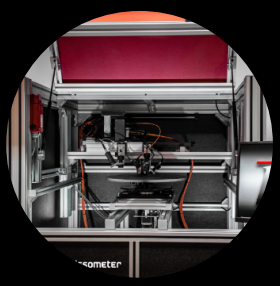

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University of Jena and TU Braunschweig collaborating on GaN-based photonic devices

Three-year OptoGaN project awarded €600,000 by Germany's BMBF

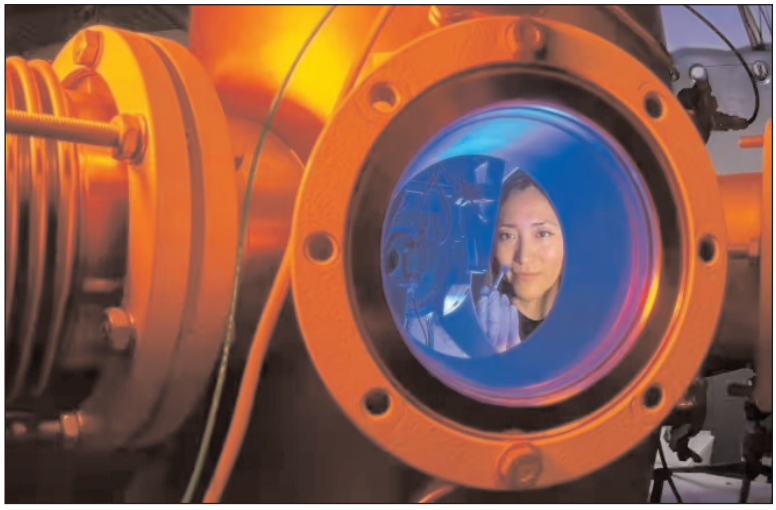
Although micro-LEDs exist as single chips and waveguides as fiber-optic cables, the materials required to make them are too heterogenous to integrate these electronics and photonics components onto a single chip. However, a novel etching technique could enable the combining of optoelectronic light sources and photonic fiber optics.

Researchers at Friedrich Schiller University Jena and Technische Universität Braunschweig have launched the joint project OptoGaN ('Highly integrated microphotonic modules in nitride technologies') focusing on porous gallium nitride, which has been awarded about €600,000 of funding by the Federal Ministry of Education and Research (BMBF) for a three-year term until October 2026.

The research groups reckon that their technology could serve an array of potential applications. The project partners hope to establish three applications with one start-up each as demonstrators. Their research could benefit technologies such as waveguides, neuromorphic computing and the trapped-ion quantum computer operated by the Quantum Valley Lower Saxony network. Meanwhile, the newly founded Nitride Technology Center (NTC) at TU Braunschweig will support the further development of nitride technology at the highest level and bring it into application.

The technology could be applied through, for example, the process of manipulating the ions of a quantum computer, which still requires large-scale laser systems. If more and more quantum bits are to be incorporated into these computers, then their laser systems must become significantly smaller, ideally no larger than a chip. However, silicon dioxide — the standard material for waveguides on chips — absorbs the critical wavelengths of light. Gallium nitride could provide a solution, as porous GaN has a low index of refraction and facilitates waveguiding of light to individual ions with minimal losses.

At TU Braunschweig, scientists etch porous semiconductor crystals made of GaN. (Photo: Max Fuhrmann/TU Braunschweig.)



Doctoral candidate Karla Jahaira Paz Corrales experiments with material samples at an ion accelerator. Image: Jens Meyer (University of Jena).

Complementary expertise in handling gallium nitride

The porous material is the result of a new, selective etching technique that turns electrically conductive areas into air-filled channels (pores). The corresponding electrical contrast is realized through ion implantation with masks. It is reckoned that this technique could even open the door to three-dimensional waveguides with complex optical light conduction. Also, gallium nitride and the novel process are compatible with the procedure used to manufacture LEDs and laser diodes to date, making it possible to realize integrated electronic and photonic circuits.

Researchers at Jena and Braunschweig are combining their complementary expertise and specialist equipment to realize these innovative semiconductor channels for light guiding, since the etching technique has both electronic and chemical components. First, researchers in Braunschweig produce the base material, layer by layer. The material is then shipped to Jena for ion implantation. The researchers in Jena dope the chip and make targeted changes to its electronic properties. Finally, the chip returns to Braunschweig, where there chemical etching process creates the final, porous structure.

www.tu-braunschweig.de/en/iht/research/research-projects
www.uni-jena.de/en/240313-optogan

Phlux shipping 1550nm InGaAs APDs in volume as export orders drive demand

Sheffield University spin-off delivers products to 15 customers

Phlux Technology (which was spun out of the UK's Sheffield University in December 2022) has won a six-figure (GBP)-value export contract and is now shipping production quantities of its 1550nm indium gallium arsenide (InGaAs) avalanche photodiode (APD) infrared sensors.

"Unlike most semiconductor companies, we didn't need to win new design slots before generating sales. Our Noiseless InGaAs APDs are drop-in replacements for traditional IR photodetectors," notes CEO Ben White. "They're ideal for making instant performance upgrades to laser rangefinders, LiDAR and optical-fiber test equipment, so we're seeing immediate demand, particularly across North America and Europe," he adds. "There will be more product announcements as we build on this success over the next few months. Just over a year after closing an initial £4m seed funding round, we've now delivered products to 15 customers."

"Securing a significant contract so quickly after their seed round is great validation of Phlux's technology, vision and execution," comments Dr Amy Nommeots-Nomm, early-stage investor at Octopus Ventures. "Phlux are proving they can deliver their incredible innovation to customers and are on an exciting trajectory to shape the future direction of LiDAR, communications and sensing," she adds. "We are excited to see them continue to deliver on their roadmap, bringing products to market, and building further strategic partnerships."

Launched in January, Phlux's Aura 1550nm APDs are claimed to be 12x more sensitive than other best-in-class InGaAs APDs. The operating range of IR-based systems can hence be immediately extended by up to 50% as well as offering accuracy and environmental stability. In new designs, it is possible to reduce the power of the laser diode that produces IR pulses and simplify both the system optics and thermal management arrangements, cutting product size and cost.

Phlux says that the performance of Noiseless InGaAs APDs is boosted by the addition of antimony alloy in the compound semiconductor fabrication process. This not only increases the sensitivity of the diodes but greatly improves their thermal stability, making them more environmentally robust, the firm adds.

www.phluxtechnology.com

Optica's Holonyak Award for Boston's Ted Moustakas

For pioneering contributions to nitride materials and optical devices

Theodore Moustakas (ECE, MSE, Physics) — Professor Emeritus and Distinguished Professor of Photonics and Optoelectronics at Boston University (BU) — has been awarded the Nick Holonyak Jr Award by Optica (formerly the Optical Society of America, OSA) for his pioneering contributions to nitride semiconductor materials and optical devices that helped build the foundation for efficient blue and ultraviolet (UV) light-emitting diodes (LEDs).

Moustakas, who joined Boston University in 1987, discovered and patented methods for making gallium nitride (GaN) films with high crystalline quality, which led to the development of blue LEDs and, eventually, white LEDs. The latter paved the way for modern smartphone and computer screens, and kicked off the ongoing transition from incandescent to LED bulbs (which now account for nearly half of the illumination market, according to a federal survey).

Intellectual property related to Moustakas' discoveries has been licensed by Boston University to more than 40 companies around the globe, including Apple, Amazon, Microsoft, Hewlett-Packard, Dell, and Sony. Moustakas himself co-founded two companies: UV LED maker RayVio and water sterilization product maker LARQ.

Moustakas cites Holonyak's "distinguished contributions to the field of optics through the development of semiconductor-based light-emitting diodes and lasers" as an inspiration during his entire career.

"The Nick Holonyak Award is one of the most prestigious awards in the semiconductor field, and Ted has more than revolutionized the field — so this recognition is, in fact, overdue," comments Distinguished Professor of Engineering Siddharth Ramachandran (ECE, MSE, Physics), an Optica Fellow.

Moustakas holds 41 US patents and has presented 138 invited, keynote and plenary talks in national and international conferences. The 363 papers he has authored in technical journals have been cited more than 19,000 times. A prime mover behind the creation of the BU Photonics Center and the BU College of Engineering's Materials Science and Engineering Division, Moustakas was named Boston University Innovator of the Year in 2013.

In addition to awarding him the Holonyak honors this year, Optica named Moustakas a fellow in 2021. Moustakas is also a fellow of the American Physical Society, the Electrochemical Society, the Materials Research Society, a life fellow of IEEE, and a charter fellow of the National Academy of Inventors.

www.bu.edu/eng/profile/theodore-moustakas

Marvell's Radhakrishnan Nagarajan receives Optica's 2024 David Richardson Medal

For manufacturing and commercialization of InP- and Si-based PICs

Dr Radhakrishnan Nagarajan has been selected as the 2024 recipient of Optica's David Richardson Medal. Nagarajan is honored for the successful manufacturing and commercialization of indium phosphide (InP)- and silicon (Si)-based photonic integrated circuits for use as optical interconnects with a wide range of applications. Described as an insightful engineer and outstanding innovator and mentor, Nagarajan's ability to move from concept to commercialization and deployment continues to have a profound impact on our industry, says Optica.

Nagarajan received his BEng from the National University of Singapore, MEng from the University of Tokyo, and PhD from the University of California, Santa Barbara (UCSB), all in electrical engineering. He is currently senior VP & chief technology officer of Optical Platforms at Marvell, where he manages development of the firm's optical platform technology and products. Concurrently, he is a visiting professor at the Department of Electrical and Computer Engineering at the National University of Singapore. Nagarajan joined Marvell from Inphi, where he was the senior VP & chief technology officer of Platforms and prior to this, he was a fellow at Infinera.

Nagarajan's other recognitions include the IEEE/LEOS Aron Kressel Award and the IPRM (Indium Phosphide and Related Materials) Award for breakthrough work in the development and manufacturing of large-scale photonic integrated circuits. He was named to Electro Optics' The Photonics100 2024, which honors the industry's most innovative people. He has been awarded 245 US patents and is a fellow of Optica, IEEE, and the Institution of Engineering and Technology (UK).

Established in 1966, the Richardson Medal recognizes significant contributions to optical engineering, primarily in the commercial and industrial sector. It honors David Richardson's unique contributions to applied optics, and is endowed by Cary Instruments and Gary Duck.

www.marvell.com
www.optica.org

Tokyo Institute of Technology's Kenichi Iga awarded Optica's Frederic Ives Medal/Jarus W. Quinn Prize

For "pioneering contributions and visionary leadership" in VCSELs

Optica (formerly the Optical Society of America, OSA) has named Kenichi Iga, Professor Emeritus and former president of Tokyo Institute of Technology, as recipient of the 2024 Frederic Ives Medal/Jarus W. Quinn Prize for his "pioneering contributions and visionary leadership in the field of semiconductor lasers and optoelectronics and a dedication to training and educating future generations".

"Kenichi Iga fundamentally changed the field with his revolutionary work on VCSELs [vertical-cavity surface-emitting laser]," comments Optica's 2024 president Gerd Leuchs. VCSELs are said to have changed semiconductor lasers from an expensive and challenging specialized device to a widely available and accessible tool manufactured in high volumes and used across an ever-increasing number of industries.

First given in 1929, the Frederic Ives Medal recognizes overall distinction in optics and is Optica's highest award. The Quinn Prize was added in 1995 in honor of Optica's first executive director Jarus W. Quinn.

Kenichi Iga,

Iga received his D.Eng degree from Tokyo Institute of Technology). He joined Tokyo Tech's Precision and Intelligence (P&I) Laboratory in 1968, eventually becoming the Teiichi Yamazaki chair professor. He served as director of Institute Library and director of the P&I Microsystem Research Center, executive director of the Japan Society for the Promotion of Science and president of Tokyo Tech.

His work is said to have significantly impacted high-speed communications. Since his first demonstration of a VCSEL in 1979 at Tokyo Tech, he has established the fundamental technical and theoretical bases for the lasers and inspired much research in the field. Today, about 75% of all telecoms lasers sold are VCSELs. Iga is also a mentor, advisor and volunteer, working to strengthen the field through training and international collaboration.

Iga is the author of several books, including 'Fundamentals of Microoptics and Surface Emitting Lasers' and 'VCSEL Industry', and more than 450 papers. He is a Fellow of Optica, IEEE, IEICE, JSAP, and Laser Society. Awards received include the Sakurai Memorial Prize, the Ichimura Award, Asahi Prize, Fujiwara Award, C&C Prize, the IEE Premium Award, the John Tyndall Award, the IEEE Daniel E. Noble Award, the Rank Prize, 2013 Bower Award and Prize in Science from the Franklin Institute, and 2021 IEEE Edison Medal. In 2001, he received the Purple Ribbon Medal from the Japanese Emperor and 2022 Person of Cultural Merit from the Japanese Government.

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Vector Photonics and University of Glasgow collaborating to develop surface-emitting lasers

Critical Technologies Accelerator one of 11 projects in Glasgow City Region to receive UK Innovation Accelerator funding

Vector Photonics Ltd (which was spun off from Scotland's University of Glasgow in 2020, based on research led by professor Richard Hogg) and an engineering unit at the University of Glasgow have signed a collaboration agreement to develop lasers that could have a use in manufacturing and consumer products.

The agreement will see Vector Photonics work closely with the Critical Technologies Accelerator (CTA), which is based within the James Watt Nanofabrication Centre (JWNC), a centre of excellence in semiconductor laser R&D at the university.

The new technology involves surface-emitting laser devices and photonic-crystal surface-emitting laser (PCSEL) systems that emit light from their top surface which can be incorporated in a number of novel applications. The technology can be used in the cutting of a range of materials during the manufacturing process. Also, because PCSEL systems work on lower power, they can also be integrated into next-generation augmented reality and virtual reality headsets.

Under the directorship of professor Tony Kelly, the CTA is one of 11 projects in the Glasgow City Region to receive UK Government funding as part of its Innovation Accelerator levelling-up program. The team is working to identify companies in the West of Scotland, like Vector Photonics, where strategic funding enables growth in the quantum and photonics business cluster. CTA supports companies with design, test and manufacturing, and utilizes the expertise of the JWNC and University of Glasgow academic researchers, enabling multiple industry partners to deliver innovative products into both existing and new emerging markets.

"The surface-emitting laser device processing and modelling collaboration between Vector Photonics and the University of Glasgow is the first to be awarded by the CTA," notes Vector Photonics CEO Neil Martin. "It leverages our pioneering work in this field and will help accelerate surface-emitting laser commercialization, including PCSELs. The resulting lasers, and associated silicon waveguide designs, offer essential, power-saving efficiency benefits in AI and data-center applications," he adds.

"Our software modelling and prototype device test results correlate, giving us every confidence of a successful outcome for this and any further research. The project is particularly pertinent as multi-billion-dollar, electronic software modelling firms Synopsis and Ansys have merged to enhance their photonics competencies," Martin continues.

"The collaboration between the CTA and Vector Photonics is an important step forward for the both of us," says Kelly. "Our design and fabrication capabilities allow us to support Vector's R&D capabilities and speed up the time to commercialize PCSEL technology," he adds. "This is the perfect demonstration of the importance of the Critical Technologies Accelerator and how it aims to help the manufacturing base in Scotland work with the local supply chain in the development of new technologies."

www.vectorphotonics.co.uk

Sivers Semiconductors announces resignation of CEO Anders Storm

Storm to remain in post for up to six-months while new CEO sought

Sivers Semiconductors AB of Kista, Sweden (which supplies lasers for AI photonics and integrated chips & modules for communications and sensor solutions) says that CEO Anders Storm has decided to leave his position for new challenges outside the company. Sivers has initiated a global search for a new CEO. Storm will remain in post until the new CEO has taken office or until the end of his six-month notice period in September.

Anders Storm.

"Anders has made significant contributions to Sivers Semiconductors by developing a global enterprise uniquely positioned in the emerging AI photonics market with its laser solutions and in Satcom space with its mmWave technology," comments chairman of the board Bami Bastani about Storm's leadership of the company over the past decade. "In 2023, Sivers had a record revenue and growth year, acquiring new customers and broadening its product portfolio," he adds.

"I will continue to lead the organization with strong commitment and dedication for the remainder of my term at Sivers," says Storm.

www.sivers-semiconductors.com

Sivers demos laser chip and array technology at OFC

Live demo features Ayar Labs' optical I/O with SuperNova light source powered by Sivers Photonics' DFB laser array

Sivers Semiconductors AB of Kista, Sweden says that its subsidiary Sivers Photonics of Glasgow, Scotland, UK — in collaboration with ecosystem partners — demonstrated its laser chip and array technology at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March).

A live demonstration at the Sivers Photonics booth featured Ayar Labs' optical I/O solution with CW-WDM MSA-compliant SuperNova light source powered by Sivers Photonics' distributed feedback (DFB) laser array. As the complexity and size of artificial intelligence (AI) models increase, traditional interconnect technology creates data bottlenecks that force GPUs and other accelerators to sit idle, limiting compute performance, increasing power consumption and driving up costs. Ayar Labs' optical I/O solution eliminates these bottlenecks, enabling customers to maximize the compute efficiency and performance of their AI infrastructure while lowering costs, latency and power consumption.

A live demonstration at the booth of LioniX International showcased the recently announced three-way partnership between Sivers, LioniX and Chilas B.V. to develop and supply a narrow-linewidth integrated O-band CW tunable 1310nm laser targeting high-growth applications across optical communications and optical sensing sectors. Lionix has introduced the highly sought-after laser to meet the growing demand for O-band solutions for use by OEMs, advanced laboratories, and industrial sensor manufacturers innovating in the communications (passive optical networks, fiber-optic communications), LiDAR, and molecular analysis markets.

"Our InP100 product platform continues to deliver leading-edge chip solutions for high-growth markets," says Sivers Photonics' managing director Andrew McKee. "We are excited to continue our partnerships with leading industry companies to deliver modules into datacoms and sensing markets," he adds.

"At this year's OFC we will see a broad range of Sivers Photonics customers demonstrate products across optical communications and optical sensing sectors, including data-center applications, LiDAR and more, powered by Sivers' advanced lasers," notes Sivers Semiconductors' CEO Anders Storm.

www.ofcconference.org
www.sivers-semiconductors.com

Sivers signs product development agreement for next-generation AI laser arrays

Initial $1.3m prototype contract in 2024, targeting production at several million units per annum beyond 2026

Sivers Semiconductors AB of Kista, Sweden (which supplies ICs and modules for communications and sensor solutions) says that its subsidiary Sivers Photonics of Glasgow, Scotland, UK has signed a product development agreement with an undisclosed company, helping to develop photonic laser arrays enabling next-generation artificial intelligence (AI).

Beginning with an initial contract worth $1.3m for delivering prototypes in 2024, the agreement is expected to grow rapidly during 2025, before moving to volume manufacturing. Upon entering full production, the annual chip volume is expected by the customer to exceed several million units per annum beyond 2026.

Sivers, which supplies customized lasers for high-speed optical solutions, reckons that it is well placed to capitalize on the rising demand for next-generation laser chips that enable solutions to rapidly growing AI computing demands.

As optical solutions become essential for advanced artificial intelligence workloads, our technology will help power the light-speed data transmission this new computing paradigm demands

The firm's optical communication technology already powers applications requiring high-bandwidth and low-latency data transmission. The new collaboration will further expand Sivers' footprint into the rapidly evolving AI hardware sector.

"As optical solutions become essential for advanced AI workloads, our technology will help power the light-speed data transmission this new computing paradigm demands," says Sivers Semiconductors' group CEO Anders Storm. "This is a fantastic opportunity short term and is a mega opportunity for exceptional continued growth from 2026," he adds.

www.sivers-semiconductors.com

Scintil integrates III-V DFB lasers and amplifiers with standard silicon photonics in production at Tower

Key step in supply chain for providing high-performance communications in data-centers, AI and 5G networks

Scintil Photonics of Grenoble, France and Toronto, Canada, a fabless developer of augmented silicon photonic integrated circuits (integrated laser arrays, 800Gb/s transmitters and receivers, tunable transmitters and receivers, as well as optical I/O for near-chip and chip-chip communication), has announced the integration of III-V distributed feedback (DFB) lasers and amplifiers with standard silicon photonics technology in production at foundry Tower Semiconductor, forming a key step in its supply chain.

Scintil's fully integrated circuits comprise what is said to be unique proprietary technology, relying on standard silicon photonics and enabling the monolithic integration of lasers and amplifiers to enable improved performance, speed, reliability and high density at low power consumption for data-center, artificial intelligence (AI) and 5G applications.

Fabricated on Tower's high-volume base PH18M silicon photonics foundry technology, which includes low-loss waveguides, photodetectors and modulators, Scintil's technology monolithically integrates DFB lasers and amplifiers on the backside of wafers. Further testing of Scintil's circuits by customers showed no need for a hermetic package, while demonstrating improved ageing and robustness.

"Thanks to our long-time collaboration, we are well-positioned to deliver laser-augmented silicon photonic ICs that redefine integration, performance and scalability," says president & CEO Sylvie Menezo. "This will position Scintil for high-volume production to meet market demands," she adds. "In addition, our technology exhibits remarkable opportunities to accommodate the integration of more materials, such as quantum dot and lithium niobate materials."

The silicon photonics transceiver market is expected to rise at a compound annual growth rate (CAGR) of 24%, reaching a total addressable market (TAM) of at least $7bn in 2025, according to the market research firm Light-Counting.

"We are excited to support Scintil in this highly integrated solution that makes use of proven production building blocks from Tower," says Edward Preisler, VP & general manager of Tower's RF business unit. "The integration of III-V optical amplifiers/lasers aligns with Tower Semiconductor's commitment to bring to market cutting-edge silicon photonic technologies."

www.scintil-photonics.com

Lumentum appoints general counsel & secretary

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has appointed Jae Kim as senior VP, general counsel & corporate secretary, reporting to president & CEO Alan Lowe. Kim will lead Lumentum's Legal department, including Corporate Affairs, Commercial Transactions, Trade Compliance, and Intellectual Property. He will also be responsible for Facilities, Real Estate and Security.

Kim succeeds Judy Hamel, who is retiring from Lumentum after serving as senior VP, general counsel and secretary since 2015. She previously held the role of senior corporate counsel at Lumentum's parent company JDSU, beginning in 2012.

"He brings a wealth of knowledge and proven track record of success across a broad range of legal areas and technology sectors," comments Lowe. "His significant experience managing all aspects of the global legal function at technology companies such as GlobalLogic and Rambus makes him an excellent fit for our organization, as we continue the next phase of our growth journey."

"I look forward to leveraging my deep legal expertise in navigating the ever-changing technology landscape to help Lumentum achieve its strategic goals," says Kim.

Kim has over 25 years of experience in corporate law, most recently as chief administrative and legal officer at Hitachi Group's GlobalLogic Inc, where he oversaw corporate legal matters, as well as Governance, Enterprise Risk Management and Insurance, Compliance, and Facilities and Employee Services. Previously, he was senior VP, general counsel at Rambus Inc, responsible for legal matters, including Litigation, IP development, M&A, Corporate Governance and Compliance.

Earlier in his career, Kim held senior legal roles at Altran/Aricent and Electronics for Imaging Inc. He was also an attorney at Silicon Valley law firm Wilson Sonsini Goodrich and Rosati, and an attorney for the United States Securities and Exchange Commission (SEC).

Kim earned his bachelor's degree in Economics from Boston University and his law degree from American University, Washington College of Law. He is also a member of the California and New York State Bars.

www.lumentum.com

Ayar Labs showcasing optical interconnect solutions for AI infrastructure at OFC

First CW-WDM MSA-compliant 16-wavelength light source unveiled

Silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Jose, CA, USA presented its latest technology advances and ecosystem partnerships at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (24–28 March).

Specifically, Ayar Labs' optical I/O solution were on display, including a demonstration of the industry's first CW-WDM MSA-compliant 16-wavelength light source, which can drive 256 optical carriers for 16Tbps of bi-directional bandwidth – a level of bandwidth essential for AI workloads.

"The explosive growth of AI models is breaking the back of existing infrastructure – traditional interconnect technology simply can't scale to the cost and throughput multi-modal AI systems will require," says CEO & co-founder Mark Wade. "Our in-package optical I/O solution gives customers the performance and energy efficiency they need as they build out their next-generation AI infrastructure," he adds. "We're pleased to showcase this innovation alongside several ecosystem partners at OFC."

As the complexity and size of AI models increase, traditional interconnect technology creates data bottlenecks that force GPUs and other accelerators to sit idle, limiting compute performance, increasing power consumption, and driving up costs. Ayar Labs says that its optical I/O solution, which includes the SuperNova light source, eliminates these bottlenecks, enabling customers to maximize the compute efficiency and performance of their AI infrastructure while lowering costs, latency and power consumption.

Only one year after introducing the industry's first 4Tbps optical solution, Ayar Labs is now unveiling the second generation of SuperNova, which powers the company's TeraPHY optical I/O chiplet and enables what is claimed to be an unrivaled 16Tbps of bi-directional bandwidth. Compliant with the CW-WDM MSA specification, the 16-wavelength light source offers compact packaging, operates at wide temperature ranges, and can supply light for 256 data channels, making it capable of handling the significantly higher throughput required for the massive growth in AI applications.

Ayar Labs says that it continues to bring together a robust ecosystem to streamline the integration of optical I/O into AI systems and ensure commercial readiness at scale. The firm is working with several industry leaders to demonstrate the value that optical solutions deliver for AI applications. Ayar Labs is highlighting two examples at OFC:

- **Corning Glass Waveguide Module:** Ayar Labs and Corning Inc have teamed up to develop a next-generation AI advance, by coupling Ayar Labs' TeraPHY optical I/O chiplets with Corning's glass waveguide module, bringing advanced optical capabilities to the AI ecosystem. Ericsson is partnering with Ayar Labs and Corning in this AI-driven solution as part of their technology exploration for future mobile systems. This joint innovation is being shown at Ayar Labs' booth. Together, they are highlighting how the technologies create future-ready, AI-enabled innovations.
- **Teramount TeraVERSE Detachable Connector**: Teramount and Ayar Labs are showcasing a concept for the next-generation TeraVERSE detachable connector to meet the infrastructure demands of next-generation AI. The detachable fiber connectivity solution features wideband surface coupling, what is claimed to be industry-leading bandwidth density, and detachability for reliable semiconductor-grade volume manufacturing of co-packaged optics and in-package optical I/O for AI. Wideband surface coupling offers high bandwidth density with negligible loss-related wavelength dependency, resulting in less lasers, power and fibers needed compared with grating coupler solutions.

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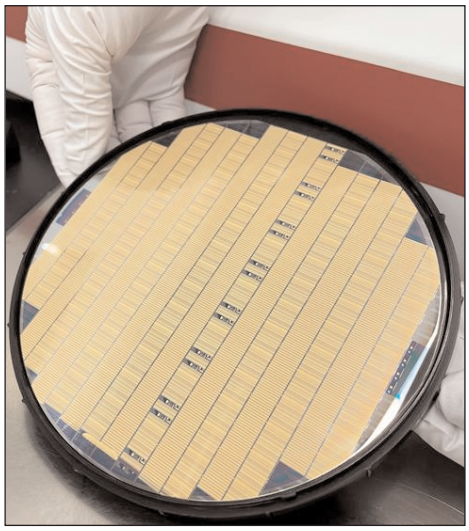
Coherent announces first 6-inch InP scalable wafer fabs

Coherent expands capacity in Texas and Sweden fabs and reduces die cost for InP opto devices

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA has established what it says is the world's first capability for 6-inch indium phosphide (InP) wafer fabrication, in its fabs in Sherman, Texas, and Järfälla, Sweden.

The expansion enables the firm to increase production capacity and lower die costs for InP optoelectronic devices, which are widely used in applications such as coherent optical communications, datacom transceivers, artificial intelligence (AI) interconnects, advanced sensing for consumer electronics and wearables, medical and automotive applications and, in the future, in 6G wireless and satellite communications networks.

The development is "a result of our continuous investment in innovation and technology development, and our years of investment and operating experience in high-volume vertical-cavity surface-emitting laser (VCSEL) array manufacturing for mobile handsets," says Dr Giovanni Barbarossa, chief strategy officer and president, Materials Segment. "Vertical integration at scale is a core strategy that we have been relying upon in several of our markets, and it has enabled our optoelectronics products to win in the marketplace by delivering world-class quality, performance, time-to-market, and cost advantage," he adds.



Coherent indium phosphide wafer.

"Moving to 6-inch wafers will enable us to continue to deliver massive productivity improvements, including manufacturing 4x the number of devices per wafer, achieve a greater than 60% reduction in die cost, and allow us to transition our fabs to higher-capacity, more-efficient automated process tools," says Dr Beck Mason, executive VP, Telecommunications. "This capability will allow us to meet the growing demand for our indium phosphide products in several of our core markets, while enhancing our competitiveness and profitability."

Coherent is in the process of qualifying several existing products on its 6-inch InP platform, including a 200G electro-absorption modulated laser (EML), 200G distributed-feedback laser and Mach–Zehnder modulator (DFB-MZ), 100G EML, high-speed photodetectors, and high-power continuous-wave (CW) lasers for silicon photonics applications. The company expects to transition the bulk of its production from 3-inch InP to 6-inch InP in the next few years to fully leverage the benefits of larger wafer size, higher yield, and improved performance that will be required to provide a sustainable competitive advantage in its communications and sensing markets.

www.Coherent.com

EFFECT Photonics raises $38m in Series D funding

Funding to accelerate development and commercialization of integrated photonic solutions and ramp production

EFFECT Photonics b.v. — a spin off from the Technical University of Eindhoven (TU/e) in The Netherlands — has secured $38m in a Series D funding round, led by Innovation Industries Strategic Partners Fund, backed by Dutch pension funds PMT and PME, along with co-investor Invest-NL Deep Tech Fund and participation from other existing investors.

The latest investment will further accelerate the development and commercialization of the firm's solutions and support ramping production to meet growing customer demands. EFFECT Photonics is focused on advancing its integrated product portfolio, which is said to dramatically drive down the costs, size and power of high-speed fiber-optics communications.

"Investor excitement marks the culmination of a dynamic year of advancements across every facet of our business, reinforcing the market momentum we've established in the rapidly growing coherent transceiver market," says CEO Roberto Marcoccia.

"EFFECT Photonics possesses not only the technology solutions but also the dedicated team, capital and backing to expedite the advancement and market penetration of integrated photonic solutions, crucially meeting the surging need for bandwidth," believes Vincent Kamphorst, investment director at Innovation Industries Strategic Partners Fund.

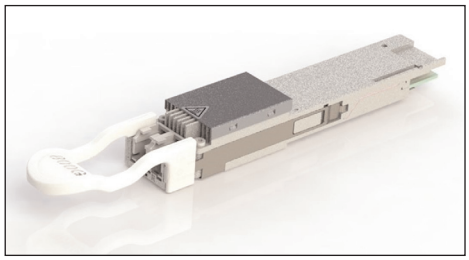
www.effectphotonics.nl

Coherent debuts 800Gbps QSFP-DD form-factor transceiver module for IP-over-DWDM

Operating modes enable reach of up to 1000km at 800Gbps and 2000km at 400Gbps

At the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March), materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA demonstrated its 800Gbps coherent transceiver module in QSFP-DD form factor, operated in 800G ZR mode transmitting over 9000ps/nm of dispersion (equivalent to about 450km of fiber).

Following the success of 400G ZR/ZR+ digital coherent optics (DCO), customers are looking for an 800G version of DCO to upgrade their transmission speed to the next level. Hyperscale data centers are driving the demand of 400G/800G DCO for data-center interconnect (DCI) applications, while service providers are starting to adapt the concept of IP-over-DWDM using DCO modules for metro and regional networks. QSFP-DD and OSFP are the most popular and compact form factors used in DCI applications.



Coherent's 800G QSFP-DD transceiver.

The new 800G transceiver uses Coherent's 140Gbaud IC-TROSA optical subassembly, which features a high-efficiency indium phosphide modulator and receiver combined with a proprietary embedded wavelength-tunable laser. The Coherent 800G QSFP-DD transceiver has several operating modes that enable it to deliver up to 1000km of reach at 800Gbps and up to 2000km at 400Gbps in well-designed networks.

"Building on the success of our 140Gbaud IC-TROSA, demonstrated at ECOC 2023 in Glasgow, Scotland, Coherent is developing compact 800G coherent modules in both QSFP-DD and OSFP form factors," says Dr Beck Mason, executive VP, Telecommunications. "These next-generation solutions not only enable higher capacity per port and lower network cost but can also significantly extend the transmission distance for 400G applications when compared to current-generation solutions," he adds.

Alpha samples of the module are currently shipping to customers. Beta versions are planned for third-quarter 2024.

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Coherent awards Tower as Outstanding Innovation and Technology Supplier

Tower's silicon photonics to be used across multiple data rates for high-speed optical transceivers

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA has recognized specialty analog foundry Tower Semiconductor Ltd of Migdal Haemek, Israel as an Outstanding Innovation and Technology Supplier for its silicon photonics based optical transceiver products. The award recognizes Tower's "unwavering long-term commitment to providing the most advanced technology solutions, enabling the development of Coherent's market-leading multiple-data-rate nodes for high-speed optical transceivers based on Tower's PH18 silicon photonics process technology".

According to Yole Group, the silicon photonics market is growing at a compound annual growth rate (CAGR) of 44% during 2022-2028, supporting growth of artificial intelligence (AI), data-center and network infrastructure.

"We are pleased to work with Tower to integrate silicon photonics into our optical transceivers for AI, datacom, and telecom markets," says Dr Yajun Wang, senior VP of Networking Technology at Coherent. "Over the years, Tower has demonstrated an innovative, customer-centric approach," he adds. "Combined with our world-class vertical-cavity surface-emitting laser (VCSEL) and indium phosphide (InP)-based lasers such as electro-absorption modulated lasers (EMLs), silicon photonics-based components will enable us to provide a full range of communications solutions to our customers."

Tower's high-volume silicon photonics technology offers area-optimized solutions with integrated optical detectors, waveguides and modulators on a single die, enabling a wide range of applications replacing the assembly of discrete components in optical modules.

www.Coherent.com

Infinera launches 1.6Tb/s optics to reduce power per bit by up to 75% for AI-driven intra-data-center connectivity

ICE-D monolithic InP PIC technology being showcased at OFC 2024

Infinera Corp of San Jose, CA, USA — a vertically integrated manufacturer of digital optical network systems — has announced ICE-D, a new line of high-speed intra-data-center optics based on monolithic indium phosphide (InP) photonic integrated circuit (PIC) technology. ICE-D optics are designed to dramatically lower cost and power per bit while providing intra-data-center connectivity at speeds of 1.6 terabits per second (Tb/s) and greater. The technology enables data-center operators to cost-effectively keep pace with relentless growth in bandwidth, says Infinera.

Driven by artificial intelligence (AI) workloads and switched network applications, market demand for high-speed (800G+), intermediate-reach (100+ meters) intra-data-center interconnect technology is projected to grow nearly tenfold over the next four years — from about 300,000 units in 2023 to more than 2.5 million units by 2027, with a total market opportunity of greater than $2.2bn, according to industry analysts at Cignal AI.

"Intra-data-center bandwidth is growing at an unprecedented rate as artificial intelligence applications transform connectivity demands between processing devices," says Scott Wilkinson, lead analyst, Networking Components at Cignal AI. "This global trend will require innovative high-speed, low-latency and power-efficient solutions to enable data-center operators to economically meet the challenge of scaling intra-data-center connectivity — today and well into the future."

Leveraging the unique capabilities of its US-based optical semiconductor fab, Infinera's intra-data-center optical connectivity technology enables highly integrated solutions that combine multiple optical functions onto a single monolithic chip, resulting in what is claimed to be industry-leading density, low latency, and power efficiency. ICE-D test chips are currently available and have demonstrated a reduction in power per bit by as much as 75% while simultaneously increasing connectivity speed.

"Infinera is excited to apply our 20+ years of pioneering innovation in optical connectivity solutions to solve the challenge of economically scaling intra-data-center connectivity to support the deluge of bandwidth stemming from AI applications," says Ron Johnson, senior VP & general manager of Optical Systems and Global Engineering at Infinera. "Our unique monolithic InP PIC technology puts us in an ideal position to develop innovative technologies to provide cost- and power-efficient, high-capacity intra-data-center connectivity solutions," he adds.

Infinera's flexible ICE-D intra-data-center optics are designed to support integration into a variety of different intra- and campus data-center optical solutions. These include digital signal processor (DSP)-based re-timed optics, linear-drive pluggable optics (LPO), and co-packaged optics (CPO) for both serial and parallel fiber applications and distances ranging from 100m up to 10km.

Infinera showcased its ICE-D intra-data-center optics and comprehensive portfolio of open optical networking solutions at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (26–28 March).

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OIF hosts multi-vendor interoperability demos & panels

47 member companies demonstrate innovations in coherent optics, electrical and energy-efficient interfaces and management specifications

The Optical Internetworking Forum (OIF) says that its record-breaking, multi-vendor interoperability demonstrations at the Optical Fiber Communication Conference & Exposition (OFC 2024) in San Diego, CA, USA (24–28 March) spotlit interoperable solutions in 800ZR, 400ZR and OpenZR+ optics; Energy Efficient Interfaces (EEI) & Co-Packaging; 112G and 224G Common Electrical I/O (CEI); and Common Management Interface Specification (CMIS) implementations.

This year's interoperability demonstration, the largest ever, not only underscored the progress of its member companies in tackling the industry's most pressing demands but will also unveil multiple industry-firsts, says OIF.

"The interoperable solutions being demonstrated in the OIF booth are critical to addressing the escalating needs of next-generation data-center networking, artificial intelligence/machine learning (AI/ML) and disaggregation applications," says OIF president Nathan Tracy of TE Connectivity. "We've seen a 38% increase in demo participants compared to last year and the addition of nine new participating companies, which emphasizes the remarkable growth and impact of OIF's work," he adds.

Interoperability demos – 800ZR, 400ZR and OpenZR+ optics, EEI & Co-Packaging, 112G and 224G CEI and CMIS

800ZR, 400ZR and OpenZR+ optics interoperability demos

The pluggable coherent optics demonstration is showcasing progress in the latest advancements in 800ZR, 400ZR and ZR+ optics interoperability, offering a comprehensive view of their capabilities and applications. Highlights include the first public 800ZR multi-vendor interop; high transmit power, OpenZR+ over a 1000km, multi-span network; OpenROADM/ITU-T over that same network; and foundational 400ZR collocated on the single-span network with 800ZR.

EEI & Co-Packaging interoperability demos

The EEI and Co-Packaging demo features pioneering methods for integrating multiple chips within a single package, driving enhanced performance and power efficiency in electronic devices. OIF members are displaying a conceptual demo of AI backend compute utilizing next-generation energy-efficient interfaces as well as live demos showcasing the latest advancements for external laser sources. This demo highlights innovative approaches that are revolutionizing the performance and power efficiency of electronic device design.

112G and 224G CEI interoperability demos

OIF is expanding its industry-first demonstration of 224G CEI multi-vendor interoperability, the electrical interface for future optical solutions. Additionally, OIF's demonstration of a 112G CEI Linear ecosystem has broadened, driven by the interoperability of multi-vendor SerDes links with multi-vendor LPOs, supported by test & measurement validation at each stage of the link.

CMIS interoperability demos

The CMIS demo will feature an array of CMIS-managed modules integrated into routers, switches and test gear from various vendors, providing a first-hand glimpse into CMIS' effective management of modules in real-world applications. Its focus is on the path to plug & play, illustrating how modules communicate their capabilities, enabling hosts to manage them seamlessly without requiring specific code for each module.

Live and Interactive Demonstrations: 47 member company participants

The demonstrations highlighted the collaborative efforts of system vendors, component vendors and test equipment vendors, emphasizing their contributions to advancing technology adoption in both present and future networks.

Participating member companies are Adtran; Alphawave Semi; Amphenol; Anritsu; AOI; Astera Labs; Ayar Labs; Broadcom Inc; Cadence Design Systems Inc; Casela Technologies; CICT/Accelink; Ciena; Cisco Systems; Coherent Corp; Corning; Eoptolink; EXFO; HG Genuine; Hisense; Infinera; Juniper Networks; Keysight Technologies; Lessengers; Linktel Technologies; Lumentum; Luxshare-Tech; MACOM Technology Solutions; Marvell; Molex; MultiLane; NEC; Nokia; Nubis Communications Inc; O-Net Technologies; Optomind; Precision Optical Technologies Inc; Quantifi Photonics; Samtec; Semtech; Senko Advanced Components; Sumitomo Electric Industries; Synopsys; TE Connectivity; US Conec; Viavi Solutions; Wilder Technologies and Wistron.

In addition to the in-booth demonstrations, OIF experts are leading two panel discussions on the exhibit floor, providing insights into the industry's latest advancements:

OIF panels

'Coherent Optics Unleashed: From 400ZR Success to 800ZR/LR Advancements and 1600ZR Kick-off – An OIF Update'.
Moderator: Karl Gass, OIF Physical & Link Layer Interoperability (PLL) Working Group (WG) optical vice chair);
Panelists: Sebastien Gareau (Ciena), Jeff Rahn (Meta), Gert Sarlet (Coherent), Tom Williams (Cisco).

'Energy Efficient Interfaces – Reining in Power Consumption Trends for Next-Generation Optical Networking'.
Moderator: Jeff Hutchins, OIF PLL WG EEI vice chair and board member (Ranovus);
Panelists: Craig Thompson (NVIDIA), OIF PLL WG electrical vice chair Yi Tang (Cisco), OIF president Nathan Tracy (TE Connectivity).

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Green photonic-crystal surface-emitting lasers

Using 2D lattice structures of different refractive index materials to control optical behavior allows greater single-mode, low-divergent beam quality at higher power.

Nichia Corp and Kyoto University in Japan reported on extending the capability of photonic-crystal surface-emitting lasers (PCSELs) into the green band of the visible spectrum [Natsuo Taguchi et al, Appl. Phys. Express, v17, p012002, 2024].

The researchers describe green PCSEL developments so far as being at a "primitive level" compared with blue PCSELs, or green edge-emitting laser diodes and vertical-cavity surface-emitting laser diodes. However, the team has hopes that such devices could be attractive for materials processing, high-brightness illumination, and display applications.

Photonic crystals (PCs) use two-dimensional lattice structures of different refractive index materials to control optical behavior. One particular hope for PCSELs is to use this control to enable the easier achievement of single-mode behavior at higher output power, improving beam quality.

The researchers comment: "By utilizing a singularity (e.g. Γ) point of the PC, the PCSELs realize both vertical and lateral single-mode oscillation and low-divergence radiation beams with angles of less than 0.2°." PCSELs could also avoid catastrophic optical damage (COD) from intense light density by spreading the optical power over a larger resonator volume.

The PC was formed in the p-GaN contact layer of the PCSEL epitaxial material, using a silicon dioxide (SiO_2) filling material rather than the more usual air of previous studies (Figure 1). By creating the PC after the active layer, the lattice constant (a) of the PC could be adjusted relative to the measured gain wavelength of the active layer of the epitaxial structure.

Filling the lattice with SiO_2 avoids current leakage via conductive particles in the sidewalls of the lattice holes, making for more stable current control, and reduced

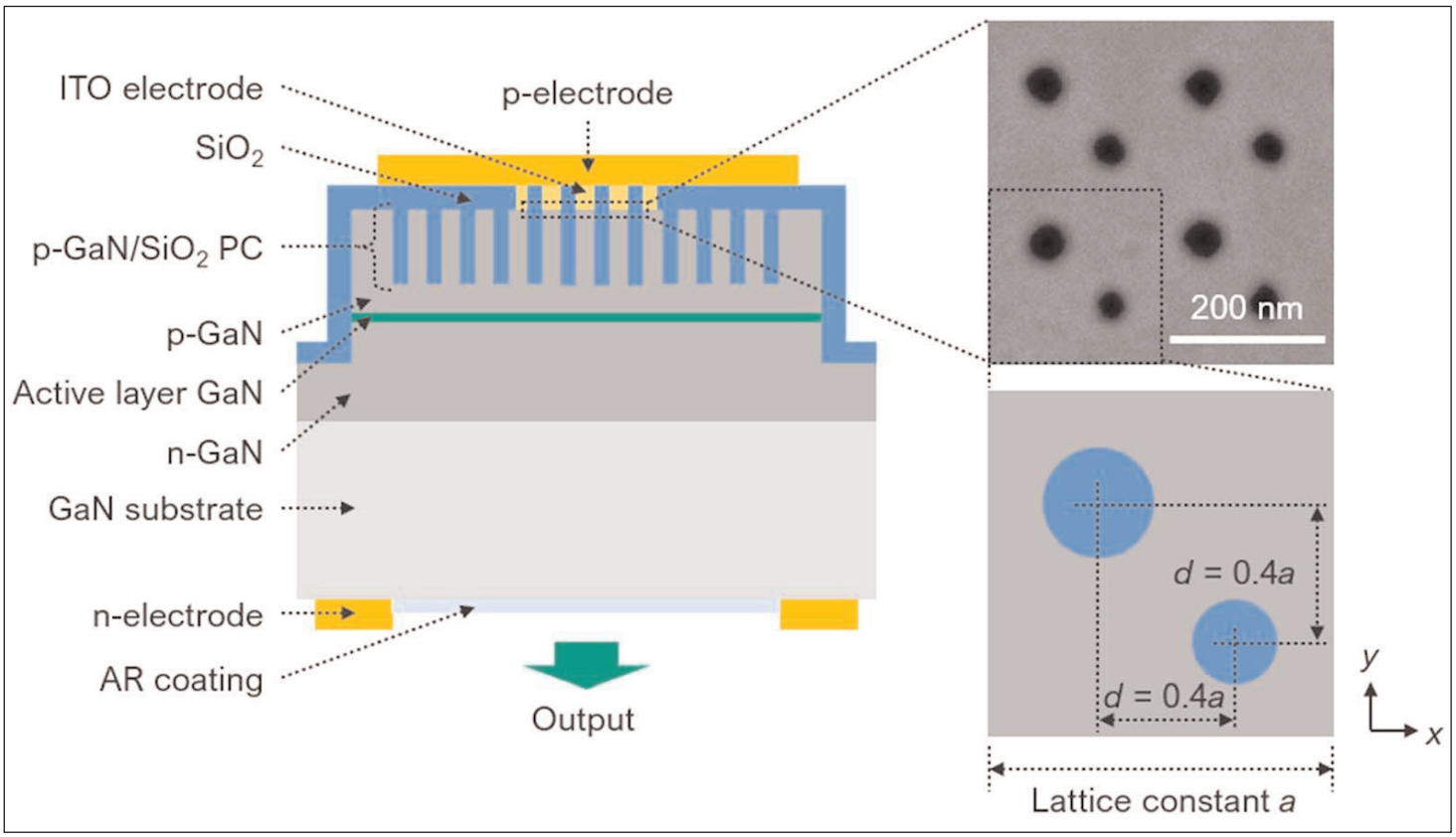

Figure 1. Structure of green-wavelength GaN-based PCSEL: (a) cross-section of diced chip (b) (top) scanning-electron-microscope (SEM) image of PC at p-GaN surface with ITO electrode removed; (bottom) double-lattice PC design scheme.

parasitic leakage. The SiO_2 also increases the effective refractive index of the PC layer, shifting the guided mode towards the PC and enhancing the coupling with the optical field.

A draw-back of using SiO_2 is reduced refractive index contrast with GaN, making the control of the optical waves inside the PC plane more difficult. This was compensated for by increasing the diameter of the holes, and using a double-lattice structure with a unit cell consisting of two holes offset by 0.4a in both the
x and y directions. The researchers say that this was "to obtain sufficient in-plane confinement and coupling even in the case of low refractive index contrast between p-GaN and SiO_2 filling the PC."

The PC formation process consisted of depositing indium tin oxide (ITO) transparent conductor on the III–nitride epitaxial material, followed by drilling the PC lattice holes with inductively coupled plasma reactive-ion etch (ICP-RIE) and filling with SiO_2 via plasma chemical vapor deposition (CVD). The ITO material was removed from the structure except for a 300μm-diameter circular central region to serve as conduit between the p-electrode and p-GaN.

The researchers report that the SiO_2 fill cylinders in the PC contained a small air void in their centers, according to SEM imaging. The team comments: "The shape of the void was uniform within the PC plane, and the presence of the void thus was considered not to significantly impact the behavior of the PCSEL."

The device was completed by mesa etching down to the n-GaN layer, depositing a SiO_2 covering the mesa except for the central ITO region; depositing the p- and n-electrodes to the top and bottom surfaces, respectively; and applying an anti-reflective (AR) coating to the bottom circular laser output region. The devices were diced and flipped onto sub-mounts for performance measurements.

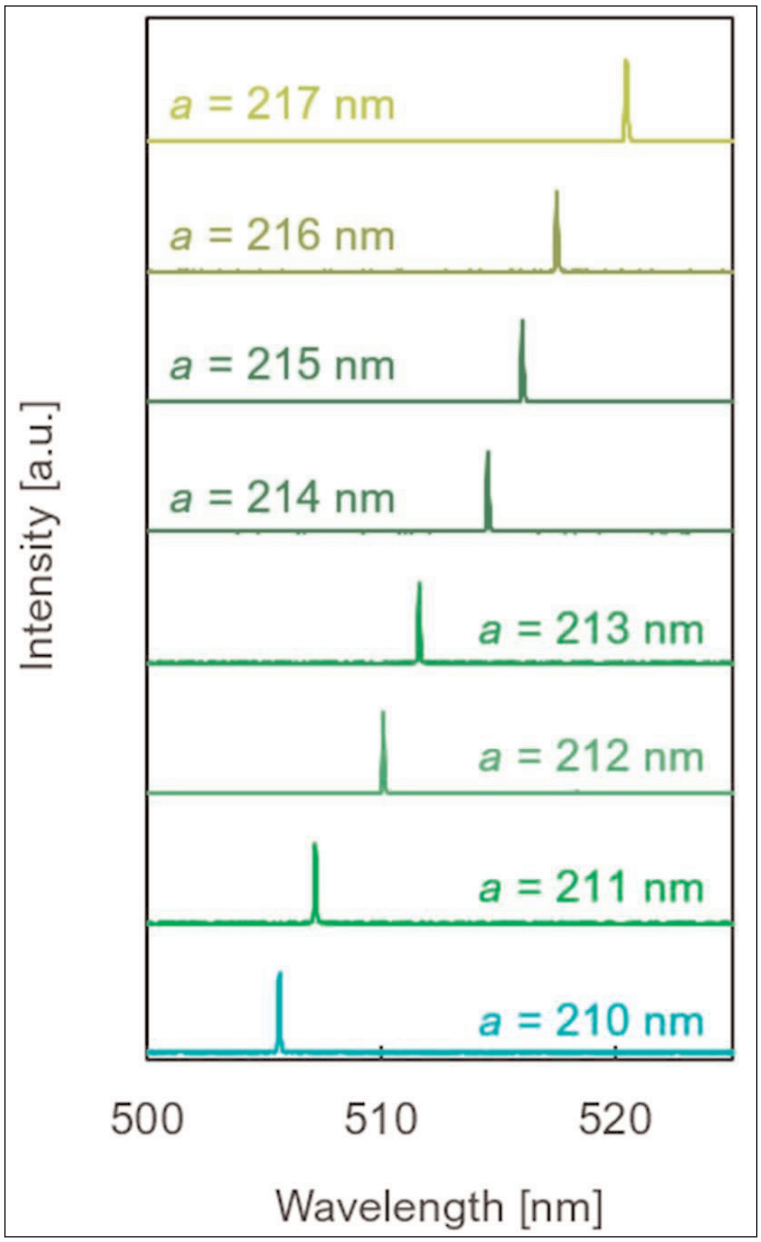

Figure 2. Lasing spectra of devices with different PC lattice constants.

A device with a PC lattice constant a of 210nm achieved around 50mW maximum output with a 5A injection current of 500ns pulses at 1kHz repetition rate. The wall-plug efficiency (WPE) for this was 0.1%. The laser threshold was at 3.89kA/cm^2 current density. The slope efficiency was 0.02W/A. The output laser light was linearly polarized with a 0.8 ratio. The divergence angle of the circular far-field pattern (FFP) was of order 0.2°. The laser wavelength was 505.7nm.

A certain amount of tuning of the laser wavelength could be achieved by varying the PC lattice parameter, a, between 210 and 217nm (Figure 1). The maximum emission wavelength, for the 217nm device, was 520.5nm. Since the gain peak of the active layer was around 505nm, lasing was more difficult to achieve at the longer wavelengths, resulting in increased thresholds with the higher PC lattice constants.

The researchers also report that some of the higher PC lattice constant devices exhibited flat-band lasing with line-shaped FFPs. The team attributed the flat-band lasing to fluctuations in the PC structure and relatively low coupling coefficients with the PC.

The researchers comment: "The WPE can be improved by optimizing both the PC and the epitaxial crystal layers. For the PC, stronger in-plane coupling and vertical radiation are expected to be obtained by optimizing the geometry. The epitaxial crystal layers should be designed to maximize the intensity of the fundamental guided mode in the PC region, while also considering the non-luminescent loss of injected carriers."

A further desideratum for future research would be to achieve continuous-wave operation. ■

https://doi.org/10.35848/1882-0786/ad126f

Author: Mike Cooke

Probing InGaN RGB micro-LEDs on silicon

Researchers seek to guide future improvements.

Xiamen University and LatticePower Co Ltd in China report on the characteristics of micron-scale light-emitting diodes (LEDs) fabricated from aluminium indium gallium nitride (AlInGaN) structures grown on silicon (Si) with a view to their use in displays, particular for virtual-reality and augmented-reality (VR/AR) systems [Xi Zheng et al, Appl. Phys. Lett., v124, p051103, 2024].

The team comments: "Few investigations have been carried out on the chromatic characteristics of the InGaN-based red, green and blue (RGB) micro-LEDs system grown on silicon substrates, which can contribute to a better understanding of the designs of the driver, back-plane integration, and heat dissipation."

The researchers used metal-organic chemical vapor deposition (MOCVD) on 4-inch (111) silicon to prepare the materials for the respective micro-LEDs (Figure 1).

LEDs with 8μm and 20μm diameters were fabricated: The first step was to deposit silver/titanium/tungsten (Ag/Ti/W) on the p-GaN contact layer, using electron-beam evaporation. The material was flipped and bonded onto a (100) Si substrate, and the (111) growth substrate was removed. The n-contact electrode consisted of indium tin oxide (ITO). Silicon dioxide (SiO_2) was used for passivation.

While the green and blue multiple quantum well (MQW) active regions used 8-period structures with InGaN wells and GaN barriers, the red device had only three wells of InGaN separated by AlN/AlGaN/GaN hybrid barrier layers. The aim was to reduce lattice mismatch, relieving the strain of the high-indium-content InGaN epitaxial layers.

The longer-wavelength red-emitting devices suffered from reduced performance. Current-voltage measurements showed an ideality factor (n, 'ideal'=1) increasing with wavelength: 1.79, 2.60 and 3.08 for the blue, green and red micro-LEDs, respectively. The team comments: "When the factor n is larger than 2, the inferior carrier injection efficiency may originate from the severe defect-assisted non-ideal carrier transport,

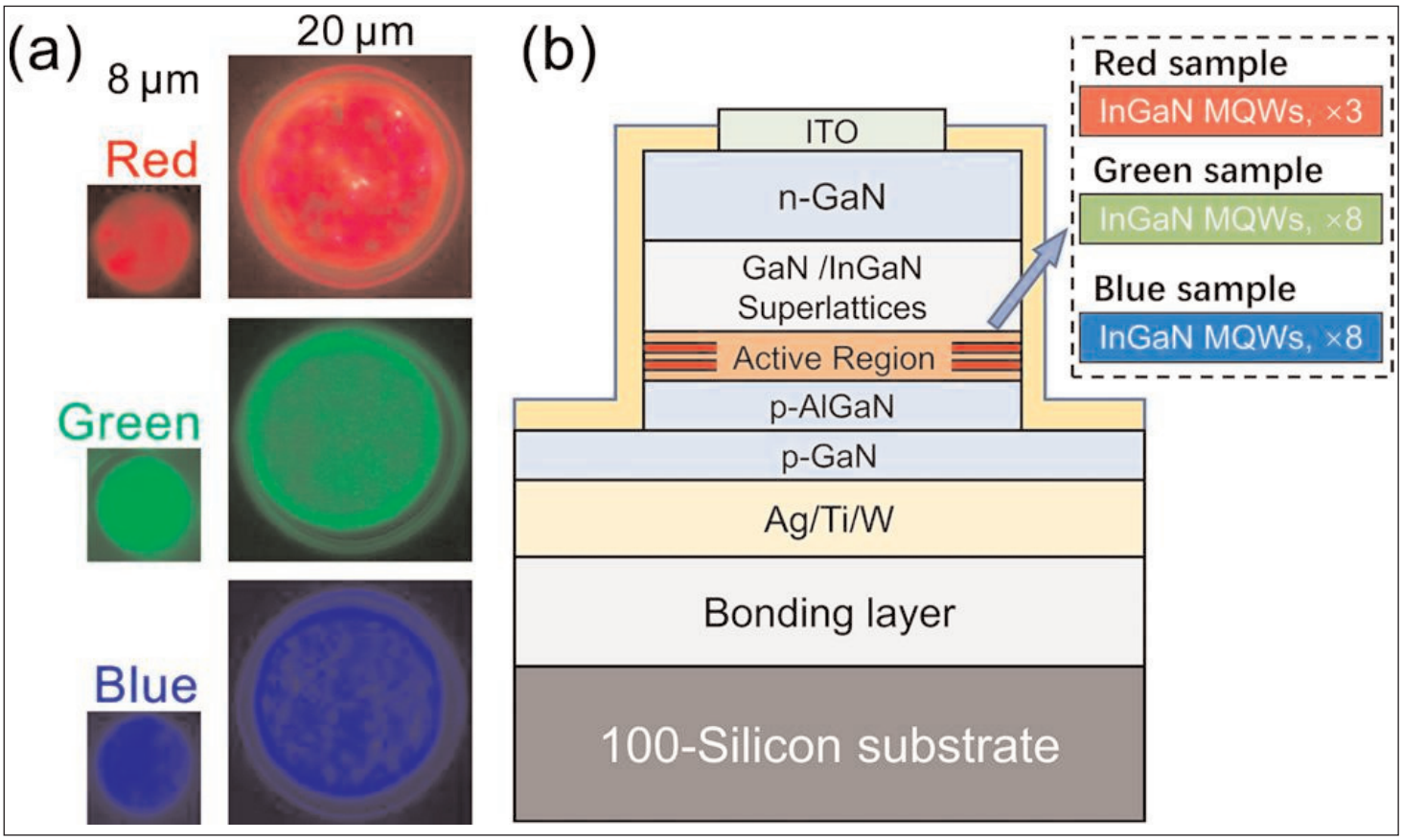

Figure 1. (a) Electroluminescence emission images (at 1A/cm^2) of red, green and blue micro-LEDs with diameters of 8μm and 20μm, respectively. (b) Schematic cross-section for red/green/blue micro-LEDs.

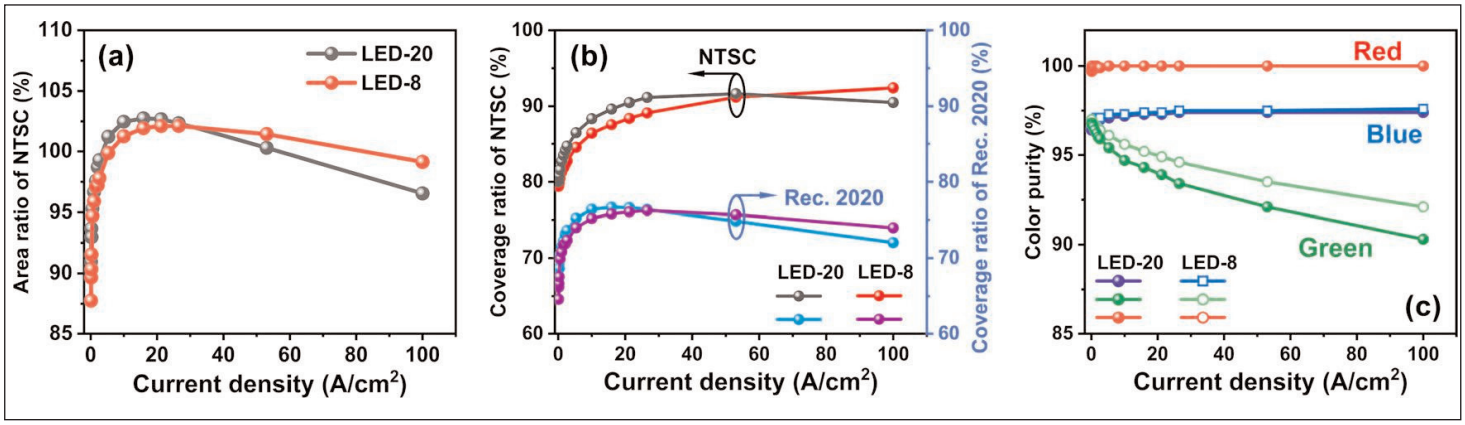

Figure 2. (a) Current density dependence of area ratio of NTSC for mixed RGB micro-LED systems. (b) Coverage ratio of NTSC and Rec. 2020 under different current densities. (c) Color purity versus current density for separate RGB micro-LEDs with dimensions of 8μm and 20μm.

including trap-assisted tunneling, carrier leakage etc, the larger n of the red micro-LEDs can be attributed to the non-radiative centers induced by defects."

Study of the light-emission of the 8μm- (Table b) and 20μm-diameter (Table c) LEDs showed reduced external quantum efficiency (EQE_{max}) maximum performance for the longer wavelengths, and smaller diameter. Also, the full-width at half-maximum (FWHM) of the emission spectrum was broader for the green and red devices.

The reduced performance of the smaller devices is attributed to the increased importance of sidewall damage leading to greater non-radiative recombination of electron and hole charge carriers.

Table 1. Micro-LED performance, 8μm diameter.

Color	EQE_{max}	Wavelength	FWHM	EQE droop @100A/cm²
Blue	6.1% (@16A/cm²)	467nm	22nm	9.6%
Green	3.8% (10A/cm²)	545nm	35nm	26.6%
Red	0.23% (0.265A/cm²)	689nm	70nm	55.3%

Table 2. Micro-LED performance, 20μm diameter.

Color	EQE_{max}	Centroid wavelength	FWHM	EQE droop @100A/cm²
Blue	8.2% (2.65A/cm²)	467nm	23nm	18.6%
Green	5.1% (5.3A/cm²)	544nm	36nm	36.2%
Red	0.62% (0.1A/cm²)	688nm	72nm	59.5%

Also, stronger quantum-confined Stark effect (QCSE) and higher defect densities in the higher-indium-content MQWs needed for longer wavelengths results in a more severe droop in EQE at higher current injection from the maximum value. QCSE refers to the presence of strong electric fields in strained semiconductor structures from the different charge polarizations of the chemical bonds in the various layers.

The reduced droop effect in the smaller devices was attributed to "better current crowding and heat dissipation in a smaller mesa".

The devices also suffered from a blue-shift at higher current injection due to screening of built-in QCSE electric field and band-filling effects effectively widening the bandgap.

The researchers calculated the color performance of the devices in combination and separately (Figure 2). The researchers used comparison standards from the ITU-Recommendation BT.2020 (Rec. 2020) and National Television Systems Committee (NTSC). Area ratios compare the color triangle areas on the chromaticity diagram of a notional display using the RGB LEDs relative to the standard (hence it can exceed 100%). The coverage ratio only includes the display triangle area inside the standard relative to the standard (and hence must be less than 100%).

In terms of color purity of the RGB devices, the green LED was seen to suffer from a severe decline as the current injection increased. The team comments: "Since the color gamut of the RGB mixed system is more sensitive to the chromaticity coordinate of the green self-emitting unit, the lower color purity of the 20μm green micro-LED can result in the decrease in the area ratio and the coverage ratio of the standard color gamut of the RGB mixed micro-LED systems."

The researchers also studied the thermal stability of the devices between 290K and 350K. The shift for the 20μm LEDs was larger than for 8μm. The researchers say that this suggests that "the micro-LEDs with a shrunken mesa dimension can exhibit superior chromatic stability with temperature, which can be explained by the better heat dissipation and higher color purity of the 8μm micro-LEDs." ■

https://doi.org/10.1063/5.0192430

Author: Mike Cooke

UCSB reports first N-polar InAlGaN HEMT

Researchers demonstrate devices with very low 179Ω/square sheet resistance channel.

University of California Santa Barbara (UCSB) in the USA has reported the first N-polar indium aluminium gallium nitride (InAlGaN) quaternary back-barrier high-electron-mobility transistor (HEMT) [Robert Hamwey et al, IEEE Electron Device Letters, vol 45, issue 3 (March 2024), p328–331].

The advantages of growing III-N heterostructures for HEMTs with AlGaN ternary barriers in the N-polar direction have included record high output power, power density, and power-added efficiency at 94GHz, compared with devices based on the more usual Ga-polar structure. The use of quaternary InAlGaN enables high Al content without increasing the strain due to lattice mismatching. AlGaN suffers from an upper limit in Al concentration before cracking occurs.

The epitaxial structure for the HEMT was grown by metal-organic chemical vapor deposition (MOCVD) on 4°-miscut sapphire (Al_2O_3) substrate (Figure 1). Such substrates are used to avoid hexagonal hillock defect formation, which commonly occur in N-polar growth. Iron (Fe) doping created a semi-insulating GaN buffer layer, before an unintentionally doped (UID) layer. The channel of the device consisted of a two-dimensional electron gas (2DEG), which formed in the GaN channel layer near the AlN spacer and InAlGaN back-barrier layers. The back barrier was grown at 910°C. The material was capped with 5nm silicon nitride (SiN_x) for protection before HEMT fabrication processing.

The UCSB team points out three advantages arising from the N-polar orientation: "(i) improved carrier confinement of the 2DEG with a wide-bandgap back barrier, (ii) direct access from the source and drain contacts to the GaN channel, rather than through a wide-bandgap barrier, which leads to a decreased 2DEG contact resistance, and (iii) the ability to achieve a shorter gate-to-2DEG distance by reducing the channel layer thickness rather than the barrier layer thickness."

Materials analysis after growth suggested that the first few nanometers of InAlGaN had graded Ga content, while the main body was $In_{0.12}Al_{0.73}Ga_{0.15}N$. The lattice mismatch was estimated to be 0.44%.

Room-temperature Van der Pauw Hall measurements gave a 2DEG sheet carrier density (ns) of $2.85 \times 10^{13}/cm^2$, a mobility of $1048 cm^2/V\text{-}s$, and an isotropic sheet resistance of 209Ω/square. The team comments: "We believe that the large 2DEG density is a result of the relatively thick channel and barrier layers,

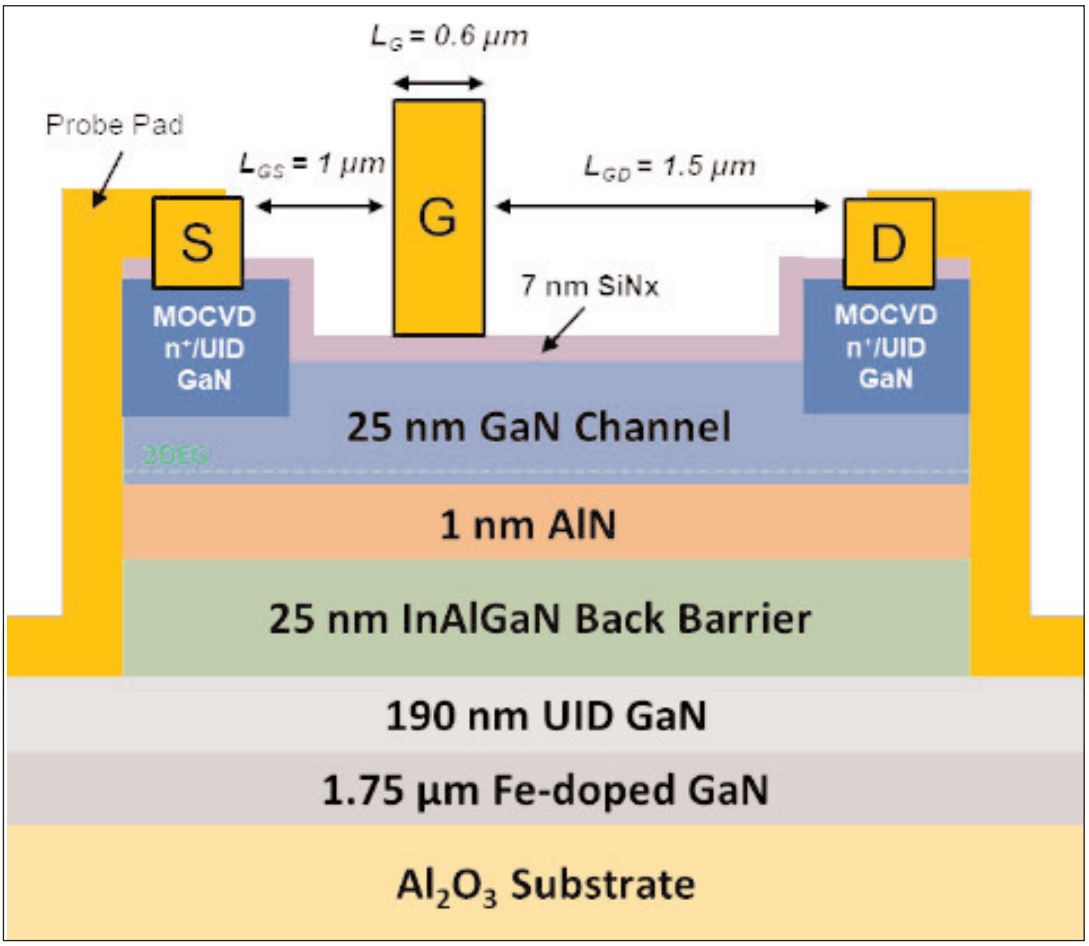

Figure 1. Planar HEMT device structure.

as well as the ionization of hole traps at the net negatively polarized barrier/buffer interface."

Patterning for the HEMT fabrication used an i-line stepper. The source and drain contact regions consisted of MOCVD-regrown n^+-doped/UID GaN with nickel/gold metal electrodes. The gate metal–insulator–semiconductor (MIS) gate stack used MOCVD SiN_x as the dielectric insulation and nickel/gold as the metal. Nickel/gold was also used for probe pads.

The source–drain direction was oriented parallel to the <11$\bar{2}$0> direction of the crystal structure. The substrate miscut was such that steps formed along this direction. The researchers comment: "This choice was made considering previous work which showed superior conductivity for devices with electron transport aligned parallel to the surface steps." In fact, measurements along the step direction gave a sheet resistance of 179Ω/square, lower than the isotropic value. The calculated mobility in this direction was estimated to be 1225cm^2/V-s.

In DC measurements the HEMTs demonstrated a peak drain current (I_D) of 1.92A/mm and an on-resistance of 0.62Ω-mm at 0V gate potential. The threshold voltage (V_{TH}) was –10.6V (normally-on, depletion-mode). The large value of $|V_{TH}|$ is attributed to the large ns, requiring a large gate potential to deplete the carrier concentration and switch off current flow between the source and drain. Other reports of AlGaN/GaN N-polar HEMTs typically have $|V_{TH}|$<10V. For many applications a 'normally-off' (enhancement-mode) behavior with positive V_{TH} is preferred.

The peak transconductance (g_m) was 212mS/mm. The researchers report that their device demonstrates 31% and 66% increases over N-polar InAlN/GaN HEMTs of similar dimensions in peak I_D and peak g_m, respectively.

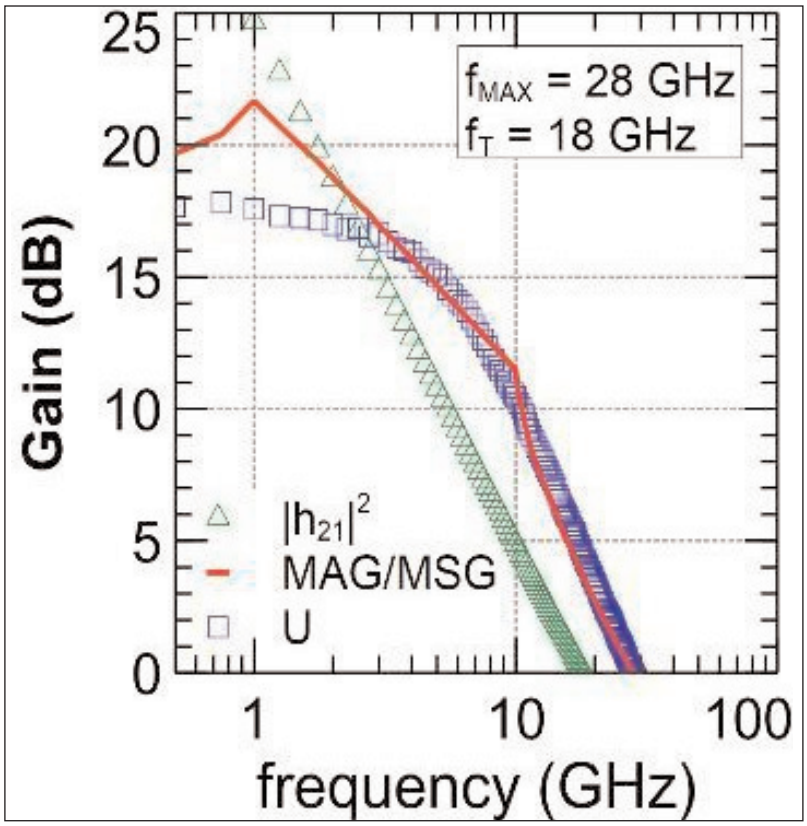

Figure 2. Intrinsic HEMT small-signal response at peak f_{max} bias (–9V gate, 5V drain).

The frequency performance was measured in the range 0.5–67GHz (Figure 2). The researchers extracted current-gain cut-off (f_T) and power-gain cut-off (f_{max}) frequencies of 18GHz and 28GHz, respectively. ■

https://ieeexplore.ieee.org/document/10373188

Author: Mike Cooke

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Carbon removal for boosting GaN electron mobility

Researchers report record maximum and room-temperature values of electron mobility in gallium nitride and explore the impact of carbon contamination on mobility.

Researchers based in Japan have reported record high electron mobility performance for gallium nitride (GaN) by reducing carbon contamination to avoid "mobility collapse" from that source [Shota Kaneki et al, Appl. Phys. Lett., v124, p012105, 2024].

The team from Sumitomo Chemical Co Ltd, Kyoto University, Nagoya University and the Institute of Materials and Systems for Sustainability (IMaSS) reports that a sample with a carbon concentration ([C]) as low as 1:4x10^{14}/cm^3 exhibited a record high room-temperature mobility (μ_{RT}) of 1480cm^2/(V-s) and a further record for the maximum μ_{MAX} of 14,300cm^2/(V-s) at 62K. The researchers point out that their μ_{MAX} value is almost double the previous record.

The group used its quartz-free hydride vapor phase epitaxy (QF-HVPE) growth method to enable tight control of silicon (Si), C, and oxygen contamination. Quartz is crystalline silicon dioxide. The material is often used in equipment subjected to high-temperature processes.

Table 1. The Si and C impurity concentrations, along with the results from Hall measurements for the three kinds of sample.

Sample	[Si]	[C]	n	μ_{MAX}	μ_{RT}
1	4.2x10^{15}/cm^3	2.0x10^{15}/cm^3	1.1x10^{15}/cm^3	5810cm^2/V-s	1090cm^2/V-s
2	4.3x10^{15}/cm^3	1.1x10^{15}/cm^3	2.4x10^{15}/cm^3	7890cm^2/V-s	1220cm^2/V-s
3	1.5x10^{15}/cm^3	1.4x10^{14}/cm^3	1.1x10^{15}/cm^3	14,300cm^2/V-s	1480cm^2/V-s

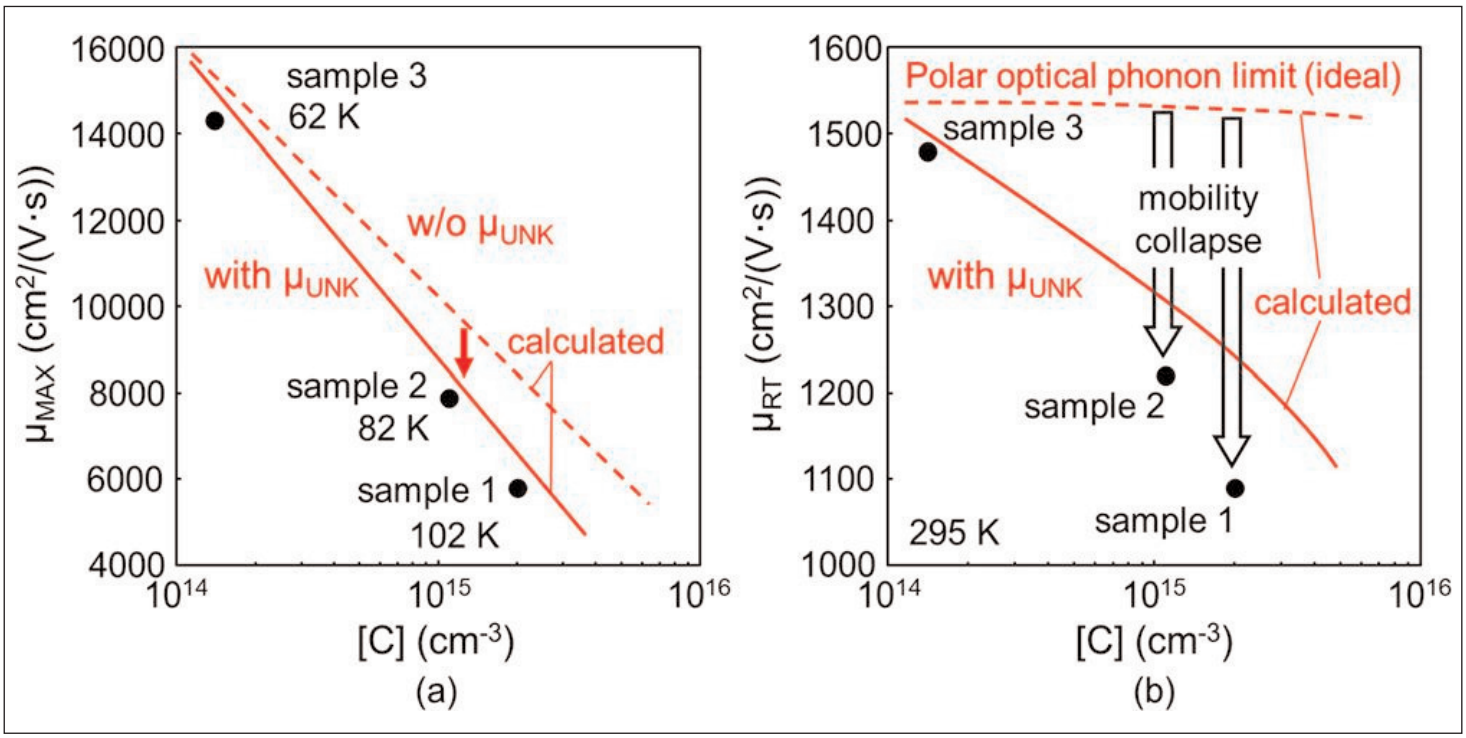

Figure 1. [C] dependence of (a) μ_{MAX} and (b) μ_{RT}. Observed data plotted as closed circles. Red broken curves represent conventional theory, whereas red solid curves represent values calculated under the assumption of additional mobility component, μ_{UNK}.

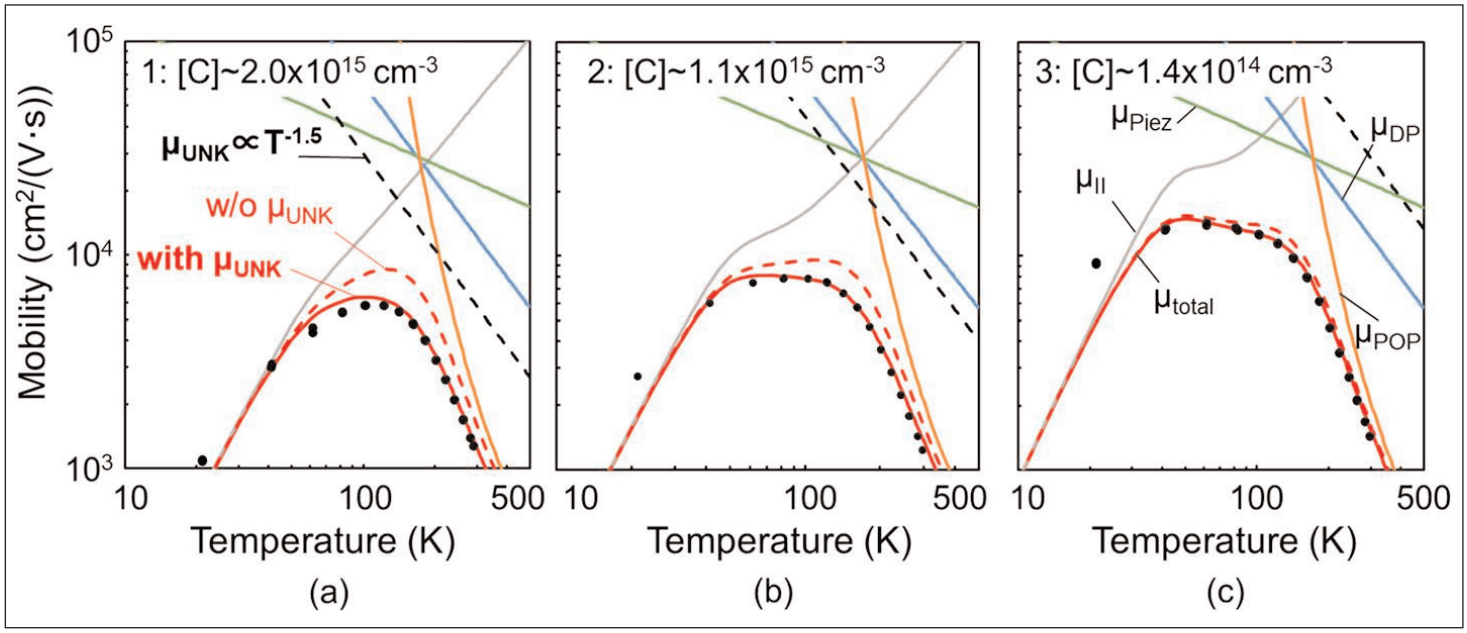

Figure 2. Hall mobilities as a function of temperature for samples (a) 1, (b) 2, and (c) 3. Black filled circles represent experimental data. Gray, blue, orange and green solid curves are calculated Hall mobilities for μ_{II}, μ_{DP}, μ_{POP} and μ_{Piez} components, respectively, without (broken) and with (solid) μ_{UNK}.

Apart from achieving record mobility performance, the team also sought empirical understanding of the "collapse" caused by C contamination with a view to achieving the full capability of GaN in terms of more efficient and compact power devices for constructing inverters for electric vehicles and power converters for renewable energy.

Carbon contamination is a particular problem for the metal-organic III–nitride growth methods mostly used in manufacturing, where the metal ions gallium, indium and aluminium are linked with organic components to give precursors such as trimethyl-Ga. A methyl group (CH_3) consists of carbon and hydrogen. The QF-HVPE method of Sumitomo et al avoids organic chemistry and hence uncontrolled C incorporation.

The researchers prepared samples for Hall measurements from materials grown by their QF-HVPE process on 2-inch freestanding GaN substrates prepared by the group's void-assisted separation method. The test samples consisted of 6mm x 6mm squares of n-type GaN layers after the growth substrate was removed by back-side polishing.

The layer growth took between 5 hours and 8 hours, resulting in a thickness of 300–500μm. After substrate removal, the material was 200–400μm thick. The growth temperature was 1050°C and the growth pressure was atmospheric. The threading dislocation density (TDD) of the growth substrates was uniform and between $1x10^6/cm^2$ and $3x10^6/cm^2$.

The sample contamination consisted of a small piece of carbon placed in the flow path of the ammonia (NH_3) N-source gas. The size of the carbon piece controlled the impurity concentration (Table b), as determined by secondary-ion mass spectrometry (SIMS). Aluminium/titanium electrodes for Hall measurement were placed on the corners of the square samples from the center of the materials.

The temperature dependence of the Hall parameters between 20K and 300K (RT, room temperature) was used to assess the contributions of scattering mechanisms to reducing mobility, such as by ionized impurities (II), acoustic-deformation potentials (DP), polar optical phonons (POP), and piezoelectric (Piez) effects. The mobility was found to increase at vary low temperature, reach a peak (μ_{MAX}) and then fall off as room temperature was approached (μ_{RT}).

The researchers compared their data with conventional theory for μ_{MAX} and μ_{RT} dependence with carbon concentrations (Figure 1). At the low temperatures of μ_{MAX}, the dominant mobility contribution was from impurity scattering. Although the measured values were lower than the conventional expectation, the difference was relatively small. However, at room temperature phonon scattering is expected to dominate in its impact on mobility, but the measured results continued to show a large impact from the presence of carbon, giving a "mobility collapse".

The team empirically attempted to characterize the "unknown" impact on mobility in a term, μ_{UNK} (Figure 2). Total mobilities were calculated without and with an unknown (UNK) component varying as $T^{-1.5}$, respectively. A variation with temperature as $T^{-1.5}$ improved the fit.

One must remember that mobility contributions, at least in simple theories, combine in inverse sums (μ_{i1}/μ_i) to give the inverse of effective mobility ($1/\mu_{eff}$), since increased "scattering" reduces carrier mobility.

The variation of the size of the added contribution, $\mu_{UNK} = K/T^{1.5}$, was fitted approximately by a 1/[C]

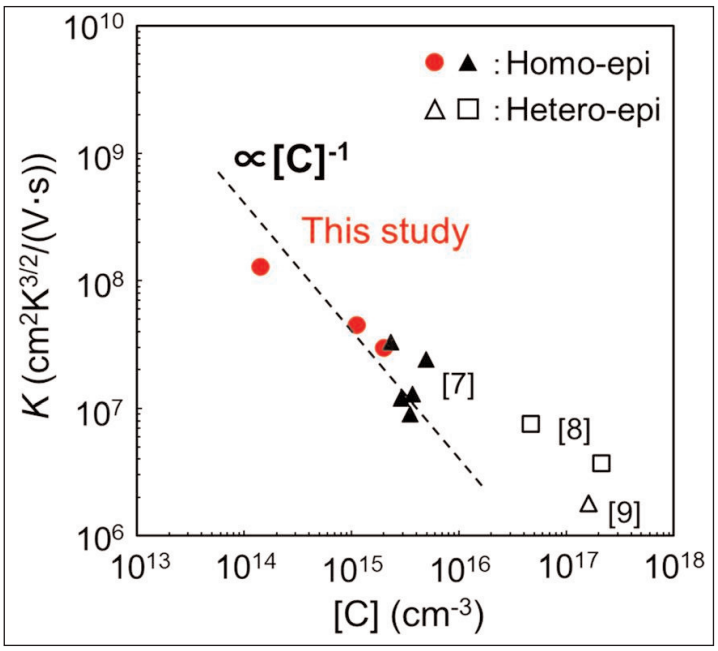

Figure 3. Relationships between pre-factor K for μ_{UNK} and [C] for samples 1–3, together with data from previous reports.

trend (Figure 3). Temperature exponents for μ_{UNK} between 1 and 2 provided similar capabilities in terms of fitting the experimental data.

The team comments: "Because the ionized impurity scattering has already been considered in the conventional theory, the [C] dependence of K in [(Figure 3)] strongly indicates that the carbon impurity induced an extra scattering mechanism other than the ionized impurity scattering. A scattering due to local strain around a deep-C acceptor is one possibility." ■

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Fully vertical GaN-on-SiC Schottkys with low on-resistance

Replacing complex buffer with ultrathin AlGaN significantly enhances performance.

Beijing University of Technology and Peking University in China have reported improved performance for fully vertical Schottky barrier diodes (SBD) fabricated from gallium nitride on silicon carbide substrate (GaN/SiC) by using an ultra-thin aluminium gallium nitride (AlGaN) buffer instead of the more usual complex, thick AlN/AlGaN structures [Yuting Sun et al, Semicond. Sci. Technol., published online 24 January 2024].

The team comments: "This epitaxial strategy can also be used for SiC/GaN heterogeneous integration by combining the merits of both GaN and SiC on a single platform."

The researchers further implemented other enhancements such as employing cap layers to protect against material decomposition during high-temperature annealing, and fluorine ion implants for edge termination.

Vertical GaN electronics structures enhance the ability to handle high power and voltage since the peak electric field usually occurs far from the surface, enhancing robustness against breakdown, unlike in lateral devices. The best performing vertical devices are produced on freestanding or bulk GaN substrates, but these tend to be small and costly.

Recent developments in SiC substrate manufacturing have resulted in 8-inch diameter wafers becoming commercially available from Wolfspeed and Tankeblue for mass production, raising the prospect for lower costs for SiC and GaN/SiC devices. A further advantage of SiC as a base for GaN power electronics is SiC's high thermal conductivity, enabling better thermal management of Joule heating effects.

The III–nitride layers for the vertical SBD (Figure 1) were grown on n^+-SiC substrate, using metal-organic chemical vapor deposition (MOCVD). The substrate was pre-treated with trimethyl-aluminium before MOCVD of a 700nm n^+-GaN buffer layer.

The pre-treatment resulted in an ultra-thin layer of AlGaN forming through inter-atomic self-diffusion at the GaN/SiC interface. The AlGaN layer was measured at 2nm thick, according to electron energy-loss spectroscopy (EELS).

The III-nitride epitaxy was completed with a 3μm n^--GaN drift layer. The root-mean-square roughness was 0.22nm, according to atomic force microscopy (AFM).

The researchers comment: "The reasonable crystal quality and surface roughness demonstrate the effectiveness of the ultrathin AlGaN buffer layer on accommodating the mismatch between GaN and SiC."

The ohmic cathode contact consisted of annealed

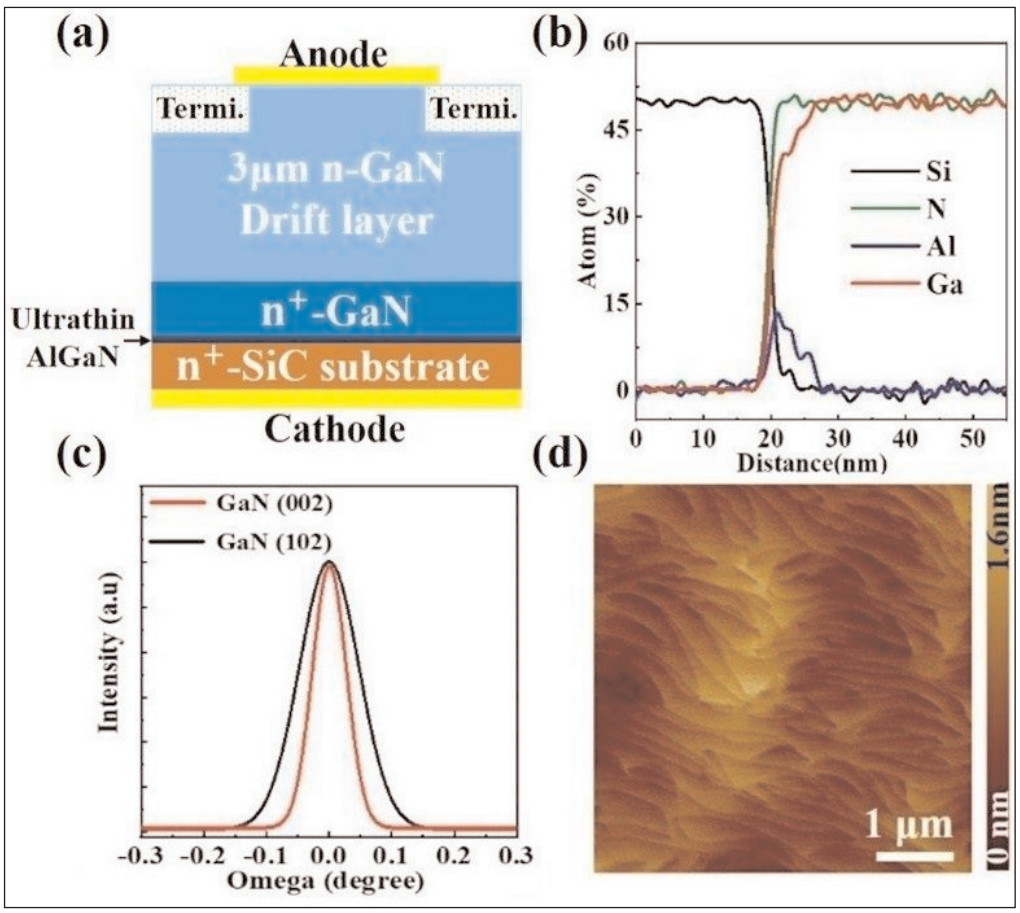

Figure 1. (a) Schematic cross-section of fully vertical GaN-on-SiC SBD. (b) EELS profiles obtained at GaN/SiC interface. (c) Symmetric (002) and asymmetric (102) x-ray diffraction rocking curves and (d) AFM image (5μmx5μm) of GaN grown with ultrathin AlGaN buffer.

nickel. The researchers used a silicon dioxide (SiO_2) capping layer to retain material quality during the 900°C rapid thermal annealing (RTA) process. The cap was removed by a hydrofluoric acid dip. Without the cap layer the AFM surface roughness increased significantly, with the GaN atomic surface steps completely disappearing. By contrast, the AFM roughness of the capped device material only increased slightly.

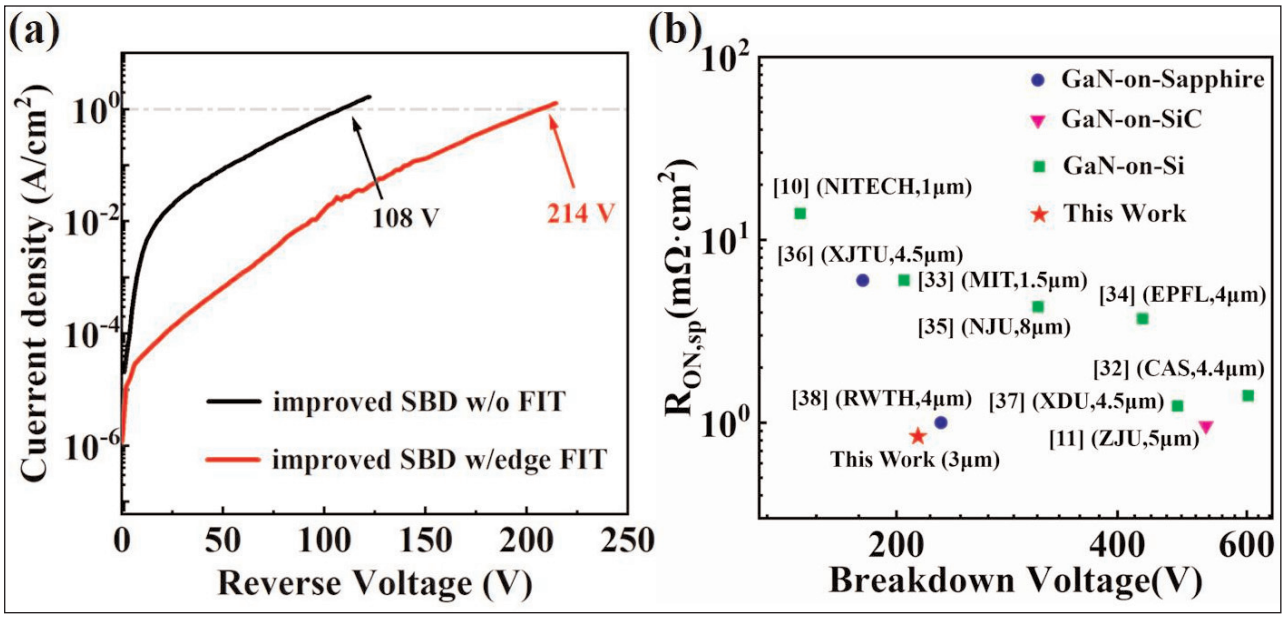

Figure 2. (a) Reverse current–voltage characteristics of improved SBD without FIT and with edge FIT. (b) Benchmark of RON,sp versus BV of fully vertical or quasi-vertical GaN SBDs on foreign substrates.

The surface decomposition of non-capped annealing results in reduced Schottky metal/semiconductor contact quality and thus deterioration of the current–voltage behavior.

The researchers report: "Although the surface roughness increased from 0.22nm to 0.28nm with a little more surface pits after annealing, orderly arranged atomic steps were still clearly visible on the GaN surface of the improved SBD. These results indicate that the SiO_2 capping layer can effectively protect the GaN surface against decomposition during RTA."

The device was completed with fluorine ion implantation for edge termination, and deposition of nickel/gold for the Schottky anode contact.

The use of an ultrathin AlGaN layer reduced the specific on-resistance ($R_{ON,sp}$) of the SBD to 1.5mΩ-cm^2, compared with 50mΩ-cm^2 for a reference SBD with 50nm-thick heavily doped $Al_{0.25}Ga_{0.75}N$ buffer layer. The researchers attribute the better performance of the ultrathin AlGaN layer SBD to increased tunneling current, while the much larger band offset of the thick AlGaN buffer weakens the tunneling capability.

In terms of device performance, capping during RTA reduced on-resistance by a factor of almost 2. The Schottky barrier height was 0.79eV with capping, and 1.02eV without. Also, capping during RTA reduced the ideality factor from 1.22 to 1.08 (ideal=1). Further, the corresponding on/off current ratios were 8.5x106 and 5x10^9, an improvement of almost three orders of magnitude (28dB).

The improved SBD with capping during RTA had an on-resistance of 0.85mΩ-cm^2, which the team describes as "a relatively small value among the reported vertical GaN diodes on foreign substrates fabricated by complex fabrication process".

The forward current at 3V bias reached 1.8kA/cm^2 density. The team comments: "The superiority of the forward I–V characteristics indicate that the ultrathin AlGaN buffer layer is effective for realizing fully vertical GaN SBD on SiC substrate with low $R_{ON,sp}$ and stable conductivity based on simplified epitaxy stack."

The effect of increasing the device temperature in the range 25–120°C was found to be a slow ramp in $R_{ON,sp}$ of 0.00345mΩ-cm^2/°C. The turn-on voltage was simultaneously affected by a slow decrease rate of 0.0016V/°C.

The researchers found the effect of the fluorine ion termination (FIT) to be an increase in reverse breakdown voltage (BV, for 1A/cm^2) from 108V to 214V (Figure 2).

The researchers report: "The theoretical BV is 221V for a device with the same drift layer (a thickness of 3μm at a doping concentration of 1.5x10^{17}/cm^3). A slightly lower measured BV of 214V indicates the good crystal quality of the drift layer as well as the effectivity of the edge termination of this work."

The low resistance compared to other reports of SBDs on foreign (i.e. non-GaN) substrates suggests "good conductivity of the epi-stack". The team adds: "Much higher BV can be achieved by lowering the n-type doping concentration." Drift layers in other reports typically have doping concentrations a factor of ten lower. ■

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Author: Mike Cooke

Silicon carbide substrate costs falling as larger diameters adopted

Number of 8-inch SiC fabs under construction or planned globally reaches 11.

With the continuous surge in demand for silicon carbide (SiC) substrates in recent years, the call for cost reduction in SiC has been growing stronger, as the ultimate product price remains the key determinant for consumers, says market research firm TrendForce.

The cost of SiC substrates accounts for the highest proportion of the entire cost structure, reaching about 50%. Cost reduction and utilization rate improvement in the substrate segment are hence particularly crucial. Large-size substrates, due to their cost advantages, are therefore gradually being adopted, with high expectations.

Chinese SiC substrate maker TankeBlue Semiconductor calculates that upgrading from 4-inches to 6-inches can reduce costs by 50% per unit, and upgrading from 6-inches to 8-inches can cut costs by an additional 35%.

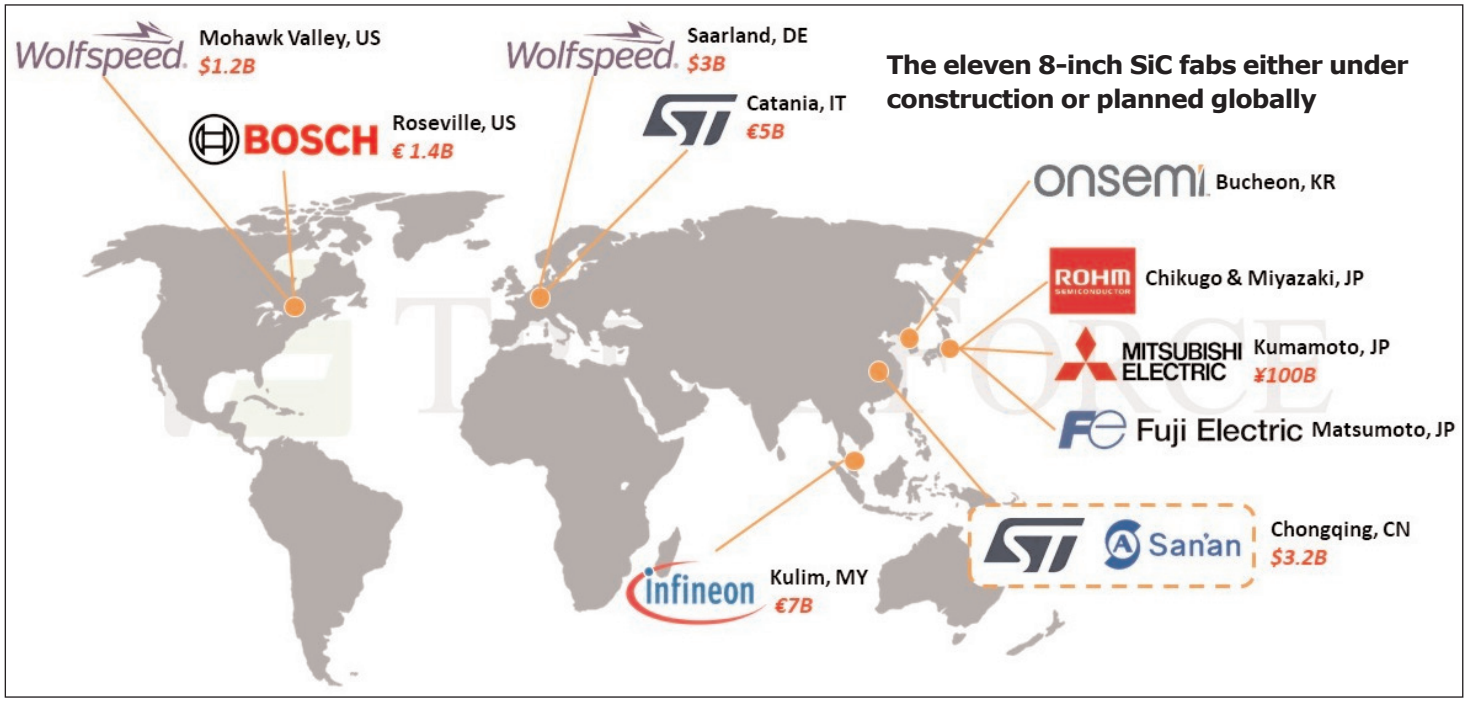
Meanwhile, 8-inch substrates can yield more chips, resulting in lower edge wastage. In simple terms, 8-inch substrates offer a higher utilization rate, which is the main reason why major manufacturers are actively developing them.

Currently, 6-inch SiC substrates are still dominant, but 8-inch substrates are beginning to penetrate the market. For example, in July 2023 Wolfspeed announced that its 8-inch fab had begun shipping SiC MOSFETs to Chinese customers, indicating its bulk shipment of 8-inch SiC substrates. TankeBlue has also started small-scale shipments of 8-inch substrates, with plans to achieve medium-scale shipments by 2024.

Accelerated advancement of 8-inch SiC substrate lineup

Since Wolfspeed first showcased samples in 2015, the 8-inch SiC substrate has undergone a development history of 7–8 years, with significant acceleration in technology and product development in the past two years.

Apart from Wolfspeed, which has achieved mass production, there are seven firms that are expected to



achieve mass production of 8-inch SiC substrates this year or in the next 1–2 years.

In terms of investment, Wolfspeed continues to construct the John Palmour Silicon Carbide Manufacturing Center (SiC substrate facility) in North Carolina, USA. This facility will further drive the expansion of substrate production capacity to meet the increasing demand for 8-inch wafers.

Coherent also announced plans last year to expand its production of 8-inch substrates and epitaxial wafers, with large-scale expansion projects in the USA and Sweden. In terms of product export channels, Coherent has received a $1bn investment from Mitsubishi Electric and Denso to provide long-term 6/8-inch SiC substrates and epitaxial wafers to both companies.

Europe-based STMicroelectronics also invested in the 8-inch domain last year by partnering with Hunan Sanan Semiconductor to construct an 8-inch SiC wafer fab in China. The latter will accompany it by establishing an 8-inch SiC substrate plant, ensuring a stable supply of material for the joint venture. Simultaneously, ST is developing its own substrates and previously collaborated with France-based Soitec to achieve mass production of 8-inch SiC substrates.

Regarding Chinese manufacturers, currently over 10 enterprises have entered the sampling and small-scale production stages for 8-inch SiC substrates. These include companies such as Semisic Crystal Co, Jingsheng Mechanical & Electrical Co, SICC Co, Summit Crystal Semiconductor Co, Synlight Semiconductor Co, TanKeBlue Semiconductor Co, Harbin KY Semiconductor, IV Semitec, Sanan Semiconductor, Hypersics, and Yuehaijin Semiconductor Materials Co.

In addition, many other Chinese manufacturers are currently researching 8-inch substrates, such as GlobalWafers, Dongni Electronics, Hesheng Silicon Industry, and Tiancheng Semiconductor.

At present, the gap between Chinese substrate manufacturers and the international giants has narrowed significantly. Companies like Infineon have established long-term partnerships with Chinese manufacturers such as SICC Co and TanKeBlue. From a technological standpoint, this narrowing gap reflects the overall improvement in substrate technology globally. Moving forward, concerted efforts from various manufacturers are expected to drive the development of 8-inch substrate technology.

Overall, there is a growing momentum in the overall development of 8-inch SiC substrates, with significant breakthroughs in both quantity and quality.

Global 8-inch SiC fabs accelerate expansion

As substrate materials continue to break through technological ceilings, the global increase in the number of new 8-inch SiC fabs reached new heights in 2023.

According to TrendForce, about 12 expansion projects related to 8-inch wafers were implemented in 2023. Among them, eight were led by global manufacturers such as Wolfspeed, Onsemi, STMicroelectronics, Infineon, Rohm, and others. STMicroelectronics also collaborated with Sanan Semiconductor on one project. Additionally, three projects were spearheaded by Chinese manufacturers such as Global Power Technology, United Nova Technology Co, and J2 Semiconductor.

From a regional perspective, significant investments in new 8-inch SiC fabs are expected in key regions such as Europe, America, Japan, South Korea, China, and Southeast Asia. As of now, there are about 11 8-inch fabs either under construction or planned globally.

These include two facilities by Wolfspeed (in Mohawk, NY, USA, and Saarland, Germany), one by Bosch (in Roseville, USA), one self-built by STMicroelectronics

(in Catania, Italy), one joint venture with Sanan (in Chongqing, China), one by Infineon (in Kulim, Malaysia), one by Mitsubishi Electric (in Kumamoto, Japan), two by Rohm (in Chikugo and Kunitomi, Japan), one by ON Semiconductor (in Bucheon, South Korea), and one by Fuji Electric (in Matsumoto, Japan).

Regarding the direction of expansions by manufacturers, the investments by Bosch and ON Semiconductor in 2023 are directly aimed at the automotive SiC market. STMicroelectronics' planned 8-inch SiC chip factory in Italy also targets the electric vehicle market. While other manufacturers have not explicitly stated the targeted applications for future production capacity, electric vehicles are the primary growth engine for SiC both currently and in the future, making it a focal point for expansion among major manufacturers.

In the electric vehicle sector, the 800V high-voltage platform has emerged as a clear development trend. The 800V platform requires higher-voltage power semiconductor components, prompting manufacturers to begin developing 1200V SiC power devices.

From a cost perspective, although 6-inch wafers are currently mainstream in the short term, the trend towards larger sizes like 8-inch is inevitable for cost reduction and efficiency improvement purposes. The electric vehicle market is therefore expected to drive continuous growth in demand for 8-inch wafers in the future.

From a supply chain perspective, transitioning to 8-inch wafers represents a breakthrough for SiC manufacturers. According to industry insights, the 6-inch SiC device market has entered a phase of intense competition, particularly in the SiC junction barrier diode (JBD). For smaller-scale and less competitive enterprises, profit margins are increasingly squeezed, indicating an impending round of consolidation and restructuring in the future. ■

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CA 94538, USA
Tel: +1 510 438 4700
Fax: +1 510 683 5901
www.axt.com

Crystal IS Inc
70 Cohoes Avenue,
Green Island,
NY 12183,
USA
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
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.

Freiberger Compound Materials
Am Junger Loewe Schacht 5,
Freiberg, 09599,
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
Wald 10, 84568 Pleiskirchen,
Germany
Tel: +49 8728 911 093
Fax: +49 8728 911 156
www.35reclaim.de

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
E-mail: sales@tecdia.com
www.tecdia.com

Wafer Technology Ltd
34 Maryland Road, Tongwell,
Milton Keynes, Bucks, MK15 8HJ, UK
Tel: +44 (0)1908 210444
Fax: +44 (0)1908 210443
www.wafertech.co.uk
Wafer Technology Ltd is a UK based producer of III-V materials and epitaxy-ready substrates offering the widest product range in the business.

Wafer World Inc
1100 Technology Place, Suite 104,
West Palm Beach,
FL 33407,
USA
Tel: +1-561-842-4441
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

IQE
Cypress Drive,
St Mellons,
Cardiff
CF3 0EG, UK
Tel: +44 29 2083 9400
Fax: +44 29 2083 9401
www.iqep.com
IQE is a leading global supplier of advanced epiwafers, with products covering a diverse range of applications within the wireless, optoelectronic, photovoltaic and electronic markets.

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France
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Fax: +33 1 45 10 69 53
www.ommic.fr

Soitec
Parc Technologique des Fontaines,
Chemin des Franques, 38190
Bernin, France
Tel: +33 (0)4 76 92 75 000
www.soitec.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

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

Riber
31 rue Casimir Périer, BP 70083,
95873 Bezons Cedex,
France
Tel: +33 (0) 1 39 96 65 00
Fax: +33 (0) 1 39 47 45 62
www.riber.com

SVT Associates Inc
7620 Executive Drive,
Eden Prairie, MN 55344,
USA
Tel: +1 952 934 2100
Fax: +1 952 934 2737
www.svta.com

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
Livermore, CA 94551,
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
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com
EV Group is a technology and market leader for wafer processing equipment. Worldwide industry standards for aligned wafer bonding, resist processing forthe MEMS, nano and semiconductor industry.

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Old Kilpatrick, near Glasgow G60 5EU,
Scotland, UK
Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com

Plasma-Therm LLC
(see section 6 for full contact details)

SAMCO International Inc
532 Weddell Drive,
Sunnyvale, CA, USA
Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

SPTS Technology Ltd
Ringland Way, Newport NP18 2TA,
Wales, UK
Tel: +44 (0)1633 414000
Fax: +44 (0)1633 414141
www.spts.com

SUSS MicroTec AG
Schleißheimer Strasse 90,
85748 Garching, Germany
Tel: +49 89 32007 0
Fax: +49 89 32007 162
www.suss.com

Synova SA
Ch. de la Dent d'Oche,
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

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

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

10 Gas and liquid handling equipment

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

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

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

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

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

VACUUM BARRIER VBC CORPORATION

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

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

11 Process monitoring and control

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

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

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

LayTec AG
Seesener Str. 10–13,
10709 Berlin,
Germany
Tel: +49 30 89 00 55 0
Fax: +49 30 89 00 180
www.laytec.de

LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

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

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WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)
Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald,
Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

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

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

13 Characterization equipment

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

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

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

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

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

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

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

17 Assembly/packaging foundry

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

18 Chip foundry

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

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

19 Facility equipment

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

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

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20 Facility consumables

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

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

21 Computer hardware & software

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

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

22 Used equipment

Brumley South Inc
422 North Broad Street,
Mooresville,
NC 28115,
USA
Tel: +1 704 664 9251
Email: sales@brumleysouth.com
www.brumleysouth.com

BSI

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Decatur, GA 30035,
USA
Tel: +1 770 808 8708
Fax: +1 770 808 8308
www.ClassOneEquipment.com

23 Services

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

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
www.tecdia.com

24 Resources

Al Shultz Advertising Marketing for Advanced Technology Companies
1346 The Alameda,
7140 San Jose, CA 95126, USA
Tel: +1 408 289 9555
www.alshuktz.com

SEMI Global Headquarters
San Jose, CA 95134,
USA
Tel: +1 408 943 6900
www.semi.org

Yole Développement
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France
Tel: +33 472 83 01 86
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event calendar

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7–11 April 2024
SPIE Photonics Europe 2024, co-located with SPIE Optical Systems Design 2024
Palais de la Musique et des Congrès, Strasbourg, France
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-europe

14–18 April 2024
IEEE International Reliability Physics Symposium (IRPS 2024)
Hilton DFW Lakes, Dallas, TX, USA
E-mail: IRPSreg@ieee.org
www.irps.org

16–18 April 2024
22nd European Advanced Process Control and Manufacturing (APC|M) Conference
CinemaxX, Hamburg, Germany
E-mail: isabel.dietrich@silicon-saxony.de
www.apcm-europe.eu

22–26 April 2024
2024 Materials Research Society (MRS) Spring Meeting & Exhibit
Seattle, WA, USA
www.mrs.org/meetings-events/spring-meetings-exhibits/2024-mrs-spring-meeting

30 April – 2 May 2024
27th annual Components for Military & Space Electronics conference & exhibition (CMSE 2024)
Four Points by Sheraton (LAX), Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

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

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

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

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

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

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

Microwave Week

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

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

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

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

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

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

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

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

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

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

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

14–18 October 2024
2024 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Fort Lauderdale, FL, USA
E-mail: cs@cshawevent.com
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3–8 November 2024
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