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Infineon opens Phase 1 of Malaysian 200mm SiC power semi fab

First GaN epi wafer pilot line for Hong Kong • Halo raises $80m
SiCrystal tripling SiC wafer capacity • Sivers Photonics to spin off

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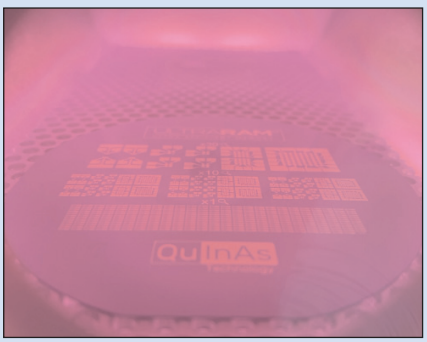
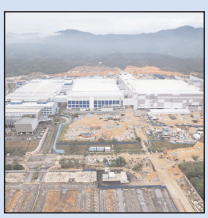
p36 SiCrystal is constructing a new building to triple SiC wafer production capacity in Nuremberg by 2027.



p43 Innovate UK has awarded a £1.1m one-year project to industrialize ULTRARAM, led by Quinas with IQE and Lancaster and Cardiff universities.

p82 Germany's Fraunhofer IAF is first to use MOCVD rather than magnetron sputtering to fabricate and characterize aluminum yttrium nitride.



Cover image: Infineon has officially opened the first phase of a new 200mm-wafer silicon carbide power semiconductor fab at its Kulim 3 site in Malaysia, joined by both the Malaysian Prime Minister and the Chief Minister of the state of Kedah. **p22**

editorial

Wider-bandgap = wider scope

In late July, the US subsidiaries of GlobalWafers were assigned $400m in CHIPS Act funding. As well as establishing the first US 300mm silicon wafer plant and a facility to produce 300mm silicon-on-insulator wafers, this includes converting part of its silicon epiwafer manufacturing facility in Texas to produce 150mm and 200mm silicon carbide (SiC) epiwafers (see page 14).

Regarding substrates, Japanese firm ROHM's German subsidiary SiCrystal is tripling its SiC wafer production capacity in Nuremberg by 2027 (page 36). Meanwhile, Germany's Infineon has opened the first phase of a new 200mm-wafer SiC power semiconductor device fab in Malaysia (page 22).

Beyond silicon carbide, fellow wide-bandgap semiconductor material gallium nitride is being pushed further from its initial optoelectronic and RF microelectronic applications to higher-voltage power semi applications, enabling greater economies of scale on 200–300mm silicon substrates.

Most recently, UVC-LED maker MassPhoton said that it will establish Hong Kong's first R&D center for GaN epitaxy technology, and develop Hong Kong's first production-scale 200mm GaN epiwafer pilot line (page 32). The Hong Kong Microelectronics R&D Institute is to be set up within the year, featuring pilot lines for both SiC and GaN, since such 'third-generation' semiconductors are a "key area of technological development" to the Hong Kong Government in order to "reduce the dependence on traditional silicon-based materials and devices, as well as critical equipment, achieving a more independent and controllable supply chain".

US-based process equipment maker Veeco's compound semiconductor-related revenues are declining, but it is "focused on long-term opportunities within power electronics and photonics" (page 44). It recently shipped a 300mm GaN-on-silicon MOCVD evaluation system to a power device customer and aims to place two SiC CVD evaluation systems by early 2025.

Germany-based MOCVD/CVD equipment maker Aixtron's second-quarter 2024 revenue was up 11.4% year-on-year. Whereas 83% of Q1/2024's equipment revenue comprised MOCVD/CVD systems for making GaN- and SiC-based power electronic devices, MOCVD systems for making LEDs rebounded from just 5% of equipment revenue a year ago to 43% in Q2, driven by micro-LED developments (see page 46, as well as the latest research, spanning UV-A to red wavelengths, on pages 72–79). However, of Aixtron's Q2's order intake, as much as 57% is for SiC- and 29% for GaN-based power electronics, driven by major follow-up orders from existing customers such as Nexperia (page 49).

Burgeoning demand for gallium in GaN-based power electronics and micro-LEDs highlights supply constraints from the government-imposed licensing since August 2023 of exports from China (which has over 90% of the world's gallium production capacity) that has almost doubled the price of gallium for Western markets. Increased attention is hence being focused on gallium recycling (e.g. by AXT and Neo — see pages 40–41).

Longer-term, a prospect is migration to ultrawide-bandgap semiconductor materials. For example, researchers in German have demonstrated the practical implementation of an AlN-based supply chain for power semis (see page 34), and Fraunhofer IAF is first to use MOCVD to fabricate aluminium yttrium nitride (AlYN). In the USA, aided by a DARPA grant, Cornell University is working to overcome technical challenges that have limited the adoption of AlN. Even longer term, there is also the prospect of boron nitride being developed as an ultrawide-bandgap semiconductor.

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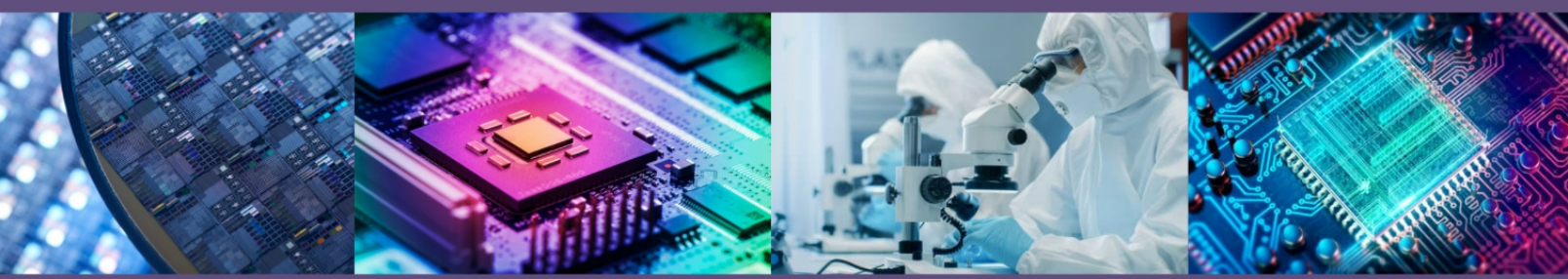

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Shipments of mini-LED backlight LCD displays to surpass OLED displays in 2025

LCD TV displays with mini-LED backlight unit to grow from 6.2 million in 2024 to 9.3 million in 2025

According to the 'Mini-LED Backlight Market Tracker' from market research firm Omdia, LCD TV displays equipped with a mini-LED backlight unit will reach 6.2 million units in 2024, while Samsung Display and LG Display will produce 6.8 million units of OLED TV displays (including both WOLED and QD OLED TV variants). However, by 2025 the mini-LED backlight TVs are forecasted to reach 9.3 million units, surpassing the 7.5 million units of OLED TVs for the first time.

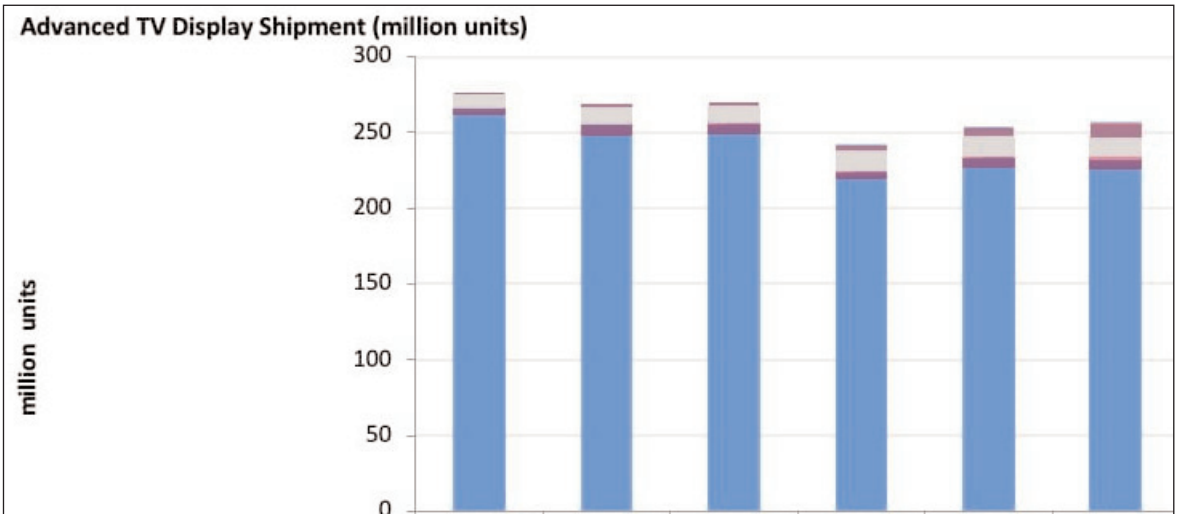
Specifically, Samsung, LG Electronics, Sony, TCL and Hisense are all targeting double-digit growth in their mini-LED backlight TV display shipments in 2024 and 2025.

Since 2022, the market for LCD TV displays with mini-LED backlights and quantum dot materials has seen substantial growth. This is driven by continuous cost reductions through effective supply chain management of the mini-LED backlight and advances in quantum dot materials. While OLED TV displays are celebrated for their infinite contrast ratio, exceptional color gamut and fast response times, the combined mini-LED backlight and quantum dot-equipped LCD TV display is now challenging OLED TV's dominance. The mini-LED backlight enhances dimming functions and HDR capabilities while quantum dots boost color gamut performance, leading LCD TV OEMs and panel makers to adopt both technologies to raise their product specifications.

"OLED TV panels offer significant advantages in the high-end TV market, such as higher brightness, better environmental friendliness due to fewer components and materials, no halo effect on the screen since there is no mini-LED grouping for dimming zones, and a strongly established premium TV image among consumers," comments David Hsieh, senior research director in Omdia's Displays practice.

"However, mini-LED backlights are now competitive in several aspects: a mature supply chain, the shift to larger LCD TV displays, the cost-effective 500–2000 dimming zones, the production of super larger size like 85-inches and above, and ample capacity for LCD TV open cells," he adds. "Therefore, there will be intense competition between mini-LED backlight LCD TVs and OLED TVs moving forward, which will help expand the high-end TV segment and align with the trends towards larger sizes," Hsieh concludes.

https://omdia.tech.informa.com/advance-your-business/displays/mini-led-backlight-market-tracker



	2020	2021	2022	2023	2024	2025
Micro LED TV		0.0000	0.0000	0.0001	0.0002	0.0011
Mini LED Backlight TV					0.3	1.3
QLED TV + Mini LED Backlight*	0.5	1.9	3.0	3.5	5.8	8.0
Quantum Dot LED (QLED) LCD TV	9.1	10.7	10.2	13.0	13.0	12.7
QD OLED TV		0.0	1.1	1.1	1.3	1.5
WOLED TV	4.5	7.4	6.4	4.2	5.5	6.0
Standard LCD TV	262.2	248.5	249.7	220.0	227.4	226.5

Source: Omdia

* Mini LED Backlight LCD TV* = Mini LED Backlight LCD TV includes the high density (LED ≤150 µm) medium density (LED ≒ 200 µm and low density (LED ≥ 300 µm), excluding FALD (Full Array Local Dimming) Backlight.

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Qorvo's below-seasonal June-quarter revenue follows major ramp at Samsung

Revenue and profits to rebound in September quarter

For its fiscal first-quarter 2025 (ended 29 June 2024), Qorvo has reported a further decline in revenue to $886.7m, down 5.8% on last quarter's $941m but up 36% on $651.2m a year ago, and exceeding the $850m mid-point of guidance by $37m.

Revenue is dominated more than ever by Qorvo's increasing exposure to the seasonal ramp patterns at its two largest customers Apple and Samsung, leading to a decline in Advanced Cellular Group (ACG) revenue. "We're coming off a big flagship ramp at our second largest customer with tremendous content," notes president & CEO Bob Bruggeworth. "We're offsetting that with growth outside of them."

By business segment, revenue comprised:

- *Advanced Cellular Group (ACG)* $642.3m, down 1.7% on last quarter's $653.6m but up 55.8% on $412.2m a year ago;
- *Connectivity & Sensors Group (CSG)* $114.9m, down 6.4% on last quarter's $122.8m but up 15.7% on $99.3m a year ago;
- *High-Performance Analog (HPA)* $129.5m, down 21.3% on last quarter's $164.6m and 7.3% on $139.7m a year ago, due to the seasonal timing of large programs for defense (given its dominant size within HPA), together with a slower rollout of DOCSIS 4.0.

On a non-GAAP basis, gross margin has fallen further, from 42.9% a year ago and 42.5% last quarter to 40.9%, including about 200 basis points of impact from under-utilization. As well as the typical seasonal decline in Qorvo's largest customer (comprising products that contain higher levels of external content) plus the seasonal decline in defense programs, this reflects a higher percentage of high-cost Android 5G mass-market product that was manufactured during periods of lower utilization. However, gross margin is at the high end of the 40–41% guidance range, benefiting from product mix on higher revenue. "Given anticipated product mix and production schedules, we currently believe fiscal Q1 will mark the low point of gross margin in fiscal 2025," says senior VP & chief financial officer Grant Brown.

Operating expenses have grown further, from $232.7m a year ago and $253.2m last quarter to $264.5m (above the expected $260m). This was driven partly by R&D spending rising from $168.1m last quarter to $174.9m, but also included $4m from Qorvo's digital transformation project (a three-year initiative to modernize the firm's core systems and business processes, to increase operational efficiency, unlock internal data to leverage new software capabilities including AI, and support broad-based growth objectives in diverse dynamic markets.).

Net income was $83.5m ($0.87 per diluted share, exceeding the $0.60–0.80 guidance due to the higher revenue and gross margin, offset by the slightly higher operating expenses). This was down from $135.5m ($1.39 per diluted share) last quarter but up from just $33.6m ($0.34 per diluted share) a year ago.

"Qorvo exceeded the mid-point of June quarterly guidance for revenue, gross margin and EPS," notes Brown.

Operating cash flow has fallen from $202.3m last quarter to $81.1m. Capital expenditure (CapEx) has risen further, from $32.7m to $38.2m. Free cash flow was hence $42.9m (down from $169.6m).

Qorvo exceeded the mid-point of June quarterly guidance for revenue, gross margin and EPS

During the quarter, cash and equivalents rose by $53.1m, from $1029.3m to $1082.4bn. Long-term debt outstanding remains about $1549bn.

Also during the quarter, Qorvo repurchased $125m of stock at $101 per share. In addition, Qorvo retired $27m of its 2024 notes and has about $412m remaining. These notes will mature in mid-December. Subject to changes in the interest rate environment and other factors, Qorvo currently expect to retire these short-term notes later this year.

Net inventory balance was increased back up to $727m (after dipping to $710.5m last quarter), as Qorvo supports the seasonal ramp at its largest customer.

Acquisition Anokiwave fully integrated into Qorvo's HPA segment

Anokiwave Inc of Boston, MA, USA (acquired during the June quarter) has now been fully integrated into Qorvo's HPA segment. "Added capabilities in silicon beam-forming ICs and IF-to-RF conversion [e.g. for SATCOM, D&A, and 5G applications] are complementary to our transmit/receive RF front-ends as well as our power management IC portfolio," says Bruggeworth.

"We are developing more highly integrated placements that combine our capabilities to bring greater value-add to our customers," he adds. "We are investing in technology leadership to broaden our market exposure and drive growth, and we are executing on cost and productivity initiatives to structurally enhance our gross margin."

Beijing and Dezhou packaging operations transitioned to Luxshare

"We are leveraging internal factories and advanced packaging facilities that are critical differentiators for each of our operating segments, while outsourcing to our robust foundry and OSAT [outsourced semiconductor assembly and test] partner network where we benefit from their scale and R&D investments," says Brown.

In mid-December, Qorvo said that it was divesting its assembly & test facilities in Beijing and Dezhou, China, via a new multi-year partnership with Luxshare Precision Industry Co Ltd of Dongguan City, Guangdong (which acquired their operations and assets, including the property, plant and equipment, as well as the existing workforce to enable continuity of operations). After completing the sale during the June quarter, Qorvo continues to maintain its sales, product and test engineering, and customer support staff in China.

These divestments align with previous actions, including the closure of Qorvo's Florida manufacturing operations and the sale of its Farmers Branch facility in Texas.

Also, Qorvo has now completed the transition of its BAW filter production lines to exclusively 8-inch wafers, and running product through the Beijing and Dezhou facilities.

Strategic highlights during June quarter

● *Automotive market*

Qorvo was selected to supply V2X front-end modules (FEMs) for a leading China-based automotive V2X reference chipset platform set to ramp at multiple automotive OEMs in calendar 2025. To expand automotive engagements, the firm is leveraging its ultra-wideband portfolio across a range of applications, including secure access, digital key, kick sensors, child presence detection and detection of intrusion.

"We are also expanding our opportunities in EVs to include solid-state circuit breakers," notes Bruggeworth. "Given the smaller size, enhanced reliability and better thermals of our silicon carbide solutions, we enable solid-state circuit breakers that can disconnect electrical overloads in case of failure to maintain safe and efficient power distribution," he adds.

● *Consumer markets*

Qorvo secured a new engagement to supply a switch mode DC-to-DC charger for a wearable accessory for an Android OEM. "We continue to expand our power management portfolio and we are engaged to supply our newest battery management solution for power tools, scooters, e-bikes and other consumer products," says Bruggeworth.

Qorvo is also supporting a range of applicants with its Matter and ultra-wideband technologies, including door locks, smart lighting and indoor navigation. "We are combining Matter with ultra-wideband to support the emerging Aliro standard for controlling digital access to smart homes and offices," notes Bruggeworth.

To support global broadband deployments, Qorvo's Wi-Fi solutions enable cellular, cable and satellite backhaul applications in developed and emerging markets. Qorvo recently surpassed 75 million Wi-Fi 6 FEMs shipped into the India Wi-Fi market. "We continue to expand our Wi-Fi portfolio and we are seeing increasing customer interest in our 2GHz, 5GHz and 6GHz BAW filters for Wi-Fi CPE applications," says Bruggeworth. "In other consumer applications, we are expanding our customer engagements with four sensing touch sensors, primarily for laptop track pads as well as other consumer applications."

● *Defense & Aerospace markets*

Qorvo secured design wins across segments, including AESA radars, large defense programs, and SATCOM deployments where Qorvo participates in both the low Earth orbit (LEO) satellite and the ground-based consumer terminal.

In D&A markets, Qorvo is the beneficiary of underlying drivers, including the trend of one-to-many, the transition of mechanical systems to active electronic scanning systems, increasing system-level functionality, and size constraints requiring advanced multi-chip packaging.

New product launches during the quarter included three new highly integrated RF multi-chip modules (MCMs) for X-band, S-band and L-band advanced radar applications. The new modules integrate filters, switches and amplifiers to simplify design and enable a superior performance, low noise, reduced power consumption and smaller form factor required for phased-array and multi-function radar systems.

● *Infrastructure markets*

Qorvo launched a single-chip inverse cable equalizer that is programmable in the field and electronically simulates signal loss at various cable lengths. For operators, this eliminates the additional parts and tech time required to accommodate short runs during DOCSIS 4.0 field installations. Qorvo's single-chip solution also features a switched bypass mode that allows operators to utilize the firm's solution in every line amplifier and field extender regardless of distance.

For massive MIMO 5G base stations, Qorvo introduced what is claimed to be a best-in-class transmit pre-driver, engineered specifically for 32-node massive MIMO systems and scalable up to 64-nodes.

● *Industrial and Enterprise markets*

Qorvo is seeing continued demand for new orders for AC-to-DC high-density server power supplies.

During the quarter, Qorvo began sampling what is claimed to be the industry's first 4mΩ silicon carbide JFET, with best-in-class on-resistance ($R_{DS(ON)}$) among 650–750V power devices. "This is especially important for applications such as circuit protection that are migrating from traditional switch mode static switches that are on for longer durations," notes Bruggeworth. "This is a significant milestone for solid-state circuit breakers and it highlights the trend we are seeing from mechanical to semiconductor-based electrical systems for residential, commercial and industrial applications."

For Wi-Fi enterprise access points, Qorvo is engaged to supply ultra-wideband to enable indoor navigation in office buildings, shopping malls and factories. "By adding ultra-wideband to Wi-Fi access ►

points, the access points become the anchor or reference point, enabling precision navigation for ultra-wideband-enabled devices," says Bruggeworth. "As an added benefit, ultra-wideband can reduce costs by identifying the optimal location for access point placement during Wi-Fi installation," he adds.

"Lastly, we're leveraging our force-sensing touch sensor technology in new industrial markets, including handheld medical devices that measure oxygen levels."

● *Mobile markets (primarily smartphones and tablets)*

Qorvo's largest opportunity remains at its largest customer. "We are investing in multiple multi-year programs to increase our content and continue to grow revenue with this customer," says Bruggeworth.

R&D investments for future programs include products that Qorvo is currently supplying to this customer as well as new products that it is not currently supplying. Within the Android ecosystem, Qorvo remains the primary RF supplier. "We collaborate with Android OEMs on their product roadmaps over multiple years and we are positioned to drive growth as 4G devices move to 5G and enter our SAM [serviceable addressable market]," says Bruggeworth.

"In calendar 2024, we expect Android 5G unit volumes to grow greater than 10%. We are also positioned to grow with 5G Advanced, which occurs with new releases of the 5G standard," he adds. "Content drivers in 5G events include an additional transmit path, non-terrestrial network connectivity and requirements for Power Class 2 amplifiers to increase output power, improve data throughput and extend cell site coverage."

During the quarter, Qorvo ramped multiple new products, leveraging its newest BAW and LRT (low-loss resonator technology) SAW processes. "For an Android OEM, we commenced shipments of the most functionally dense mid-high band [MHB] PAD [power amplifier duplexer] on the market," says Bruggeworth. The new MHB PAD integrates the diversity receive content that was historically offered in a separate SAW-based module. It is a highly complex MCM that features Qorvo's internal BAW, LRT SAW and gallium arsenide (GaAs) heterojunction bipolar transistor (HBT) as well as CMOS and silicon-on-insulator (SOI) sourced from Qorvo's foundry network. It improves efficiency and reduces power consumption while shrinking board-space requirements by about 35%.

Within mass-market smartphones, Qorvo secured multiple design wins with its recently launched portfolio of low-, mid-, high-band PADs. Each LMH PAD integrates the low-, mid- and high-band main-path content that previously required two placements. This saves about 40% in board space, simplifies design and helps customers accelerate their time to market, reckons Qorvo.

In mobile Wi-Fi, MediaTek selected Qorvo as the exclusive supplier of Wi-Fi 7 FEMs for customers of their DX4 Wi-Fi chipset. MediaTek's DX4 chipset and Qorvo's Wi-Fi 7 FEMs are optimized to deliver superior performance for flagship and mass-market smartphones, Qorvo says.

Qorvo also expanded its ultra-wideband wins in the Android ecosystem to include an additional handset customer. Motorola's Moto X50 Ultra, which launched in the June quarter, features Qorvo's ultra-wideband system-on-a-chip (SoC). "This is our first win in a mid-tier smartphone and is an early indicator of ultra-widebands proliferating across mass-market smartphone portfolios," says Bruggeworth.

The September quarter and, to a lesser degree, December quarter will benefit from a higher mix of customized solutions for flagship-tier phones. That product mix generally includes a higher amount of externally sourced silicon and SOI content.

Outlook – sequential increases in revenue, gross margin and EPS

For its fiscal second-quarter 2025 (to end-September 2024), Qorvo expects revenue to rise sequentially to $1.025bn (plus or minus $25m), although this will still be down slightly year-on-year due mainly to a hiatus in Android smartphone revenues, following ramps in first-half calendar 2024 for key models including both Samsung's S24 (involving over $5 of content) and Google's Pixel ($15 of content).

Gross margin should recover to 46–47%, due mainly to the product mix (since inventories of higher-cost Android 5G mass-market product have sold through, mostly by end-June) but also aided by the impact of under-utilization lessening to about 100 basis points or less (then becoming negligible for the second half of the fiscal year). "The September quarter and, to a lesser degree, December quarter will benefit from a higher mix of customized solutions for flagship-tier phones," says Brown. "That product mix generally includes a higher amount of externally sourced silicon and SOI [silicon-on-insulator] content. It is not impacted by internal utilization levels," he adds. "That compares to our prior two quarters where revenue was comprised of a larger mix of high-cost standard products that were burdened by prior periods of under-utilization."

Operating expenses are projected to rise sequentially by $10.5m to $275m, driven mainly by about $10m from the firm's digital transformation. "During fiscal 2025, we continue to expect about $40m of expense related to this project," says Brown.

Diluted earnings per share should more than double to $1.75–1.95 for the September quarter.

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Guerrilla RF's second-quarter 2024 revenue grows 61.7% year-on-year to a record $6.1m

Gross margin rises from 59% to 65.3%

For second-quarter 2024, Guerrilla RF Inc (GRF) of Greensboro, NC, USA has reported revenue of $6.1m, up 61.7% on $3.8m a year ago. The firm develops and manufactures radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless OEMs in markets including network infrastructure for 5G/4G macro and small-cell base stations, SATCOM, cellular repeaters/DAS, automotive telematics, military communications, navigation, and high-fidelity wireless audio.

Automotive Market product sales continued to be soft, falling to 31% of total revenue, down from 57% for full-year 2023.

Wireless Infrastructure grew to 35% of total revenue, up from 9% for full-year 2023.

"Even though we are seeing weakness in the Automotive Market, increased 5G deliveries enabled us to reach a new revenue record of $6.1m," says founder & CEO Ryan Pratt.

Gross margin rose from 59% a year ago to 65.3%. Operating expenses have been cut further, from $5.66m to $5.19m. This has contributed to operating loss being cut from $3.4m a year ago to $1.2m.

Net cash used in operating activities narrowed from $3.1m a year ago to $1.2m.

Adjusted EBITDA loss (before interest expense, provision for income taxes, depreciation and amortization) has been cut from $2.68m a year ago to just $0.472m. "The management team is pleased with this progress towards EBITDA breakeven as it targets achieving sustained positive operating cash flow," says founder & CEO Ryan Pratt. Cash reserves have fallen from $0.78m a year ago to $0.64m.

"During the quarter we continued to execute on our growth plans, releasing 12 new products into production and expanding our opportunities in the Catalog Markets and Infrastructure Markets with the acquisition of a GaN device portfolio," says Pratt. At the end of April, Guerrilla RF completed the strategic acquisition of the portfolio of gallium nitride power amplifiers and front-end modules of Singapore-based Gallium Semiconductor — which designs and manufactures RF GaN products for 5G mobile communications, aerospace & defense, and industrial, scientific & medical (ISM) applications — opening up opportunities in the telecom, radar and industrial markets.

Product backlog (sales that have been committed to by customers but not yet completed, shipped or invoiced) was $5m at the end of Q2/2024, down from $5.5m a year ago. "We anticipate the Automotive Market weakness to continue throughout 2024 and, as a consequence, are reducing our revenue guidance by 5% to $20–25m for the full-year 2024," says Pratt. "Having generated $11.2m in revenue for the first half of 2024, I believe we are well positioned to meet our revised revenue guidance of $20–25m for 2024 even though Q3 is historically our softest quarter."

Since the end of Q2/2024, on 5 August, Guerrilla RF completed a $22m private placement with a single institutional investor, raising net cash proceeds of about $21.6m (after deduction of expenses). "We plan to use the new capital to accelerate the company's growth, pay down outstanding debt and strengthen our competitive position through investing in new market penetration, expanded product offerings, additional R&D initiatives, and purchases of new capital equipment," says Pratt.

The firm has also restructured its primary credit facility by reducing the outstanding principal balance and interest rate while extending the maturity until the end of 2028.

www.guerrilla-rf.com

Guerrilla RF raises $22m in private placement with institutional investor

Capital to fund growth plan

Guerrilla RF has closed a private placement with a single institutional investor generating gross proceeds of $22m.

Founded in 2013, Guerrilla RF develops and manufactures radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless OEMs in markets including network infrastructure for 5G/4G macro and small-cell base stations, SATCOM, cellular repeaters/DAS, automotive telematics, military communications, navigation, and high-fidelity wireless audio. The firm has a portfolio of 100+ RF and microwave devices (with 50+ new products in development). Shipments exceed shipped 200 million units.

"With this investment, I believe that Guerrilla RF has the necessary resources to drive significant growth," says CEO & founder Ryan Pratt. "We are excited by the alignment of this investment with those of our existing shareholders."

www.guerrilla-rf.com

Skyworks' margins rebound despite a more-than-seasonal decline in revenue from largest customer

Mobile revenue to grow 20% in September quarter as inventory levels and order patterns normalize

For its fiscal third-quarter 2024 (to 28 June), Skyworks Solutions Inc of Irvine, CA, USA (which manufactures analog and mixed-signal semiconductors) has reported revenue of $905.5m, above the $900m guidance but down 13.4% on $1046m last quarter (normally Skyworks' seasonally weakest quarter) and 15.5% on $1071.2m a year ago.

Revenue from Skyworks' largest customer has fallen sequentially by "a little bit more than normal seasonality" (shrinking from 68% of total revenue last quarter to 65%) after some build-up of inventory in March–April. "So, we pushed the brakes in June," says senior VP & chief financial officer Kris Sennesael.

Mobile product revenue hence fell further, by 21% sequentially (below the normal seasonal weakness), falling from 66% to 61% of total revenue while Skyworks cleared out the excess inventory.

Broad Markets product revenue rose by a modest 1% sequentially for a second consecutive quarter since bottoming in the December quarter, rising further from 34% to 39% of total revenue. Skyworks under-shipped natural demand while allowing the distribution channel and customers to consume excess inventory and normalize in certain end-markets including near-term inventory corrections in the wireless infrastructure, automotive and industrial sectors.

On a non-GAAP basis, gross margin was 46%, down on 47.5% a year ago but rebounding from last quarter's low of 45%. This reflects: ongoing cost-reduction actions internally as well as externally with suppliers (including yield improvements and test time reductions); a favorable shift in product mix (from Mobile to higher-margin Broad Markets, as the latter recovers); and higher factory utilization rates (after a sixth consecutive quarter of reducing internal inventory, from $835.5m to $822.8m).

Operating expenses have risen further, from $192m (18.4% of revenue) last quarter to $197m (21.8% of revenue). This was towards the top end of the targeted $192–198m range, reflecting strategic investments in technology and product roadmaps.

Net income has fallen further, from $276.3m ($1.73 per diluted share) a year ago and $250.7m ($1.55 per diluted share) last quarter to $195m ($1.21 per diluted share).

"Skyworks generated solid results and strong profitability consistent with our guidance," says chairman, CEO & president Liam K. Griffin.

Operating cash flow was $273.5m (operating cash flow margin of 30.2%), down from $305.7m a year ago.

Capital expenditure has been reduced further from $31.3m a year ago and $27.6m last quarter to $24m (less than 3% of revenue), as Skyworks has got past the years of spending 10–12% of revenue to build out its manufacturing assets (especially its filter operation, as well as its back-end operation involving complex integration, assembly & test). The firm is now focusing more on creating additional capacity through operational improvements (including driving efficiency, yield improvements, test time reductions, and die shrinks) rather than adding more CapEx.

Free cash flow was hence $249.1m, down on $274.4m a year ago, although free cash flow margin rose from 25.6% to 27.5%. "We continue to drive robust cash flow through consistent levels of profitability, careful working capital management and moderating CapEx intensity," says Sennesael.

During fiscal Q3/2024, Skyworks paid $109m ($0.68 per share of common stock) in dividends. Also, the firm restarted its share buyback program, repurchasing 764,000 shares of common stock for a total of $77m.

Despite this, cash and investments grew further during the quarter, from $1205.4m to $1283.9bn. Debt remains about $994m (down from $1292.3m a year ago).

Dividend increase and payment

"We remain committed to delivering shareholder value through a disciplined approach to capital allocation," says Sennesael. "Given our conviction in Skyworks' long-term strategic outlook and consistent strong cash generation, we announced a 3% increase to our quarterly dividend [from $0.68 per share last quarter] to $0.70 per share [a 2.4% dividend yield]." This is payable on 10 September, to stockholders of record at the close of business on 20 August.

June-quarter business highlights

Business highlights during fiscal Q3 included:

- securing 5G content for premium Android smartphones including Google Pixel 8a, Samsung Galaxy M, Oppo Reno12 and several others;
- supporting the launches of Wi-Fi 7 tri-band routers and access points with NETGEAR, TP-Link and Cambium Networks; and
- accelerating the design-win pipeline in automotive, including telematics, infotainment and CV2X.

September-quarter outlook

For fiscal fourth-quarter 2024 (to end-September), Skyworks expects revenue to rebound to $1–1.04bn.

"The largest customer will be slightly above 65% of total revenue, and it will be up on or about 20% sequentially, as we execute and support our large customer in

ramping up new products that they are bringing to market," says Sennesael.

Mobile product revenue should be up about 20% sequentially. "We are seeing encouraging signs that inventory levels and order patterns are normalizing," notes Griffin.

"In Broad Markets, we expect modest improvement, representing three consecutive quarters of sequential growth," Sennesael says.

"We've accelerated revenue growth. We will have better utilization in the factories and that will exponentially result in further gross margins improvements," he adds.

Gross margin is projected to rise by 50 basis points sequentially to 46–47%. "We anticipate gross margin expansion during the remainder of 2024 [in the December quarter], driven by our cost-reduction actions, favorable mix shift [to higher-value products, with growth for higher-margin Broad Markets products] and higher utilization rates."

Operating expenses should increase further to $197–203m as Skyworks continues to make strategic investments in technology and product roadmaps in both Mobile and Broad Markets in order to drive share gains and increase diversification.

Diluted earnings per share are expected to rebound to $1.52.

"We do expect, beyond the September quarter, further sequential growth [going into the December quarter] and actually an acceleration of that sequential growth, returning back to year-over-year growth in our Broad Markets business," says Sennesael.

"In Mobile, we are energized about the prospects of generative AI, catalyzing a meaningful smartphone replacement cycle and driving higher levels of RF complexity," says Griffin. "We expect new AI features will only be available on the latest next-generation smartphones, potentially fueling a multi-year upgrade cycle. We are uniquely positioned, given our long-standing relationships with the leading smartphone OEMs, best-in-class RF technology and a global manufacturing footprint," he adds.

"In Broad Markets, we anticipate modest growth for the balance of 2024. In edge IoT, where demand is improving, we have a strong design-win funnel for WiFi 7 systems and we expect a healthy multi-year upgrade cycle, given faster data transfer speeds and lower latency," says Griffin.

"In traditional data-center and wireless infrastructure, inventory levels remain elevated, which is prolonging the recovery as we continue to under-ship natural demand. However, once industry conditions stabilize, we expect end customers to replenish inventory back to normal levels. In automotive and industrial, we are working through excess inventory levels but seeing signs of stabilization. We remain bullish on our design-win pipeline across our power isolation, RF and digital broadcast solutions for the connected car and EV markets," he adds.

AI-enabled smartphones will further elevate the technological burden, resulting in premium for on-board space, requiring higher levels of integration and advanced packaging, energy efficiency translating to lower power consumption, low latency, pushing the boundary of signal integrity and higher throughput and connectivity upgrades with 5G Advanced and 6G. These increased technological demands play to Skyworks' strengths

"Over the medium to long term, we believe generative AI will migrate to the edge. Most significantly, we believe the rollout of compelling AI applications will drive a smartphone replacement cycle, one that is currently the longest in history, standing at over four years, and leading to higher levels of RF complexity," says Griffin. "In edge IoT, AI-enabled devices increasingly incorporate machine learning to support language and computer vision models. Robust RF is critical to facilitate the continuous training to inference between device and cloud," continues Griffin.

"Over time, automotive OEMs will train on big data in the cloud and screen software downloads through over-the-air updates, supporting higher levels of autonomy in vehicles. To facilitate these trends, OEMs need power and extremely fast RF connectivity. For next-generation data centers, complex workloads supporting large language models will propel upgrade cycles in switch, compute and optical networks. Over the medium to long term, Skyworks is well positioned with our high-performance timing solutions, targeting 800 gig and 1.6 terabit Ethernet switches and optical modules," he believes.

"Ultimately, our view is there will be a hybrid approach to AI computing, a combination of on-device and cloud-based. Data can be trained in the cloud and deployed to the edge for inference on new inputs. More complex AI tasks will be processed in the cloud and less complex, on-device," Griffin says.

"In addition to these new usage cases, AI-enabled smartphones will further elevate the technological burden, resulting in premium for on-board space, requiring higher levels of integration and advanced packaging, energy efficiency translating to lower power consumption, low latency, pushing the boundary of signal integrity and higher throughput and connectivity upgrades with 5G Advanced and 6G. These increased technological demands play to Skyworks' strengths, given our deep customer relationships, exceptional engineering talent and strong IP portfolio."

www.skyworksinc.com

GlobalWafers assigned $400m CHIPS Act funding to boost onshore wafer manufacturing in USA

Conversion of silicon epi facility to 150mm & 200mm SiC epi joins first US 300mm silicon wafer plant and expanded SOI plant

The US Department of Commerce has signed a non-binding preliminary memorandum of terms (PMT) to provide GlobalWafers America LLC and MEMC LLC (subsidiaries of GlobalWafers Co Ltd of Hsinchu, Taiwan, the world's third largest supplier of semiconductor wafers) up to $400m in proposed direct funding under the CHIPS and Science Act to help onshore critical semiconductor wafer production.

Currently, just five companies, including GlobalWafers, hold over 80% of the global 300mm silicon wafer manufacturing market, and about 90% of silicon wafers are sourced from East Asia.

The proposed CHIPS investment would support the construction of new wafer manufacturing facilities and the creation of 1700 construction jobs and 880 manufacturing jobs, and support projects with total capital expenditures of about $4bn across Texas and Missouri.

"GlobalWafers will play a crucial role in bolstering America's semiconductor supply chain by providing a domestic source of silicon wafers," says US Secretary of Commerce Gina Raimondo.

The proposed funding would involve GlobalWafers building and expanding facilities in:

- Sherman, Texas: Establish the first 300mm silicon wafer manufacturing facility for advanced chips in the USA.
- St. Peters, Missouri: Establish a facility to produce 300mm silicon-on-insulator (SOI) wafers.

Further, GlobalWafers plans to convert part of its existing silicon epitaxy wafer manufacturing facility in Sherman, Texas to silicon carbide (SiC) epitaxy wafer manufacturing, producing 150mm and 200mm SiC epitaxy wafers.

Supporting the development of a local semiconductor workforce in Texas, GlobalWafers is a member of the Southern Methodist University-led Texoma Tech Hub and is involved in the North Texas Semiconductor Workforce Development Consortium led by the University of Texas Dallas. GlobalWafers is also part of a partnership with Sherman High School, Denison High School, and Grayson College to establish an electronics lab at the schools that provide targeted training towards technician certifications required for new hires in the semiconductor industry.

Likewise, in St. Peters, MEMC is developing an apprenticeship program for Maintenance Technicians with the National Institute for Industry and Career Advancement (NIICA) and local high schools. Further, MEMC is collaborating with St. Charles Community College on a program named MegaTech, which supports dual-enrolled high school students as they step into careers involving advanced manufacturing and automation.

As explained in its first Notice of Funding Opportunity, the Department may offer applicants a PMT on a non-binding basis after satisfactory completion of the merit review of a full application. The PMT outlines key terms for a potential CHIPS incentives award, including the amount and form of the award.

The amount of the award is subject to due diligence and negotiation of award documents and is conditional on the achievement of certain milestones.

www.sas-globalwafers.com
www.nist.gov/chips/notice-funding-opportunity-commercial-fabrication-facilities

MACOM dedicates Lowell Campus to John Ocampo

Dedication ceremony honors late chairman

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) has held a special dedication ceremony to inaugurate the John L. Ocampo Technology Campus, in memory of the late John Ocampo, who passed away in November 2023. The campus in Lowell is home to one of MACOM's semiconductor wafer fabrication facilities, research and development centers, and its corporate headquarters.

John Ocampo.

Ocampo served as a director and chair of the board of directors of MACOM Technology Solutions Holdings Inc since March 2009, and played a pivotal role in the firm's growth, transformation and success over that time. Throughout his career, John was widely known as an innovator and successful entrepreneur within the semiconductor industry.

"John was instrumental in transforming MACOM into a leading technology company in the semiconductor industry," comments president & CEO Stephen G. Daly. "Dedicating this campus to John's legacy is a fitting tribute to his passion for engineering and technology and his immeasurable contributions to MACOM."

www.macom.com

onsemi unveils complete power solution to improve energy efficiency for data centers

T10 PowerTrench family and EliteSiC 650V MOSFETs combine to reduce power losses during energy conversion

onsemi of Scottsdale, AZ, USA claims that the combination of its latest-generation T10 PowerTrench family and EliteSiC 650V MOSFETs create a solution that offers unparalleled efficiency and high thermal performance in a smaller footprint for data-center applications.

As data centers become increasingly power-hungry to support the tremendous processing requirements of AI workloads, the need for boosting energy efficiency is paramount.

Compared with a typical search engine request, an AI-supported engine request requires more than 10x the power, leading to data-center power needs expected to reach an estimated 1000TWh globally in less than two years (according to the IEA report 'Electricity 2024'). To process one AI-supported request, energy is converted four times from the grid to the processor, which can result in an energy loss of about 12%. Using the T10 PowerTrench family and EliteSiC 650V solution, data centers are able to reduce power losses by an estimated 1%. If implemented in data centers globally, the solution could reduce energy consumption by 10TWh annually (equivalent of the energy required to fully power nearly one million homes per year (based on annual household power consumption from US Energy Information Administration).

The EliteSiC 650V MOSFET is said to offer superior switching performance and lower device capacitances to achieve higher efficiency in data centers and energy storage systems. Compared with the previous generation, the new-generation silicon carbide (SiC) MOSFETs have halved the gate charge and reduced both the energy stored in output capacitance (E_{oss}) and the output charge (Q_{oss}) by 44%. With no tail current during turn-off and superior performance at high temperatures, they can also significantly reduce switching losses compared with super-junction (SJ) MOSFETs. This allows customers to downsize system components while increasing the operating frequency, resulting in an overall reduction in system costs.

Separately, the T10 PowerTrench family is engineered to handle high currents, crucial for DC–DC power conversion stages, and offers increased power density and superior thermal performance in a compact footprint. This is achieved through a shield gate trench design with an ultra-low gate charge and an on-resistance ($R_{DS(on)}$) of less than 1mΩ. Additionally, the soft recovery body diode and lower Q_{rr} effectively minimizes ringing, overshoots and electrical noise to ensure optimal performance, reliability and robustness under stress. The T10 PowerTrench family also meets the stringent standards required for automotive applications.

The combined solution also meets the stringent Open Rack V3 (ORV3) base specification required by hyperscale operators to support the next generation of high-power processors.

"AI and electrification are reshaping our world and skyrocketing power demands. Accelerating innovation in power semiconductors to improve energy efficiency is key to enabling these technological megatrends. This is how we power the future responsibly," says Simon Keeton, group president, Power Solutions Group, at onsemi. "Our latest solution can significantly reduce power losses that occur during the energy conversion process and have a meaningful impact on the demands for the next generation of data centers."

www.onsemi.com/

onsemi launches EliteSiC M3e MOSFET technology

Introduction of future SiC generations to be accelerated through 2030

In the face of escalating climate crises and a dramatic rise in global energy demands, governments and industries are committing to ambitious climate goals aimed at mitigating environmental impact and securing a sustainable future. Key to these efforts is the transition to electrification to reduce carbon emissions and embrace renewable energy resources.

In a step towards accelerating this global transition, intelligent power and sensing technology firm onsemi of Scottsdale, AZ, USA has introduced EliteSiC M3e MOSFETs as its latest-generation silicon carbide technology platform, sampling now in the industry-standard TO-247-4L package. The firm also disclosed plans to release multiple additional generations through 2030.

"The future of electrification is dependent on advanced power semiconductors. Today's infrastructure cannot keep up with the world's demands for more intelligence and electrified mobility without significant innovations in power. This is critical to the ability to achieve global electrification and stop climate change," says Simon Keeton, group president of onsemi's Power Solutions Group. "We are setting the pace for innovation, with plans to significantly increase power density in our silicon carbide technology roadmap through 2030 to be able to meet the growing demands for energy and enable the global transition to electrification."

The firm reckons that its EliteSiC M3e MOSFETs will play a fundamental role in enabling the performance and reliability of next-generation electrical systems at lower cost per kW, influencing the adoption and effectiveness of electrification initiatives. With the ability to operate at higher switching frequencies and voltages while minimizing power conversion losses, this platform is suitable for a wide range of automotive and industrial applications such as electric vehicle powertrains, DC fast chargers, solar inverters and energy storage solutions. Additionally, the EliteSiC M3e MOSFETs can enable the transition to more efficient, higher-power data centers to meet the exponentially increasing energy demands that power a sustainable artificial intelligence engine, onsemi adds.

Platform delivers efficiency leap

Onsemi says that, through its design engineering and manufacturing capabilities, the EliteSiC M3e MOSFETs achieve a significant reduction in both conduction and switching losses on the field-proven planar architecture. Compared to previous generations, the platform can reduce conduction losses by 30% and turn-off losses by up to 50% (based on internal testing, compared with the EliteSiC M3T MOSFETs). By extending the life of SiC planar MOSFETs and delivering what is claimed to be industry-leading performance with EliteSiC M3e technology, onsemi says that it can ensure the robustness and stability of the platform for critical electrification applications.

The EliteSiC M3e MOSFETs also offer what is claimed to be the industry's lowest specific on-resistance (RSP) with short-circuit capability which is critical for the traction inverter market that dominates SiC volume. Packaged in onsemi's discrete and power modules, the 1200V M3e die delivers substantially more phase current than previous EliteSiC technology, resulting in about 20% more output power in the same traction inverter housing. Conversely, a fixed power level can now be designed with 20% less SiC content, saving costs while enabling the design of smaller, lighter and more reliable systems.

Additionally, onsemi provides a broader portfolio of intelligent power technologies including gate drivers, DC–DC converters and e-Fuses to pair with the EliteSiC M3e platform. The end-to-end onsemi combination of optimized, co-engineered power switches, drivers and controllers are said to enable advanced features via integration, lowering overall system cost.

Accelerating EliteSiC product development roadmap

Global energy demands are projected to soar over the next decade, making the need for increased power density in semiconductors paramount. onsemi says that its innovation across its silicon carbide roadmap — from die architectures to novel packaging techniques — will continue to address the general industry demand for increased power density.

With each new generation of silicon carbide, cell structures will be optimized to efficiently push more current through a smaller area, increasing power density. When coupled with the company's packaging techniques, onsemi says that it will be able to maximize performance and reduce package size. By applying the concepts of Moore's Law to the development of silicon carbide, onsemi says that it can develop multiple generations in parallel and accelerate its roadmap to bring several new EliteSiC products to market at an accelerated pace through 2030.

"We are applying our decades of experience in power semiconductors to push the boundaries of speed and innovation in our engineering and manufacturing capabilities to meet the rising global energy demands," says Dr Mrinal Das, senior director of technical marketing in onsemi's Power Solutions Group. "There is a huge technical interdependency between the materials, device and package in silicon carbide. Having full ownership over these key aspects allows us to have control over the design and manufacturing process and bring new generations to market much faster."

www.onsemi.com/solutions/technology/silicon-carbide-sic

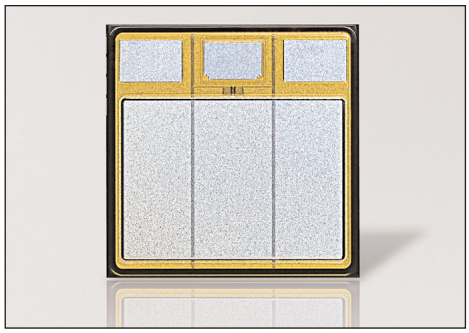
onsemi to supply Volkswagen with SiC-based power box solution across EV brands

onsemi to be primary provider of fully optimized power system solution based on EliteSiC M3e platform

Intelligent power and sensing technology firm onsemi of Scottsdale, AZ, USA has signed a multi-year deal with Volkswagen Group to be the primary supplier of a complete power box solution as part of its next-generation traction inverter for its Scalable Systems Platform (SSP). The solution features silicon carbide-based technologies in an integrated module that can scale across all power levels — from high-power to low-power traction inverters to be compatible for all vehicle categories.

"By offering a complete power system solution that encompasses the entire power sub-assembly, we provide Volkswagen Group with a single, simplified modular and scalable platform that maximizes efficiency and performance for their vehicle lineup," says president & CEO Hassane El-Khoury. "This new approach allows for the customization of power needs and the addition of features for different vehicles without compromising on performance, all while reducing cost."

Based on its latest-generation EliteSiC M3e MOSFETs, onsemi's unique power box solution can handle more power in a smaller



onsemi's EliteSiC M3e MOSFET.

package, which significantly reduces energy losses, says onsemi. The inclusion of three integrated half-bridge modules mounted on a cooling channel further improves system efficiency by ensuring that heat is effectively managed from the semiconductor to the coolant encasement. This leads to better performance, improved heat control and increased efficiency, allowing EVs to drive further on a single charge, the firm adds. By using this integrated solution, Volkswagen can easily transition to future EliteSiC-based platforms.

"We are very pleased to have onsemi as a strategic supplier for the power box of the traction inverter for our first tranche in the SSP platform," comments Dirk Große-Loheide, member of the Extended Executive Committee Group Procurement and member of the board Volkswagen Brand for 'Procurement'. "onsemi has convinced us with a deeply verticalized supply chain from the growth of the raw material up to the assembly of the power box," he adds.

"On top of the verticalization, onsemi has furthermore provided a resilient supply concept with regional silicon carbide fabs across Asia, Europe and the USA," notes Till von Bothmer, senior VP VW Group Procurement for Powertrain. "In addition, onsemi will continuously provide the latest SiC generation to ensure competitiveness."

Volkswagen Group will also benefit from onsemi's planned investment to expand its silicon carbide manufacturing in the Czech Republic. The investment will establish an end-to-end production facility in Europe for the traction inverter power system. The proximity of onsemi's facility can fortify Volkswagen's supply chain while improving logistics and allowing for faster integration into the manufacturing process, onsemi adds.

www.onsemi.com

UK–Swiss joint funding for project to develop SiC power MOSFET gate technology using ALD oxides

Hitachi Energy Switzerland collaborating with Oxford Instruments and University of Warwick

After the UK and Switzerland governments signed a memorandum of understanding in 2022 to harness collective strengths of the two countries, followed recently by a first joint funding call, 26 projects to enhance UK and Swiss collaborations and capabilities in emerging fields of technology have been selected to receive total funding of £7.8m from Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation) and CHF9.1m from the Swiss innovation agency Innosuisse.

Development of SiC power MOSFET gate technology using ALD oxides

One of the projects involves Zurich-based Hitachi Energy Switzerland collaborating with UK-based Oxford Instruments Plasma Technology (OIPT) and the University of Warwick (UoW).

Hitachi Energy Switzerland has a track record of developing automotive-grade silicon carbide (SiC) power metal-oxide-semiconductor field-effect transistors (MOSFETs), with a reputation for products with novel MOS interfaces. OIPT has developed a novel oxide deposition process that uses a remote plasma source in a commercial atomic layer deposition (ALD) system. It has been demonstrated that this process is suitable for the formation of gate oxides in wide-bandgap semiconductors. A research team at the University of Warwick recently developed an ALD silicon dioxide (SiO_2) deposition process on SiC that has the potential to be commercialized. The project will bring together the three groups and their corresponding expertise to demonstrate the potential of ALD oxides in the formation of electric vehicle (EV)-grade 1.2kV SiC MOSFETs.

The aim of the project is to address one of the most pressing issues in the adaptation of this technique by fundamentally changing the way of forming a crucial part of the device, the gate oxide. Conventional dielectric and SiC interfaces suffer from a high density of defect states, hampering the further uptake of this technology. The proof-of-concept project will demonstrate the viability and advantages of utilizing ALD-deposited oxides (SiO_2 and high-k dielectrics such as aluminium oxide, Al_2O_3) in a commercial SiC MOSFET device.

Key aims of the project include:

- the first demonstration of a commercially relevant planar 1.2kV SiC MOSFET that contains OIPT's remote plasma ALD-deposited SiO_2 and high-k dielectric (for example Al_2O_3) gate oxides;
- demonstration of the interface quality (for example, high channel mobilities due to a low density of interface traps) in these structures through the extraction of key performance indicators such as specific on-resistance or channel mobilities;
- demonstration of process benefits by benchmarking with existing commercial products;
- long-term reliability testing on the demonstrator MOSFETs will demonstrate whether the ALD oxides remain stable over the lifetime of a commercial automotive semiconductor product;
- integration of the novel ALD oxidation process into a research-grade trench MOS capacitor and trench MOSFET structure.

www.hitachienergy.com
https://warwick.ac.uk/research/rtp/warwick-scientific-services/sectors/energy/powerelectronics/
https://plasma.oxinst.com

Penn State granted $600,000 to help fund Silicon Carbide Innovation Alliance

Appalachian Regional Commission grant to help build semiconductor workforce in Pennsylvania

The Appalachian Regional Commission (ARC) — an economic development partnership agency of the federal government and 13 state governments including Pennsylvania — has awarded $600,000 to Penn State University's Silicon Carbide Innovation Alliance (SCIA, launched in early April) to develop a series of educational courses, workshops and paid academic and industrial internships focused on workforce development in Pennsylvania for the growing semiconductor industry.

The SCIA is a coalition of industry leaders, academic institutions and government support led by Joshua Robinson, professor of materials science & engineering, of physics, of chemistry and of engineering science and mechanics at Penn State. The initiative aims to catalyze R&D of semiconductors such as silicon carbide (SiC).

However, the USA is currently not producing enough silicon carbide to meet demand, which is expected to be two to three times higher by 2030. Part of the solution is developing an American workforce in SiC research and production, which the ARC grant is designed to address by helping to build this workforce in Pennsylvania.

"The proposed project represents progress toward addressing a regional and national educational need for next-generation workers in the semiconductor industry," Robinson says. "Penn State aims to broaden impact by developing hands-on training in semiconductor characterization that can be developed into online workforce development content accessible to the entire commonwealth of Pennsylvania across all levels of education."

The SCIA partnered in applying for the grant with SEDA-Council of Governments, a community and economic development agency in

Lewisburg, and one of seven Local Development Districts developed in collaboration between local governments, the state of Pennsylvania, federal agencies and ARC. The aim is to enhance the quality of life and economic advantage for residents and businesses in the 11 central Pennsylvania counties through its partnerships and initiatives. In addition, Robinson notes that SCIA worked with a variety of semiconductor industry partners.

The SCIA's industry partners include HORIBA, onsemi, Morgan Advanced Materials, Thermo Fisher Scientific, Coherent and Malvern Panalytical. "Each partner will provide guidance and leadership in creating these workforce development assets and have committed cash and other resources to ensure the workshops and courses align with our state-of-the-art educational abilities and facilities," says Robinson.

One such facility at Penn State is the Materials Characterization Laboratory (MCL), which maintains a broad range of analytical instruments for characterizing the structure, chemistry and composition of materials from the macro to nanoscale. The MCL also conducts educational activities that fit into the goals of the grant.

"Each year the MCL supports researchers from more than 45 different academic departments at Penn State," notes Josh Stapleton, MCL director and associate research professor. "Most often we support these researchers by training them to become independent operators of these instruments so that they can advance their research. The MCL specializes in providing training focused on the practical and hands-on skills our students need."

The MCL also facilitates collaborations with industry, featuring an extensive list of enterprise partners including those in the semiconductor industry.

"Additionally, we already work with more than 85 different companies each year," Stapleton says. "The combination of knowledge of what industry needs and our decades of experience providing practical characterization training has us well positioned to support the training of Pennsylvania's new semiconductor workforce," he reckons.

The grant funds were matched with nearly $600,000 in industry cash, as well as a University cash match and in-kind equipment, for a total of more than $1.4m over three years. Robinson envisions that this money will enable the SCIA to become a hub for economic development and research innovation in the Appalachian region, primarily by establishing a workforce platform that will attract companies from around the USA and talented corporate and academic researchers and students. Specifically, grant money will be used to develop a series of educational courses, workshops and paid internships geared towards students and existing workers.

Along with Robinson, co-principal investigators on the project include Suzanne Mohney, professor of materials science & engineering and of electrical engineering, and Max Wetherington, assistant research professor of molecular spectroscopy.

www.scia.psu.edu

Russia's Element and ETU LETI form joint venture Letiel

JV to focus on SiC-based power devices and photon integrated circuits

The joint venture Letiel LLC has been formed, owned 51% by Russian microelectronics company PJSC Element and 49% by St Petersburg Electrotechnical University LETI (ETU LETI), according to data from the Unified State Register of Legal Entities (USRLE), reports Moscow-based news agency Interfax. The JV is headed by Element's technology development director Konstantin Okunev.

"We plan to actively develop the area of high-tech power semiconductor devices and in future take leading positions among global manufacturers of silicon carbide devices," says Element's president Ilya Ivantsov. "The objective of the joint venture with LETI will be to develop and research technologies to produce SiC devices, on the basis of which we will be able to build a modern and competitive power electronics product and technology line for various sectors of industry."

The new JV will perform R&D on SiC-based power devices, for application in electric vehicles, aircraft navigation systems and other sectors.

The venture also plans to study and design promising photon integrated circuits (highly stable optical signal generators on ring resonators), used in equipment for cellular networks, satellite systems and radio-location.

"Mass production of solutions in the area of the electronic component base for power electronics and photon integrated circuits will be rolled out at the facilities of Element Group's new plant in Zelenograd," the firm says.

Element was formed in 2019 from 19 microelectronics design, development and manufacturing assets belonging to investment group Sistema PJSFC and state corporation Rostec. Key portfolio firms are chip factory Mikron and microchip, molecular electronics research institute NIIME and electronics research institute NIIET. The group now includes about 30 enterprises.

https://gkelement.ru/

SemiQ adds S7 package option to QSiC 1200V power module family

Optimized for new designs and improved operation in legacy applications

SemiQ Inc of Lake Forest, CA, USA — which designs, develops and manufactures silicon carbide (SiC) power semiconductors and 150mm SiC epitaxial wafers for high-voltage applications — has added an S7 package to its QSiC family of 1200V, half-bridge MOSFET and Schottky diode SiC power modules. The new products further enhance design flexibility by providing compact, high-efficiency, high-performance options for new designs while supporting drop-in-replacement in legacy systems that require more efficient operation.

The additions see the availability of a 529A MOSFET module (GCMX003A120S7B1), a 348A MOSFET module (GCMX005A120S7B1), and two low-noise SiC Schottky diode half-bridge modules (GHXS300A120S7D5 and GHXS400A120S7D5) in an S7 package with industry-standard 62mm footprints and a height of just 17mm.

The new package addresses the size, weight and power requirements of demanding applications ranging from induction heaters, welding equipment and uninterruptible power supplies (UPS) to photovoltaic and wind inverters, energy storage systems, high-voltage DC–DC converters and battery charging systems for electric vehicles (EVs). As well as the compact form factor of the modules themselves, high-efficiency, low-loss operation helps to reduce system heat dissipation and supports the use of smaller heatsinks.

"Our aim is to provide a comprehensive portfolio of SiC technologies that allow designers to optimize the efficiency, performance and size of today's demanding applications," says president Dr Timothy Han. "Adding new package option to our 1200V QSiC MOSFET and SiC diode module families further extends the choices available to designers who need to create completely new applications or who are looking to upgrade legacy systems without significant redesign."

Crafted from high-performance ceramics, SemiQ's modules are claimed to achieve exceptional performance levels and support increased power density and more compact designs, especially in high-frequency and high-power environments.

To guarantee a stable gate threshold voltage and premium gate oxide quality for each module, SemiQ conducts gate burn-in testing at the wafer level. In addition to the burn-in test, which contributes to mitigating extrinsic failure rates, various stress tests – including gate stress, high-temperature reverse bias (HTRB) drain stress, and high-humidity, high-voltage, high-temperature (H3TRB) — are employed to attain the necessary automotive- and industrial-grade quality standards. All parts have undergone testing surpassing 1400V.

www.semiq.com/module-packages

Vishay introduces 16 new Gen 3 1200V silicon carbide Schottky diodes spanning currents of 5–40A

MPS design yields lower forward voltage drop, capacitive charge and reverse leakage current, boosting efficiency and reliability for switching power designs

Discrete semiconductor and passive electronic component maker Vishay Intertechnology Inc of Malvern, PA, USA has introduced 16 new Gen 3 1200V silicon carbide (SiC) Schottky diodes. Featuring a merged PIN Schottky (MPS) design, the devices combine high surge current robustness with low forward voltage drop, capacitive charge and reverse leakage current to increase efficiency and reliability in switching power designs.

The new-generation SiC diodes consist of 5–40A devices in the TO-220AC 2L, TO-247AD 2L and TO-247AD 3L through-hole and D2PAK 2L (TO-263AB 2L) surface-mount packages. The diodes offer a low capacitance charge down to 28nC, while their MPS structure — which features a backside thinned via laser annealing technology — delivers a reduced forward voltage drop of 1.35V. In addition, the devices' low typical reverse leakage current down to 2.5µA at 25°C reduces conduction losses, ensuring high system efficiency during light loads and idling. Unlike ultra-fast diodes, the Gen 3 devices have virtually no recovery tail, which further improves efficiency.

Typical applications for the diodes include AC/DC PFC and DC/DC ultra-high-frequency output rectification in FBPS and LLC converters for solar power inverters; energy storage systems; industrial drives and tools; and data centers.

For the harsh environments of these applications, the devices combine operating temperatures up to +175°C with forward surge ratings up to 260A for high robustness. In addition, diodes in the D2PAK 2L package feature a molding compound with a high CTI≥600, ensuring excellent electrical insulation at elevated voltages.

Offering high reliability, the RoHS-compliant and halogen-free devices have passed higher-temperature reverse bias (HTRB) testing of 2000 hours and temperature cycling testing of 2000 thermal cycles.

Samples and production quantities of the new SiC diodes are available now, with lead times of 13 weeks.

www.vishay.com

Infineon opens first phase of largest SiC power semiconductor fab in Malaysia

Malaysia's Prime Minister and Kedah State's Chief Minister attend inauguration

Infineon Technologies AG of Munich, Germany has officially opened the first phase of a new 200mm-wafer silicon carbide (SiC) power semiconductor fab at its Kulim 3 site in Malaysia. Malaysian Prime Minister The Right Honourable Dato' Seri Anwar Ibrahim and Chief Minister of the state of Kedah The Right Honourable Dato' Seri Haji Muhammad Sanusi Haji Mohd Nor joined Infineon's CEO Jochen Hanebeck to symbolically launch production.

The first phase of the fab, comprising an investment of €2bn and creating 900 jobs, will focus on the production of silicon carbide power semiconductors and will include gallium nitride (GaN) epitaxy.

The second phase, comprising an investment of up to €5bn, will create what is expected to become the world's largest 200mm SiC power semiconductor fab. Overall, up to 4000 jobs will be created.

"Since the demand for semiconductors will constantly rise, the investment in Kulim is highly attractive to our customers, who are backing it with their prepayments," says Infineon's CEO Jochen Hanebeck. "It also increases the resilience of the supply chain for critical components needed for the green transition"

Infineon has secured design wins worth about €5bn and has received about €1bn in prepayments from existing and new customers for the ongoing expansion of the Kulim 3 fab. These design wins include six OEMs in the automotive sector as well as customers in the renewable energy and industrial segments.

Kulim 3 will be closely connected to site in Villach, Austria, which is Infineon's global competence center for power semiconductors. Infineon already increased capacity for SiC and GaN power semiconductors in Villach in 2023. As 'One Virtual Fab' for wide-bandgap technologies, both manufacturing sites now share technologies and processes that allow for fast ramping and smooth and highly efficient operation, says Infineon.

Infineon's CEO Jochen Hanebeck, Malaysian Prime Minister YAB Dato' Seri Anwar Ibrahim and Chief Minister of the state of Kedah YAB Dato' Seri Haji Muhammad Sanusi Haji Mohd symbolically launch production of phase one of Infineon's 200mm SiC Power Fab. Witnessing the event are: Ng Kok Tiong, senior VP & managing director, Infineon Kulim; Dr Rutger Wijburg, chief operations officer of Infineon; Yang Berhormat Senator Tengku Datuk Seri Utama Zafrul Tengku Abdul Aziz, Minister of Investment, Trade & Industry Malaysia (MITI) and YB Dato' Seri Haji Norizan bin Khazali, Kedah State Chief Secretary (from right to left).

Aerial view of Infineon's SiC Power Fab in Kulim: The 200mm SiC power fab will strengthen Infineon's role as the global leader in power semiconductors.

The project also offers a high grade of resilience and flexibility, ultimately benefitting customers, it adds.

The expansion should benefit from economies of scale already achieved for 200mm manufacturing in Kulim. It will also complement Infineon's position in silicon, based on 300mm manufacturing in Villach and Dresden. Infineon is hence strengthening its technology across the entire spectrum of power semiconductors, in silicon as well as SiC and GaN. In addition, the investment in wide-bandgap capacity in Kulim strengthens the local ecosystem as part of the growing semiconductor hub Malaysia.

Infineon's operations in Malaysia began in 1973 in Melaka. In 2006, it opened Asia's first front-end fab in Kulim. The firm currently has more than 16.000 staff in Malaysia.

www.infineon.com

Daihen uses Infineon's 2000V SiC module in highest-power-density grid storage ground power conditioner

First product to achieve connection to storage batteries at DC link voltage of 1500V

Infineon Technologies AG of Munich, Germany that its CoolSiC 2000V modules have been selected by Daihen Corp of Tokyo, Japan for its unit-type power conditioners for grid storage batteries.

Both grid storage batteries and the power conditioners that are linked to them play a vital role in facilitating the wider adoption of renewable energy sources like solar and wind power generation. To enhance the effectiveness of power generation, storage and transmission, there has been increasing demand for higher-voltage storage batteries and power conditioners. Moreover, with the expansion of storage battery systems on a larger scale, finding suitable locations and minimizing construction costs have emerged as significant challenges.

The unit-type power conditioner for grid storage batteries launched by Daihen in March is said to be the industry's first product to achieve connection to storage batteries at a high DC link voltage of 1500V. The higher voltage enables the product to be used with large-capacity storage battery facilities, which has resulted in a 40% reduction (for grid storage batteries equivalent to 12MW/60MWh, with Daihen's power conditioner for 1000V storage batteries) in the footprint of grid storage batteries compared with the conventional product.

The high power density is achieved by using Infineon's 62mm CoolSiC MOSFET 2000V module (FF3MR20KM1H). In addition to the characteristics of silicon carbide that enable high voltage, better thermal dissipation and high power density, Infineon's SiC products feature M1H trench technology that increases the gate drive voltage range and provides high robustness and reliability against gate voltage spikes. Infineon was the pioneer in the industry to introduce the 2000V class for a SiC module. This has been instrumental in simplifying the inverter circuit configuration, the firm claims. Furthermore, the optimized 62mm package has led to a substantial reduction in system size, contributing to enhanced efficiency and performance, it adds.

"To increase the voltage of power conditioners, the circuit configuration of conventional 1200V devices had become complicated," notes Akihiro Ohori, general manager, Development Department, Energy Management System Division, Daihen. "However, by adopting Infineon's 2000V SiC modules, we were able to achieve a simplified circuit configuration and control design, thereby reducing development resources and the footprint," he adds.

www.infineon.com/coolsic

Mitsubishi Electric sampling 8W and 14W GaN MMIC power amplifier chips

Power levels and frequencies enable smaller, lower-power Ka-band SATCOM earth stations for higher data capacity

Tokyo-based Mitsubishi Electric Corp is sampling 8W and 14W gallium nitride (GaN) monolithic microwave integrated circuit (MMIC) power amplifiers, shipped as customer-board-friendly bare chips, suitable for use in emergency communications and Ka-band multi-carrier satellite-communication (SATCOM) earth stations.

While the mainstream frequency for satellite communications is currently the Ku-band (13–14GHz), the higher-frequency Ka-band (27.5-31GHz) offers multi-beam technology and much wider bandwidth for transmitting more data. The two new GaN MMIC power amplifiers will support the power levels and frequencies required for Ka-band satellite communications transmitters capable of handling large amounts of data.

In addition, due to a new high-output, high-efficiency GaN HEMT, Mitsubishi Electric's new chips are claimed to achieve unsurpassed miniaturization and increased power-added efficiency (PAE) of more than 20% at maximum linear power.

By adding more Ka-band products to its lineup, Mitsubishi Electric expects to meet the growing demand for high-capacity communications and to contribute to smaller and more power-efficient satellite communications earth stations.

The new products were exhibited at the IEEE MTT-S International Microwave Symposium (IMS) 2024 in Washington DC, USA (18–20 June).

www.ims-ieee.org
www.mitsubishielectric.com/en/products-solutions/semiconductors-devices

Infineon launches CoolGaN Drive product family of integrated single switches and half-bridges with integrated drivers

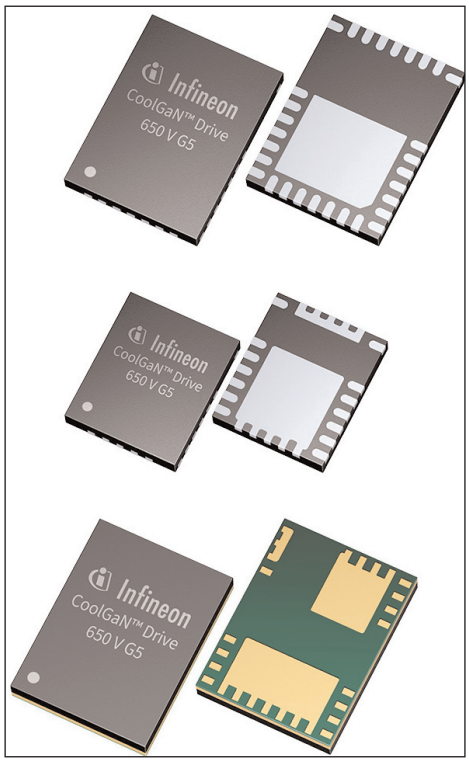
Single switches and half bridges with integrated drivers based on CoolGaN transistors 650V G5

Many different trends are taking center stage in both consumer electronics and industrial applications, such as portability, electrification, and weight reduction. All of these trends require compact and efficient designs. They also go hand in hand with unconventional PCB designs with severe space constraints that limit the use of external components.

To address these challenges, Infineon Technologies AG of Munich, Germany has expanded its GaN portfolio with the CoolGaN Drive product family, consisting of the CoolGaN Drive 700V G5 single switches (integrating one transistor plus gate driver in PQFN 5x6 and PQFN 6x8 packages) as well as the CoolGaN Drive HB 600V G5 devices (combining two transistors with integrated high- and low-side gate drivers in a LGA 6x8 package).

The new product family enables improved efficiency, reduced system size, and overall cost savings. This makes the devices suitable for longer-range e-bikes, portable power tools, and lighter-weight household appliances such as vacuums, fans and hairdryers.

"For several years, Infineon has been focused on accelerating innovation in GaN to provide targeted solutions for real-world power challenges," says Johannes Schoiswohl, senior VP & general manager, GaN Systems business line head at Infineon. "The new CoolGaN Drive product family is another proof point of how we support our customers in developing compact designs with high power density and efficiency through GaN."



Infineon's CoolGaN Drive product family consists of the CoolGaN Drive 700V G5 single switches, integrating one transistor plus gate driver, as well as the CoolGaN Drive HB 600V G5 devices, combining two transistors with integrated high- and low-side gate drivers.

The CoolGaN Drive family offers a wide range of single switches and half bridges with integrated drivers based on the CoolGaN transistors 650V G5 (launched in May). Depending on the product group, the components feature a bootstrap diode and are characterized by loss-free current measurement, and adjustable switch-on and switch-off dV/dt. They also provide OCP/OTP/SCP protection functions. As a result, the devices enable higher switching frequencies, leading to smaller and more efficient system solutions with high power density. At the same time, the bill of materials (BoM) is reduced. This not only results in a lower system weight but also reduces the carbon footprint, says Infineon.

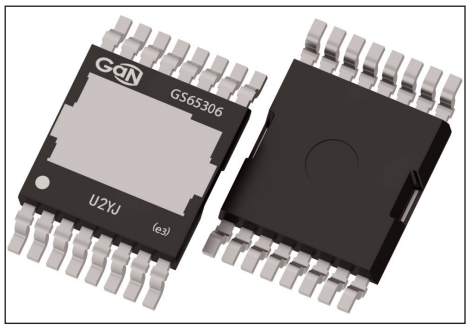
Samples of the half-bridge solutions are available now. Single-switch samples will be available from fourth-quarter 2024.

Vitesco uses Infineon's CoolGaN transistors to boost power density in DC–DC converters

CoolGaN Transistors 650V improve power efficiency of Gen5+ GaN Air

Infineon Technologies AG of Munich, Germany says that Vitesco Technologies of Regensburg, Germany (which develops and manufactures drive technologies and electrification solutions for electro-mobility) has selected its CoolGaN Transistors 650V to improve the power efficiency of its Gen5+ GaN Air DC–DC converter. The transistors are said to significantly improve the overall system performance while minimizing system cost and increasing ease of use. As a result, Vitesco created a new generation of DC–DC converters that are said to set new standards in power density (efficiency of over 96%) and sustainability for power grids, power supplies, and OBCs.

DC–DC converters are essential in any electric or hybrid vehicle to connect the high-voltage battery to the low-voltage auxiliary circuits. This includes 12V power headlights, interior lights, wiper and window motors, fans and, at 48V, pumps, steering drives, lighting systems, electrical heaters, and air conditioning compressors. In addition, the DC–DC converter is important for developing more affordable and energy-efficient vehicles with an increasing number of low-voltage functions. According to TechInsights, the global automotive DC–DC converter market is increasing at compound annual growth rate (CAGR) of 15% from $4bn in 2023 to $11bn by 2030. Gallium nitride (GaN) in particular plays a crucial role, as it can be used to improve the power density in DC–DC converters and on-board chargers (OBC).



Infineon's CoolGaN Transistors 650V.

The advantages of GaN-based transistors in high-frequency switching applications are considerable, but even more important is the high switching speed, which has been increased from 100kHz to over 250kHz. This enables very low switching losses, even in hard-switched half-bridges, with minimized thermal and overall system losses. In addition, Infineon's CoolGaN Transistors feature high turn-on and turn-off speeds and are housed in a top-cooled TOLT package. They are air-cooled, eliminating the need for liquid cooling and hence reducing overall system costs. The 650V devices also improve power efficiency and density, enabling an output of 800V. In addition, they feature an ON-resistance ($R_{DS(on)}$) of 50mΩ, a transient drain-to-source voltage of 850V, an $I_{DS,max}$ of 30A, and an $I_{DSmax,pulse}$ of 60A.

"The ultimate value of GaN is demonstrated when it changes paradigms, as in this example of moving from a liquid-cooled system to an air-cooled system," comments Johannes Schoiswohl, senior VP & general manager, GaN Systems business line head at Infineon.

With GaN Transistors, Vitesco was able to design its Gen5+ GaN Air DC–DC converters with passive cooling, which reduces the system's overall cost. The GaN devices also allow for simplified converter design and mechanical integration. As a result, the DC–DC converters can be flexibly positioned in the vehicle, reducing the workload for manufacturers. The use of GaN also allows the power of the converters to be scaled up to 3.6kW and the power density to be increased to over 4.2kW/l. The Gen5+ GaN Air DC–DC converters offer an efficiency of over 96% and improved thermal behavior compared with the Gen5 Liquid-Cooled converters. They provide a two-phase output of 248A at 14.5V continuous. The phases can be combined to achieve the maximum output power. Still, it is also possible to switch off one phase under partial load conditions and interleave the switching frequency between the two phases. In addition, by switching the input of two phases in series, the converters based on the CoolGaN power transistors 650V can be used to implement 800V architectures without exceeding the maximum blocking voltage of the device. The converters also feature an isolated half-bridge topology consisting of a GaN-based half-bridge, a fully isolated transformer, and an active rectifier unit for each phase.

Infineon's CoolGaN Transistors 650V are available now.

www.vitesco-technologies.com
www.infineon.com/gan

US ITC finds key EPC patents valid and foundational patent infringed by Innoscience

Initial determination precedes final determination by 5 November

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 — says that its gallium nitride (GaN) intellectual property rights have been upheld for the third time in three months.

The US International Trade Commission (ITC) found two of EPC's key patents valid and that one, its foundational patent, had been infringed by Innoscience (Zhuhai) Technology Co Ltd and its affiliate Innoscience America Inc.

The ITC's recommendation follows two recent decisions from the China National Intellectual Property Administration (CNIPA) that similarly validated EPC's counterpart patents in China.

EPC believes that the ITC's initial determination could lead to a ban later this year on importation of Innoscience's infringing products into the USA.

"The ITC's finding that Innoscience uses our patented technology without authorization puts EPC in an enviable position, as US and Chinese regulatory bodies have upheld the validity of our patents," says CEO & co-founder Alex Lidow. "The Commission's recommendations validate nearly two decades of hard work, resources and R&D that went into developing EPC's uniquely valuable intellectual property portfolio."

The ITC's preliminary ruling found both US patents that EPC asserted against Innoscience valid. It also found "infringement [by Innoscience] of US Patent No. 8,350,294," EPC's foundational patent used broadly across multiple industries. The second EPC patent, US Patent No. 8,404,508, was found valid but not infringed by Innoscience. The ITC's final determination is expected to be issued on 5 November.

Innoscience claims victory over EPC's '508 patent in ITC's initial decision

Remaining '294 patent at issue from ITC challenged as invalid at USPTO

Gallium nitride-on-silicon (GaN-on-Si) power solutions firm Innoscience of Suzhou, China claims that it has defeated the entirety of US Patent No. 8,404,508 of Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA in the initial determination at the US International Trade Commission (ITC). No violation was found on claim 1 (the only asserted claim) of the '508 patent, Innoscience asserts.

According to the ITC's initial determination, the chief administrative law judge found no violation as to the '508 patent, which is directed towards a method of forming an enhancement-mode GaN transistor. Innoscience hence says that it has overcome EPC's '508 patent.

The judge found violation as to the '294 patent. Innoscience disagrees with the judge, at least because the '294 patent is invalid, Innoscience claims, adding that the USPTO instituted an inter partes review (IPR) challenging all claims of the '294 patent under four different grounds and has agreed with Innoscience's invalidity arguments. The '294 IPR decision will issue in March 2025.

The '508 and '294 patents asserted by EPC are currently under review by the USPTO. Claims 1–12 of the '294 patent and claims 1–5 of the '508 patent are challenged as obvious in view of the prior art, says Innoscience. The firm also challenged at the USPTO two additional EPC patents, which EPC previously asserted at the ITC but later decided to withdraw. While EPC withdrew these patents from the ITC, Innoscience maintained its challenges of these patents at the USPTO. In all four EPC patents originally asserted by EPC, the USPTO has concluded that "there is a reasonable likelihood that petitioner [Innoscience] would prevail with respect to at least one of the claims challenged in the petition." Innoscience therefore says that it has achieved, via the preliminary decisions, a 4-for-4 record at the USPTO.

Innoscience claims that the ITC's decision further confirms that EPC's lawsuits against it are misguided. In all four USPTO rulings, three judges have initially agreed with Innoscience that the EPC patents are invalid. The firm says that, in all four proceedings, it has described multiple reasons why the four EPC patents are invalid, and for virtually every argument on invalidity, the USPTO initially agreed. Next, the USPTO will receive additional briefing and make final determinations by 26 March 2025.

The briefing schedule for petitions for review of the final initial determination includes a 19 July 2024 deadline for filing petitions and a 29 July deadline for responding to petitions. The target date for this investigation is 5 November.

www.innoscience.com
www.epc-co.com

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Navitas releases 4.5kW AI data-center power supply reference design

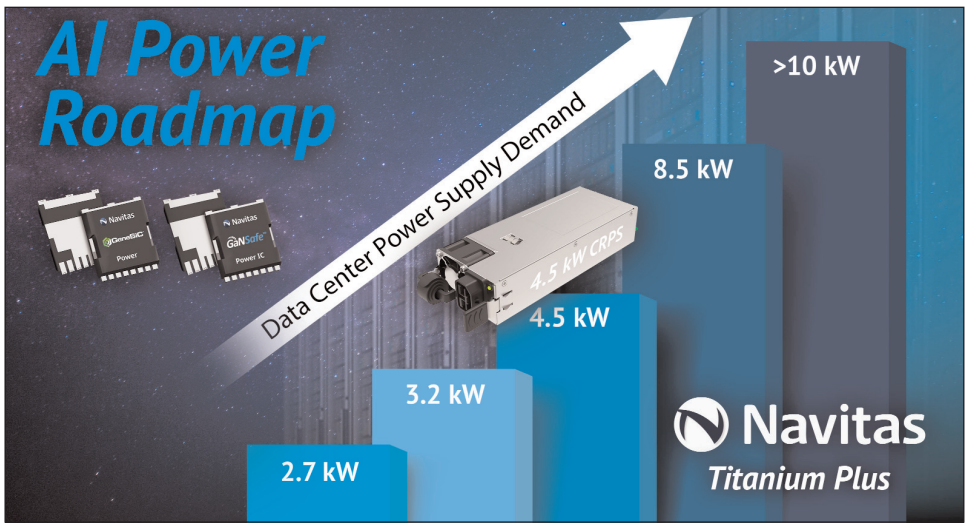
Highest power density in smallest power supply form factor for latest artificial intelligence GPUs

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA has released its 4.5kW AI data-center power supply reference design, with optimized GaNSafe and Gen-3 'Fast' (G3F) SiC power components. The optimized design enables what is claimed to be the world's highest power density with 137W/in^3 and over 97% efficiency.

Next-generation AI GPUs like NVIDIA's Blackwell B100 and B200 each demand over 1kW of power for high-power computation, 3x higher than traditional CPUs. These new demands are driving power-per-rack specifications from 30–40 kW up to 100kW.

Navitas announced its AI Power Roadmap in March, showcasing next-generation data-center power solutions for the growing demand in AI and high-performance computing (HPC) systems. The first design was a GaNFast-based 3.2kW AC–DC converter in the Common Redundant Power Supply (CRPS) form factor, as defined by the hyperscale Open Compute Project. The 3.2kW CRPS185 (for 185mm length) enabled a 40% size reduction versus the equivalent legacy silicon approach and easily exceeded the 'Titanium Plus' efficiency benchmark, critical for data-center operating models and a requirement for European data-center regulations.

Now, the latest 4.5kW CRPS185 design demonstrates how new GaNSafe power ICs and GeneSiC Gen-3 'Fast' (G3F) MOSFETs enables the world's highest-power-density and -efficiency solution. At the heart of the design is an interleaved CCM totem-pole PFC using SiC with full-bridge LLC topology with GaN, where the fundamental strengths of each semiconductor technology are exploited for the highest-frequency, coolest operation, optimized reliability and robustness, and highest power density and efficiency. The 650V G3F SiC MOSFETs feature 'trench-assisted planar' technology, which delivers what is claimed to be world-leading performance over temperature for the highest system efficiency and reliability in real-world applications.



For the LLC stage, 650V GaNSafe power ICs are claimed to be unique in the industry, with integrated power, protection, control and drive in an easy-to-use, robust, thermally adept TOLL power package. Additionally, GaNSafe power ICs offer extremely low switching losses, with a transient-voltage capability up to 800V, and other high-speed advantages such as low gate charge (Q_g), output capacitance (C_{OSS}), and no reverse-recovery loss (Q_{rr}). High-speed switching reduces the size, weight and cost of passive components in a power supply, such as transformers, capacitors and EMI filters. As power density increases, next-gen GaN and SiC enable sustainability benefits, specifically CO_2 reductions due to system efficiency increases and 'dematerialization'.

The 3.2kW and 4.5kW platforms have already generated significant market interest, with over 30 data-center customer projects in development expected to drive millions in GaN and SiC revenue, ramping from 2024 into 2025.

Navitas says that its AI data-center power supply reference designs dramatically accelerate customer developments, minimize time-to-market, and set new industry benchmarks in energy efficiency, power density and system cost, enabled by GaNFast power ICs and GeneSiC MOSFETs. These system platforms include complete design collateral with fully tested hardware, embedded software, schematics, bills-of-material, layout, simulation, and hardware test results.

"AI is dramatically accelerating power requirements of data centers, processors and anywhere AI is going in the decades to come, creating a significant challenge for our industry. Our system design center has stepped up to this challenge, delivering a 3x increase in power in less than 18 months," says CEO Gene Sheridan. "Our latest GaNFast technology, combined with our G3F SiC technology, is delivering the highest power density and efficiency the world has ever seen."

www.opencompute.org

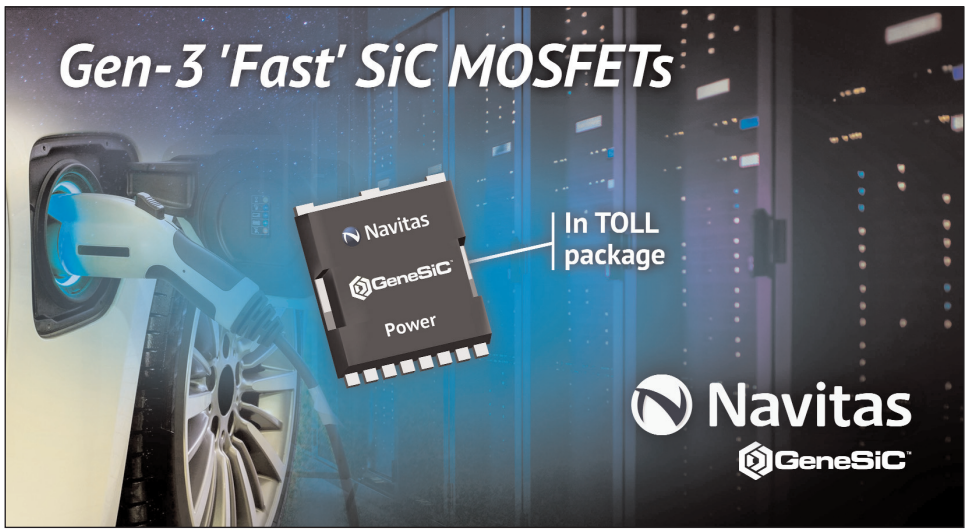
Navitas adds TOLL package to Gen-3 'Fast' 650V SiC MOSFET range

Thermally enhanced package suits high power density & high reliability

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA has extended its new portfolio of Gen-3 'Fast' (G3F) 650V SiC MOSFETs into a thermally enhanced, rugged, high-speed, surface-mount TOLL (transistor outline leadless) package designed for demanding, high-power, high-reliability applications.

Combining high-power capability and what is said to be best-in-class low on-resistance of 20–55mΩ, the 650V SiC MOSFETs have been optimized for the fastest switching speed, highest efficiency and extra power density demanded by applications such as artificial intelligence (AI) data-center power supplies, electric vehicle (EV) charging, and energy storage & solar solutions (ESS).

Navitas' GeneSiC products use a proprietary 'trench-assisted planar' technology that provides what is claimed to be world-leading efficiency performance over the temperature range, with G3F MOSFETs delivering high-speed, cool-running performance that ensures up to 25°C lower case temperatures and up to 3x longer life than alternative SiC products.



Navitas' latest 4.5kW AI power system reference design features the G3F45MT60L (650V, 40mΩ, TOLL) G3F SiC MOSFET in an interleaved CCM-TP PFC topology. Complemented by the NV6515 (650V, 35mΩ, TOLL) GaNSafe power IC in the LLC stage, the 4.5kW solution has a peak efficiency above 97% and, at 137W/inch^3, it is claimed to be the world's highest-power-density AI PSU. For 400V-rated EV battery systems, G3F in TOLL is a suitable technology for on-board chargers (OBC), DC–DC converters, and traction drives ranging from 6.6kW to 22kW.

The surface-mount TOLL package offers a 9% reduction in junction-to-case thermal resistance ($R_{TH,J-C}$), 30% smaller PCB footprint, 50% lower height, and 60% smaller size than the traditional D2PAK-7L, enabling highest-power-density solutions, as demonstrated in the 4.5kW AI solution. Additionally, with a minimal package inductance of only 2nH, excellent fast-switching performance and lowest dynamic losses are achieved.

The G3F family in TOLL package is released and available for purchase.

www.genesic.com
www.navitassemi.com

Navitas' GaNFast ICs power expanded Samsung Galaxy smartphone portfolio

Mainstream Galaxy A, as well as Galaxy Z Fold6 and Galaxy Z Flip6, gain a 25W charger

Navitas says that Samsung has expanded adoption of its GaNFast ICs from the original flagship Galaxy S22, S23 and S24 to the mainstream Galaxy A, and Galaxy Z Fold6 and Galaxy Z Flip6 smartphones with enhanced Galaxy AI features.

Since GaN runs up to 20x faster than legacy silicon and enables chargers up to 3x more power and 3x faster charging in half size and weight, GaNFast power ICs enable high-frequency, high-efficiency power conversion, achieving up to a 50% shrink versus prior designs.

The new 25W charger (EP-TP2510) features new energy-saving technology to reduce standby losses by 75% to only 5mW, which aligns with Navitas' environmental advances, where every GaNFast IC saves 4kg of CO_2 versus silicon chips, it is reckoned.

"Our production partnership with Samsung dates back to the Galaxy S22 Ultra, and today's announcement reflects the dramatic expansion of GaN from niche, flagship designs to adoption in high-volume, mainstream phones," says David Carroll, senior VP worldwide sales for Navitas.

Navitas's Q2 revenue and gross margin at higher end of guidance

Customer pipeline growth led by AI data centers, with customers ramping production with GaN and SiC-based power systems

For second-quarter 2024, gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA has reported revenue of $20.5m, down 12.6% on $23.2m last quarter but up 13% on $18.1m a year ago, and at the top of the $20m±$0.5m guidance range. Revenue for first-half 2024 was up nearly 40% year-on-year.

On a non-GAAP basis, gross margin has fallen further, from 41.5% a year ago and 41.1% last quarter to 40.3%, although this is towards the higher end of the 39.5–40.5% guidance.

Operating expenses have risen from $17m a year ago and $21.3m last quarter to $21.5m.

Net loss has increased further, from $8.65m ($0.05 per share) a year ago and $10.2m ($0.06 per share) last quarter to $12.05m ($0.07 per share).

During the quarter, cash and cash equivalents have fallen from $129.7m to $112m. Navitas has no debt.

"We are pleased with our Q2 results at the high end of our guidance, major new design wins, and significant technology advances and launches," says CEO & co-founder Gene Sheridan.

Market, customer and technology highlights during Q2/2024

- *Enterprise/AI Data Center*: Growing the family of AC–DC power platforms up to 10kW to meet nVidia's Hopper–Blackwell–Rubin roadmap (Hopper, Blackwell, Blackwell Ultra and Rubin processor platforms), with up to 480kW power demand per rack. The optimized combination of Gen-3 Fast SiC and GaNSafe technologies sets new AC–DC efficiency (97%) and power density (140W/in^3) benchmarks. The customer pipeline has doubled since the December 2023 investor day, with over 60 customer projects in development, and another seven data-center design wins in Q2/2024.
- *EV/eMobility*: Strong growth in the customer pipeline, now with over 200 projects. Strong interest in the 22kW on-board charger platform, contributing to 15 design wins in Q2, and on-track for the first GaN revenues in EV by the end of 2025.
- *Appliance/Industrial*: Customer pipeline grew beyond the $380m stated in December, with a revenue ramp expected in 2025 across diverse customers and regions, including seven of the top 10 appliance leaders. 25 new project wins are expected to ramp production in 2025 or 2026, including haircare, washers, dryers, refrigerators, heat pumps, industrial HVAC, robotics and automation applications.
- Solar/Energy Storage: As displacement technologies, SiC (for string inverters and storage) and GaN (for micro-inverters) are replacing legacy silicon chips, with over 100 customer projects, including the majority of the top 10 solar players. Six new commercial design wins in Q2, and on-track for the expected US GaN-based micro-inverter ramp next year.
- *Mobile/Consumer*: Mobile customers are increasing GaN adoption for their fast-charger portfolios. GaN adoption at Xiaomi and OPPO is expected to be 30% in 2024. Following wins for Samsung's Galaxy S23 and S24 phones, Navitas now powers chargers for Samsung's new Galaxy Z Flip6, Z Fold6 and all A-series phones. In notebook PCs, GaNFast was adopted again by Lenovo and Dell. Overall, another 16 GaNFast chargers were launched in Q2, bringing the all-time total to over 470 designs, and Navitas remains number-one in mobile fast charging.
- *New GaNSlim Portfolio*: With integration, ease-of-use and low-cost manufacturing methods — continues to grow the customer pipeline, now with over 50 customer projects across mobile, consumer and home appliance markets.

"Our leading-edge technology is fueling robust customer pipeline growth in each end-market, led by AI data centers with multiple customers ramping production with our GaN and SiC-based power systems," says Sheridan.

Outlook for Q3/2024

For third-quarter 2024, Navitas expects revenue to rebound to $22m±$0.5m. Despite this, gross margin is expected to fall to 40% ± 50 basis points. Operating expenses should remain $21.5m.

www.navitassemi.com

VisIC partners with Heraeus and PINK to deliver high-power-density BEV power modules

D³GaN technology combines with Heraeus' sintering paste and PINK's Ag and Cu sintering process

VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors — has partnered with electronic device assembly & packaging materials maker Heraeus Electronics (part of Heraeus Group of Hanau, Germany) and vacuum soldering and sintering system maker PINK GmbH Thermosysteme of Wertheim, Germany to develop an power module utilizing D³GaN technology.

The collaboration brings together VisIC's expertise in GaN-based devices, Heraeus Electronics' packaging materials know-how, and PINK's sintering technology.

The integration of VisIC's D³GaN technology with Heraeus Electronics' sintering paste and PINK's Ag and Cu sintering process and flexible sintering equipment is reckoned to set a new benchmark for power module performance in the EV market. This is expected to drive the adoption of GaN technology in electric vehicles (EV) applications.

The module is based on an Si_3N_4 (silicon nitride) metal ceramic substrate, a silver (Ag) sintering process and top-side interconnect, promising high reliability and performance for battery electric vehicles (BEVs).

Si_3N_4 is known for its excellent thermal conductivity, mechanical strength and reliability under high-temperature conditions. These properties are crucial for the demanding environment of EV applications, ensuring that the power module can withstand the rigors of everyday use while maintaining optimal performance.

The adoption of the silver sintering process by PINK enhances the thermal and electrical conductivity of the module. Silver sintering is a low-temperature bonding process that creates robust and reliable connections between components, improving the module's overall durability and efficiency. This process is critical for the high reliability required in EV powertrains, where consistent performance is non-negotiable.

Designed to meet the stringent reliability and performance standards of the EV industry, the resulting power module can deliver the high power density of over $500A_{rms}$/650V and efficiency needed for modern BEVs while also offering long-term reliability and durability at a cost point near silicon devices.

www.heraeus.com/en/het/home_electronics.html
www.pink.de/de

VisIC adds Daimler/Mercedes Benz veteran Wolfgang Wondrak as consultant

Expertise expected to accelerate adoption of GaN power conversion technology in automotive sector

VisIC has added Wolfgang Wondrak to its team as a consultant.

Wondrak has spent over three decades in leadership roles at Daimler/Mercedes Benz, where he contributed to advances in automotive electronics and technology. VisIC reckons that his background in the development and integration of automotive technologies aligns with its aims for GaN solutions in the power electronics industry.

"His extensive experience and deep understanding of the automotive industry will be invaluable as we continue to develop and expand our GaN product offerings," comments CEO Dr Tamara Baksht. "Wolfgang's insights will help us accelerate the adoption of our technology in the automotive sector, driving us closer to a future of more efficient and sustainable transportation."

At Daimler, Wondrak held key positions in power device technology, high-temperature electronics, high-reliability electronics and electric powertrains including manager of Power Electronics Advanced Engineering. His contributions are said to have been pivotal in the development of advanced powertrain systems and the integration of new technologies to enhance vehicle performance and efficiency. VisIC expects this expertise to be instrumental in guiding its strategic initiatives and product development efforts.

"VisIC's commitment to advancing power electronics is impressive, and I look forward to working with the team to bring their cutting-edge solutions to the automotive industry and beyond," comments Wondrak.

VisIC provides GaN-based high-efficiency power conversion solutions that are critical for electric vehicles, renewable energy systems, and other applications demanding high performance and reliability. The addition of Wondrak as a consultant marks a further step in the company's growth and strategic direction.

www.visic-tech.com

MassPhoton to establish Hong Kong's first GaN epi wafer pilot line at InnoPark

Region's first R&D center for GaN epitaxy process technology to be sited at Hong Kong Science Park

After a launch ceremony co-hosted with Hong Kong Science and Technology Parks Corporation (HKSTP), MassPhoton Ltd is set to establish the region's first R&D center for GaN epitaxy process technology at the Hong Kong Science Park as well as developing Hong Kong's first production-scale 8" gallium nitride (GaN) epitaxial wafer pilot line at InnoPark. With a projected investment of at least HK$200m and the establishment of a dedicated R&D team, the initiative aims to stimulate Hong Kong's 'third-generation' semiconductor industry supply chain, as well as creating more than 250 jobs.

The collaboration agreement between HKSTP and MassPhoton was formally signed by Eric Or (acting chief corporate development officer, and head of Ecosystem Development, at HKSTP) and MassPhoton's chief marketing officer Even Zhao. The signing was witnessed by professor Dong Sun (Secretary of Innovation, Technology and Industry Bureau of the Hong Kong Special Administrative Region Government), Lillian Cheong (Under Secretary for Innovation, Technology and Industry), Benjamin Wong, VP Advanced Manufacturing and New Energy Technology (Office for Attracting Strategic Enterprises), HKSTP's CEO Albert Wong, MassPhoton's CEO Dr Eason Liao, and Alex Ng (MassPhoton board member and investor).

In the 'Hong Kong Innovation and Technology Development Blueprint' announced by the Hong Kong Special Administrative Region (HKSAR) Government, one of the key strategic aims is to enhance the microelectronics innovation and technology (I&T) ecosystem and promote 'new industrialization' in Hong Kong. "We are committed to supporting the growth of leading technology sectors in the city, with third-generation semiconductors being a key area of technological development," says professor Dong Sun. "The Hong Kong Microelectronics R&D Institute is set to be established within the year, featuring pilot lines for silicon carbide and gallium nitride. This will assist startups and SMEs in prototyping, testing and certification, fostering collaboration among industry, academic and research sectors in core third-generation semiconductor technologies. The landing of MassPhoton in Hong Kong precisely aligns with our strategic development objectives and simultaneously supports the expansion of our I&T talent pool," he adds.

Signing ceremony to establish Hong Kong's first GaN epiwafer pilot line, hosted by HKSTP and MassPhoton.

"As Hong Kong's largest flagship for I&T, we host a thriving microelectronics ecosystem with over 200 companies in the Park engaged in this sector," notes HKSTP's CEO Albert Wong. "HKSTP provides top-tier infrastructure, complemented by an extensive network of partners and substantial experience in commercializing research outcomes. These resources enhance Hong Kong's R&D capabilities and industrialization in microelectronics," he adds. "The decision by MassPhoton to establish its operations in the Science Park and InnoPark, bringing its cutting-edge technology and experience to Hong Kong, will mark a significant milestone in the development of our local microelectronics industry and new industrialization initiatives."

"As the first company to establish GaN epitaxial technology in Hong Kong, we are committed to advancing the R&D as well as the mass production of high-end third-generation semiconductor wafers," states MassPhoton's CEO Dr Eason Liao. "This effort not only injects significant momentum into enhancing Hong Kong's original R&D capabilities and new quality productive forces but also provides crucial upstream wafer mass-production technology support to Hong Kong's semiconductor manufacturing industry chain."

MassPhoton was founded by Eason Liao, dedicated to developing new GaN products. Liao has transformed research results from tertiary institutions in the USA into commercialized and mass-produced semiconductor component technologies. He holds over 40 patents in fields such as GaN epitaxy and deep ultraviolet LED devices. The firm's production of GaN epiwafers, devices and other compound semiconductor epiwafers by the firm is intended to reduce the dependence on traditional silicon-based materials and devices, as well as critical equipment, achieving a more independent and controllable supply chain.

www.massphoton.com
www.hkstp.org

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German researchers demo practical implementation of AlN-based value chain for power semiconductors

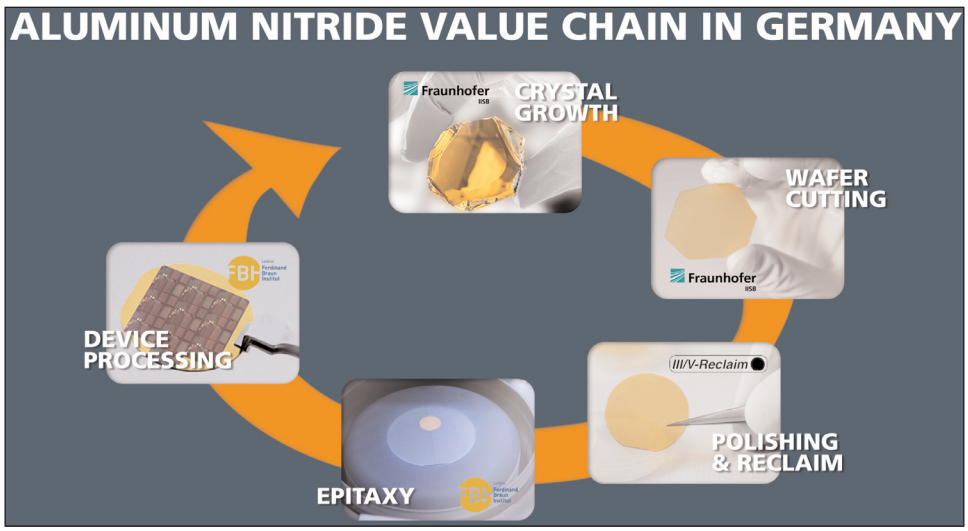
FBH, Fraunhofer IISB and III/V-Reclaim span AlN crystal growth, wafering and polishing, epi, and device fabrication

In power electronics, conventional silicon devices are being replaced by more powerful wide-bandgap (WBG) semiconductors with superior physical and electrical properties. Silicon carbide (SiC) has already established itself on an industrial scale, but devices based on gallium nitride (GaN) are also on the rise. However, it is already foreseeable that, in the future, even WBG device properties will be surpassed by ultrawide-bandgap (UWBG) semiconductors like aluminium nitride (AlN).

Devices fabricated on single-crystal AlN wafers can achieve a higher power density and efficiency compared with GaN technology. They also exhibit lower dynamic parasitic effects and higher reliability. At the same time, the high thermal conductivity of AlN enables good heat dissipation of the devices. Semiconductor technology based on AlN for power electronic transistors as well as millimeter-wave radio-frequency circuits hence has the potential to significantly reduce losses in electrical energy conversion and high-frequency transmission.

Establishing an AlN process chain in Germany

To make AlN technology accessible to industry in the medium term, the related existing activities in Germany have been combined in a strategic cluster. The aim is to establish a German value chain for AlN-based technology and to establish international leadership in this increasingly economically important field. Berlin-based Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH), the Erlangen-based Fraunhofer IISB (Institute for Integrated Systems and Device Technology) and III/V-Reclaim PT GmbH are collectively driving the initiative. They span the entire value chain, starting with the growth of AlN crystals using physical vapor transport (PVT), to wafering and polishing of epi-ready AlN-wafers, and the epitaxy of the functional device layers, up to the fabrication of transistors for power electronics and millimeter-wave applications.



The consortium has now successfully demonstrated the practical implementation of a value chain for AlN devices for the first time in Germany and Europe. To this end, AlN crystals were grown at Fraunhofer IISB and sliced into AlN wafers with a diameter up to 1.5-inches. III/V-Reclaim has developed a polishing process for epitaxial wafer production. Functional epitaxial layers were then applied to these wafers at the FBH, and AlN/GaN high-electron-mobility transistors (HEMTs) were successfully processed on them.

The first transistor generations produced with these wafers already show promising electrical properties, such as a breakdown voltage of up to 2200V and a power density superior to SiC as well as GaN-based power-switching devices.

Investment for the future

Targeting ever higher energy efficiency and progressive miniaturization is crucial for power electronic systems and in microwave communication. However, the static and dynamic conduction losses in the semiconductor materials unnecessarily increase the switching losses in supply, distribution and usage of electrical energy. This results in higher consumption of primary energy. In Europe alone, conversion losses waste several terawatt-hours of electrical energy per year, and the trend is for this to increase. To achieve significant energy savings, the semiconductor material itself must be addressed.

Compared with established silicon devices, AlN/GaN HEMTs — now successfully produced on AlN wafers — offer up to 3000 times less conduction losses than with silicon and are about ten times more efficient than SiC transistors.

The research was supported by funding from the German Federal Ministry of Education and Research (BMBF) within the ForMikro-LeitBAN and Nitrides-4-6G projects.

www.iisb.fraunhofer.de
www.fbh-berlin.com
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Halo raises $80m in Series B funding round

Halo to scale up commercialization of laser-based technology for silicon carbide substrate manufacturing

Halo Industries Inc of Santa Clara, CA, USA has raised up to $80m in an over-subscribed Series B funding round led by Thomas Tull's US Innovative Technology Fund (USIT) and joined by 8VC and SAIC.

Spun out of Stanford University in 2014 following PhD research on ultra-thin manufacturing methods for next-generation silicon wafers for solar and semiconductor applications, Halo has developed proprietary laser-based tools and processing technologies that replace traditional mechanical and thermal processes with novel light-based equivalents that provide higher quality, lower cost and enhanced functionality. This is said to minimize the cost, waste and environmental impact associated with traditional manufacturing methods.

Halo's laser manufacturing technologies can be applied to a diverse set of use cases, having been demonstrated to work on materials including silicon, diamond, sapphire, lithium tantalate, and gallium nitride.

In addition, due to the recent boom in the silicon carbide (SiC) market for highly efficient high-voltage power electronics in applications such as electric vehicles (EVs), charging infrastructure, rail, industrial motor drives, wind/solar and electric grid, Halo quickly adapted its process to the manufacturing of silicon carbide wafers.

SiC is a hard, brittle material that is challenging to cut without losing meaningful amounts, and Halo's proprietary laser-based slicing tools are claimed to significantly increase yield and quality while minimizing waste and production cost.

The new funding will hence help the firm to scale the commercialization and reach of its technology for silicon carbide substrate production.

"Amid the explosive growth in demand for next-generation power electronics with improved energy efficiency, our laser-based manufacturing tools and SiC production are critical components for maintaining momentum in clean tech development," says founder & CEO Andrei Iancu. "This financing will serve as the foundation for our future strategic engagements where our innovations can reshape market economics as well as enable entirely new device architectures and functionalities," he adds.

"Halo Industries plays a pivotal role by offering tools that solve some of the biggest pain points in the industry," comments USIT managing partner Peter Tague. "Halo Industries allows US companies to onshore manufacturing by competing on innovation, efficiency and cost, creating a durable advantage that is additive to recent industrial policies and eases supply chain challenges," he adds. "We see a bright future for Halo Industries to foster innovation across industries and diverse applications, from renewable energy and electric vehicles to telecommunications, grid infrastructure, and defense customer bases."

www.halo-industries.com

SiCrystal constructing new building to triple SiC wafer production capacity in Nuremberg by 2027

ROHM Group subsidiary SiCrystal GmbH of Erlangen, Germany is creating an extra 6000m^2 of space for the production of its monocrystalline silicon carbide (SiC) wafers by constructing a new building opposite its existing site in the north-east of Nuremberg. In cooperation with general contractor Systeambau from Hilpoltstein, constructionshould be completed by the start of 2026.

Proximity to the existing plant should ensure close integration of production processes. SiCrystal's production capacity, including the existing building, should roughly triple by 2027

"This groundbreaking ceremony marks an important milestone for SiCrystal and underlines our commitment to the metropolitan region," says chief operating officer Dr Erwin Schmitt.

Groundbreaking ceremony for the new building. From left: Jürgen Voit and Daniel Polzin (Systeambau), Volker Petersik and Dr Robert Eckstein (SiCrystal), Dr Andrea Heilmaier (Economic Officer), Mayor Marcus König, Takashi Shimane and Dr Erwin Schmitt (SiCrystal), and Harald Lötsch (Systeambau).

"SiCrystal is committing itself to Nuremberg as a location with this massive investment and is thus not only retaining jobs but also creating new ones," said Nuremberg's mayor Marcus König at the groundbreaking.

www.sicrystal.de

SweGaN secures frame agreements for QuanFINE GaN-on-SiC epiwafers

Orders double year-on-year in first-half 2024; new facility in operation

SweGaN AB of Linköping, Sweden — which develops and makes custom gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers for telecoms, satcoms, defense and power electronics applications — won orders in first-half 2024 for its benchmark QuanFINE epiwafers worth SEK17m, including three large frame agreements from undisclosed major telecom and defense market players. The firm has reported a 100% increase in orders year-on-year and begun deliveries from its new facility in Linköping as its scale-up progresses.

The firm has also completed the first QuanFINE epiwafer customer qualification with a device maker.

In the last two years, SweGaN has been undergoing an operational transformation in alignment with its growth strategy and global demand for GaN-on-SiC epiwafers. Securing a Series A investment round, it has scaled its organization, established a streamlined team, and deployed a new high-capacity production facility to drive its growth strategy and future key performance indicators.

"We celebrate three significant milestones that signal SweGaN's transition from a pure R&D company to a rigorous global semiconductor manufacturer," says CEO Dr Jr-Tai Chen. "There is a strong momentum in the telecom industry to upgrade technology from 5G to 5G Advanced," he adds. "Patented QuanFINE buffer-free GaN-on-SiC material is well suited to meet the demanding technical requirements of the new technology, particularly in terms of device efficiency and thermal management. This applies to the new telecom standard 5G Advanced as well as the strong demands for enhanced sensing capability in defense applications. The new framework orders will accelerate product development and production ramp-up, enabling SweGaN to tap the market opportunities in both the telecom and defense sectors."

With its new production facility in full swing, SweGaN reckons that it has the tools to fully embrace its scale-up strategy and significantly boost manufacturing capacity of GaN-on-SiC engineered epiwafers. Simultaneously, it aims to continue to innovate through new R&D initiatives and deepen partnerships with suppliers and customers to establish resilient supply chains.

www.swegan.se

Aehr's quarterly revenue rebounds from dip, enabling full-year growth

SiC-related orders for EVs continue, but solar, data center and AI applications growing

For its fiscal fourth-quarter 2024 (to end-May), production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has reported revenue of $16.6m, down on $22.3m a year ago but more than doubling from $7.56m last quarter, and exceeding the expected $15.4m.

Full-year revenue still grew from fiscal 2023's $65m to a record $66.2m for fiscal 2024, exceeding the revised guidance of $65m (albeit still below the revised guidance of $75–85m given in early January and the initial guidance of over $100m given in mid-July 2023, before the order push-outs for silicon carbide device applications seen since late calendar 2023 due to slower electric vehicle demand).

On a non-GAAP basis, quarterly net income was $24.7m ($0.84 per diluted share), up from $6.8m ($0.23 per diluted share) a year ago and compared with a net loss of $0.88m ($0.03 per diluted share) last quarter. Full-year net income was hence $35.8m ($1.21 per diluted share) for fiscal 2024, more than doubling from fiscal 2023's $17.3m ($0.59 per diluted share).

During the quarter, total cash and cash equivalents rose from $47.6m to $49.2m.

Order bookings were just $4m for the quarter, dropping back from a spike to $24.5m last quarter. Order backlog hence fell back from $20m to $7.3m. However, effective backlog (including orders received since the end of fiscal Q4) is $20.8m.

"Wafer-level test and burn-in of silicon carbide power semiconductors used in EVs was a key driver of our business in the last year, and we anticipate silicon carbide will continue to be a key contributor to revenue in the current fiscal year and beyond," says president & CEO Gayn Erickson. Indeed, since the end of the quarter, on 16 July Aehr announced that it had received $12.7m in orders from one of its silicon carbide test and burn-in customers for FOX WaferPak full-wafer Contactors to support production of silicon carbide power devices for electric vehicles to be delivered over the next three months.

"The silicon carbide market continues to be an enormous opportunity for Aehr as we see more auto suppliers committed to silicon carbide in their EVs, as well as roadmaps that are based on modules for their electric motor power inverters. By 2030, battery EVs are forecasted to more than triple last year's sales to 30 million, or 30% of total vehicles manufactured worldwide," he adds.

"We remain actively engaged with a significant number of new silicon carbide device and module suppliers and seek to meet their anticipated capacity coming online beginning in 2025. We are also seeing growing demand for silicon carbide devices beyond the EV market, such as solar, data center and other industrial applications for power conversion. We believe we are well positioned to continue to grow our business in silicon carbide, and we expect to receive first orders from a significant number of additional silicon carbide customers by the end of this fiscal year," Erickson says.

"We are also seeing traction with several emerging opportunities for our test and burn-in solutions in new target markets and expect bookings and revenue across a much broader range of customers and markets this fiscal year," he adds.

"One of the key new market opportunities we are focusing on is the growing demand for artificial intelligence (AI) processor test and burn-in at both the wafer level and the packaged-part level. We are currently working with an AI accelerator company and have secured a commitment from them to evaluate our FOX solution for use in production wafer-level burn-in of their high-power processors. Upon successful demonstration of wafer-level test results and throughput, we expect they will utilize our new high-power FOX-XP systems for production of their next-generation AI processors, starting this fiscal year," says Erickson.

Aehr has also announced its acquisition of Fremont-based Incal Technology Inc, a manufacturer of packaged-part reliability test and burn-in solutions for a wide range of semiconductor devices and markets, with a new product family of ultra-high-power test solutions for AI accelerators, graphics & network processors, and high-performance computing processors. "Between wafer-level and package-part, the reliability test and production burn-in market for AI processors exceeds $100m annually and, with this combined product portfolio, we believe we have the opportunity to capture a meaningful share of the market this fiscal year," says Erickson.

During the year, Aehr announced its first order for a FOX wafer-level test and burn-in system for gallium nitride (GaN) devices. "While silicon carbide will be the semiconductor material of choice for EV traction inverters, GaN is expected to gain significant penetration in the on-board charging market as well as other automotive, solar and data-center power conversion applications," notes Erickson. "We are working with several of the GaN market leaders, and received a significant number of WaferPak orders throughout the year for gallium nitride reliability test and qualification. We have now received our first forecasts for wafer-level production burn-in systems to be delivered during this

fiscal year. We continue to be encouraged by this market and believe it will be significant in market size for semiconductors and has the potential to be a solid market opportunity for Aehr's solutions."

"In the silicon photonics market, we shipped the first order from a major silicon photonics customer for the new high-power configuration of our FOX-XP system this last fiscal year. This new configuration expands our market opportunity by enabling cost-effective volume-production test of wafers of next-generation photonic ICs that are targeted for use in the new optical I/O or co-packaged optics market," says Erickson. "Nvidia, AMD and Intel have all discussed the potential for adding optical chip-to-chip communication for performance improvement and power savings for AI processors and high-performance computing chips."

"Looking ahead, we believe Aehr has significant opportunities for growth in fiscal 2025 and beyond," concludes Erickson. For fiscal 2025 (to end-May), Aehr expects revenue to grow to a new record of at least $70m, and net profit before taxes of at least 10% of revenue.

www.aehr.com

Axus wins orders for Capstone CMP system from silicon carbide device makers

Multiple system configurations and applications underscore flexibility in single-wafer SiC processing

Axus Technology of Chandler, AZ, USA — a provider of chemical-mechanical planarization (CMP), wafer thinning and surface-processing solutions — has reported strong sales momentum for its Capstone CS200 Series of CMP processing tools. In recent months, the firm has received orders from silicon carbide (SiC) semiconductor makers in Europe, Asia and North America.

Underscoring the platform's flexibility and breadth of capabilities, the Capstone orders include R&D/engineering and production-ready tools, with the latter configured for volume production of both 150mm and 200mm wafers. Built using flexible technology, Capstone is claimed to be the first new 150/200mm CMP platform brought to market in more than three decades and the first that can process two different wafer sizes simultaneously, enabling the tool to deliver industry-high throughput and yields.

Since introducing the Capstone platform in 2020, Axus has built on its range, introducing SiC-optimized wafer carriers and achieving processing milestones. The latest Capstone CS200-ia configuration integrates the firm's Aquarius wafer cleaning system to enable advanced CMP and post-CMP cleaning in a single system.

"Many of our customers represent the top tier of SiC device and/or wafer manufacturers worldwide," says Axus' director of process technology Catherine Bullock. "These customers have conducted extensive process and equipment testing to thoroughly characterize and compare various solutions for advanced SiC CMP," she adds. "All of them selected Capstone as their preferred platform. This is particularly relevant given the significant challenges and differentiation associated with CMP for SiC as compared to more mature CMP applications."

Capstone differentiators

Axus claims that Capstone offers several differentiating competitive advantages that are driving its growth in SiC CMP, including:

- a flexible architecture that can process up to four wafers simultaneously and provides both the highest throughput and the smallest footprint, minimizing overall cost of ownership (CoO);
- fully integrated, advanced post-CMP cleaning, which enables single-pass processing for both polish and clean, eliminating the need for additional post-process wafer handling, downstream process steps, and fab equipment;
- process temperature control technology that enables higher-pressure/velocity process conditions — delivering higher removal rates, higher throughput, and lower cost of consumables to substantially improve overall CoO; and
- a considerable reduction in energy and resource consumption, lowering operating and facilities costs while improving environmental sustainability.

"Silicon carbide is growing at a rapid pace — much faster than CMOS — fueled by demand for power electronics applications such as AI data centers, renewable energy and EVs," notes CEO Dan Trojan. "With our SiC engineering brain trust, proven product portfolio in CMP and related technologies, and growing base of leading suppliers and SiC customers — evidenced by this recent order influx — Axus Technology is well positioned to become the industry leader in CMP for compound semiconductors," he reckons.

Axus says that it is consulting with developers of SiC and other compound semiconductor devices to help them determine their optimal path for scaling from 150mm to 200mm production. With its recent infusion of capital funding, the company is stepping up its focus on scaling to high-volume manufacturing, enabling the company and its customers to collaborate on go-forward strategies.

www.axustech.com

AXT's Q2 revenue up 50% year-on-year

AI data-center applications promise long-term growth

For second-quarter 2024, AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — has reported revenue of $27.9m, up 23% on $22.7m last quarter and 50% on $18.6m a year ago, and exceeding the guidance of $25.5–27.5m. This reflects strong demand in various sectors, including data-center applications and satellite solar cells.

By product category, AXT saw good performance in indium phosphide substrates and healthy growth in gallium arsenide and germanium substrates.

Indium phosphide revenue was $7.7m, down slightly from $8.1m last quarter but up 67% on $4.6m a year ago, reflecting continued strong demand from data-center applications including high-speed optics for artificial intelligence (AI), as well as passive optical networks (PONs).

Gallium arsenide revenue was $9.1m, up 22% on $7.5m last quarter and up 50% on $5.4m a year ago, with broad-based improvement across applications including HBT power amplifiers, wireless switches, high-power industrial lasers, and LEDs.

Germanium substrate revenue was $2.9m, more than doubling from $1.4m last quarter and up on just $1m a year ago. Demand for satellite solar cells, which was down substantially throughout 2023, is now showing recovery.

In addition, revenue was $8.2m from the two consolidated raw material joint venture companies: BoYu (which makes high-temperature pyrolytic boron nitride crucibles and pBN-based tools for organic light-emitting diodes) and JinMei (which supplies high-purity materials including gallium and germanium, as well as InP poly and other materials). This was up more than 40% on $5.8m last quarter and above the $7.6m a year ago, driven by growing demand and recycling.

"Gallium arsenide recycling effort has been highly successful," notes co-founder, CEO & chairman Dr Morris Young. "We are now fully licensed and are processing materials that we collected over time but did not have the capability to recycle. This is visible in both our revenue and [above-normal] gross margin at JinMei," he adds. "These efforts also advance our ESG commitments and drive meaningful efficiencies in our manufacturing… Our portfolio of joint venture raw materials companies are contributing positively to our results."

Of total revenue in Q2/2024, the proportion from the Asia-Pacific region was 78%, while Europe was 17%, and North America was 5%.

Despite the proportion of total revenue contributed by the top five customers being up from 24% a year ago to 31.8%, again no customer comprised more than 10%.

"We are encouraged by the signs of adoption in new applications, such as AI where we expect that indium phosphide will be required in optical transceivers for high-speed data transmission. These applications span longer distances, such as from rack to rack, rack to aggregation point and between cloud and edge data centers," says Young.

"Today, AI applications are primarily using gallium arsenide vertical-cavity surface-emitting lasers (VCSELs) for shorter-range transmissions, which require a relatively small amount of substrate material. But as the industry moves to 800G for medium- to long-distance transmission beginning in 2025, and then to 1.6 Terabit speed, we expect that indium phosphide will be a necessary material," says Young. "We're already seeing development work happening today with next-generation silicon photonics devices and electro-absorption modulated lasers (EMLs) for high-speed data-center receivers. Those technologies use significantly more material than a gallium arsenide VCSELs. We have strong contribution in Q1 and Q2 from these applications," he adds. "Across the rest of our portfolio of products, the signs of market recovery are tangible."

On a non-GAAP basis, gross margin rose further in Q2/2024, from 9.8% a year ago and 27.3% last quarter to 27.6%, aided by the GaAs recycling program.

STAR Market listing update

On 10 January 2022, AXT's China-based wafer manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd submitted its application to list its shares in an initial public offering on the Shanghai Stock Exchange's Sci-Tech innovAtion boaRd (STAR Market) and the application was accepted for review.

Subsequently, Tongmei responded to several rounds of questions received from the Shanghai Stock Exchange (SSE). On 12 July, the SSE approved the listing of Tongmei's shares. On 1 August 2022, the China Securities Regulatory Commission (CSRC) accepted Tongmei's IPO application for review. The STAR Market IPO remains subject to review and approval by the CSRC and other authorities.

AXT notes that the process of going public on the STAR Market includes several periods of review and, therefore, is a lengthy process. Nevertheless, Tongmei hopes to accomplish this goal in the coming months.

Operating expenses have increased further, from $7.8m a year ago and $8.7m last quarter to $8.9m.

Net loss was $0.8m ($0.02 per share), cut from $1.3m ($0.03 per share) last quarter and $4.2m ($0.10 per share) a year ago, and better than the guidance of $0.03–0.05 per share.

During the quarter, cash, cash equivalents and investments rose by $2m, from $41.3m to $43.3m.

Net inventory was reduced, but only slightly to $85.8m (64% work-in-process, just 2% finished goods, and as much as 34% in raw materials) due to inventory added through the successful recycling program. With improving demand, AXT hopes to continue to reduce total inventory in 2024.

For third-quarter 2024, AXT expects revenue to fall slightly to $25–27m, due to the timing of orders. Gross margin is expected to see a slight dip. With operating expenses remaining steady, net loss per share should rise to $0.06–0.08.

"Coming off two quarters of strong growth and some fluctuation in the industrial market, we're expecting a moderation of our gallium arsenide sales in Q3," notes Young. "But we don't believe there is much excess inventory in the supply chain. We expect to continue to benefit from strengthening global demand as it occurs."

In InP, AXT is not counting on the strong growth from AI applications in Q1 and Q2 to continue into Q3. "But because it's a sort of a start-up business, an order can come in anytime," notes Young. "If that were to come in, then we can probably maintain our same level as Q2," he adds. Regarding telecom and regular datacom business, there is still some inventory to be digested in Q3. "Our largest target for inventory reduction is indium phosphide," adds chief financial officer Gary Fischer. "As our revenue grows, we expect to be in a good position to bring the inventory down. But it's taking longer than I thought."

Regarding germanium substrates: "With renewed strains in Europe and Asia, a portion of the strains was due to the timing of orders, which fell into Q2 rather than Q3," says Young. "We don't expect to see quite as strong results in Q3 of this year, but still a significant improvement from this time last year."

"Raw material is probably going to hold up… the same level as Q2," says Young.

"The first-half run rate is just over $50m. So we're now targeting to be in triple digits once again [for full-year 2024, after a dip from $141m in 2022 to $75.8m in 2023]," says Fischer.

www.axt.com

Neo selling rare metals gallium trichloride plant in Quapaw, Oklahoma

Five-year deal for Quapaw to recycle gallium scrap through Neo's facility

Neo Performance Materials Inc of Toronto, Canada has entered an agreement to sell its equity ownership interest in Neo Rare Metals (Oklahoma) LLC in Quapaw, OK, USA — which produces gallium trichloride — to the facility's general manager & co-founder Kevin Reading.

The transaction continues Neo's operational transformation and production optimization commitment to simplify global operations by "focusing on portfolio assets that reflect its scale and growth targets in a competitive global business environment".

Reading has agreed to purchase Neo's 80% equity interest in Quapaw for US$1.4m plus cash on closing (subject to normal closing adjustments), which represents a 9x multiple of the trailing 12 months of the EBITDA for the facility.

The transaction includes a five-year agreement for the purchase by Quapaw of gallium and indium from Neo's recycling facility in Peterborough, Ontario, as well as for the processing and transfer of gallium scrap to the Peterborough recycling facility.

"The sale of the Quapaw facility back to its founder is an exciting opportunity for both of us to benefit in the long term," believes Neo's president & CEO Rahim Suleman. "I look forward to our continued partnership with the entrepreneurial owner-operator team at Quapaw," he adds.

"Our relationship with Neo over the years has led this facility to improvements in health and safety initiatives that has truly made us a better facility," says Reading. "Our strong management team will continue to work closely with our Neo partners to ensure that, together, we can meet the needs of both facilities and our customers' needs."

Subject to customary conditions to closing, the transaction is expected to close in third-quarter 2024.

www.neomaterials.com

IQE plans IPO of subsidiary on Taiwan Stock Exchange

Initial phase of listing on Emerging Market Board set for first-half 2025

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK is planning an initial public offering of its Taiwanese operating subsidiary (IQE Taiwan) on the Taiwan Stock Exchange (TWSE).

The company says that it intends to sell a minority shareholding, retaining control of IQE Taiwan as it continues to leverage its strategic value. It adds that the proceeds of the initial public offering will be used across IQE to fund its growth strategy.

While the process is at an early stage, IQE has engaged Taishin Securities Co Ltd as its financial advisor to assist in preparing IQE Taiwan for the IPO. The IPO will be a two-stage process, with the initial phase of listing on the Emerging Market Board expected in first-half 2025, subject to the usual regulatory procedures and requirements.

The IPO will "accelerate the investment in our strategy for growth as we capitalize on the market opportunities ahead, including in GaN power," believes IQE's CEO Americo Lemos. "A successful IPO of IQE Taiwan will allow us to maximise the value of our asset whilst continuing to offer a secure and resilient supply chain for our global customers."

www.iqep.com

IQE expects first-half revenue growth of 25% year-on-year

Diversification strategy enabling continued growth

In a pre-close trading update for first-half 2024, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that it expects revenue to be at least £65m, in line with management expectations. This represents a year-on-year increase of at least 25% from first-half 2023's £52m and half-on-half growth of about 3% from second-half 2023.

"I am pleased with the performance we have delivered for H1, in an industry which will remain in recovery throughout 2024," says CEO Americo Lemos. "As markets correct at varying paces, we remain confident in our diversification strategy, which will enable us to take advantage of the growth opportunities ahead."

IQE expects to report its interim results on 10 September.

www.iqep.com

Nelson stands down from IQE's board

Co-founder acting as consultant for a further year to provide continued expertise and support on industry-related issues

Dr Drew Nelson OBE, who co-founded epiwafer and substrate maker IQE plc of Cardiff, Wales, UK in 1988, has stood down from the board, which has retained his services on a consultancy basis for a further year to provide continued expertise and support on industry-related issues.

Nelson is focusing on his interests in continuing to build the South Wales Compound Semiconductor cluster, the wider UK and international semiconductor and deep-tech industry, and his role as chairman of the Advisory Board of the All Party Parliamentary Group (APPG) on Semiconductors.

IQE's recently appointed board members bring industry experience and give Nelson the opportunity to pursue his interests now that IQE is supported in its next phase of growth.

From April 1999 until October 2021, Nelson was group CEO. He continued as president and a non-executive director, providing support to Americo Lemos as he transitioned into the CEO role.

"His support since I was appointed as CEO was key to the success of the transition, and his advice and guidance as a board member has been invaluable," comments Lemos.

"Drew's contributions to IQE as a founder, CEO and president cannot be understated," comments chairman Phil Smith. "He has been instrumental to the business's growth from start-up to a global innovator and leader in the sector," he adds. "Drew will continue to be a key figure in the semiconductor industry in his work with the South Wales Compound Semiconductor cluster, and other related activities, and we look forward to working with him in this capacity."

Innovate UK awards £1.1m one-year project to industrialize ULTRARAM, led by Quinas with IQE and Lancaster and Cardiff universities

Lancaster's 3" MBE antimonide material to be scaled by IQE to 6" MOCVD, before device fabrication and test by Quinas

Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation) has granted £1.1m to epiwafer and substrate maker IQE plc of Cardiff, Wales, UK, the Universities of Cardiff and Lancaster, and project coordinator Quinas Technology Ltd (which was spun off from Lancaster University in early 2023).

The one-year project is the first step towards volume production of the patented universal computer memory ULTRARAM, which was invented by Lancaster physics professor Manus Hayne.

By exploiting quantum resonant tunnelling, ULTRARAM's properties combine the non-volatility of a data storage memory (like flash) with the speed, energy efficiency and endurance of a working memory (like DRAM).

"A memory combining non-volatility with fast, energy-efficient write and erase capabilities [resulting in high endurance] has previously been considered unattainable," says project leader Dr Peter Hodgson, co-founder & chief technical officer at Quinas. "ULTRARAM's ability to switch between a highly resistive state and a highly conductive state is the key to its unique properties"

ULTRARAM has a reported switching energy per unit area that is 100 times lower than DRAM, 1000 times lower than flash, and over 10,000 times lower than other emerging memories. Its ultra-low energy credentials are further enhanced by its non-destructive read and non-volatility, which removes the need for refresh.

"Future compute will place ever-increasing demands on memory capability, driven by emerging applications like novel AI and quantum compute, as well as evolution in more traditional markets like defence and aerospace," notes Quinas' CEO & co-founder James Ashforth-Pook. "ULTRARAM's unique combination of non-volatile storage and rapid access memory addresses many of those needs, offering the potential for huge energy savings and carbon emission reduction."

Most of the funding for the project will be spent at IQE, which will scale up the manufacture of compound semiconductor layers from Lancaster University to an industrial process. "Their support is testament to our technology's commercial potential," says Hodgson. This will involve IQE developing advanced capability for the growth of gallium antimonide and aluminium antimonide for the first time. The project follows significant investment to boost the UK semiconductor industry and the establishment of the world's first compound semiconductor cluster in South Wales.

"We are delighted that Innovate UK is supporting this ambitious project, and that IQE has committed to developing the first part of ULTRARAM mass production," says Lancaster team lead Hayne, who is also co-founder & chief scientific officer at Quinas.

It is estimated that the global memory chip market will be worth about $320bn by 2030 but the UK currently has no stake in it. "ULTRARAM represents a tremendous economic opportunity for the UK," says Hayne.

"I am delighted to support our spinout Quinas on its journey to scale this Lancaster-led innovation to an industrial process suitable for a semiconductor foundry fab, thereby generating impact from research through commercialization," comments Jessica Wenmouth, Lancaster University's head of research commercialization. "This project not only aligns with Lancaster University's strategy to foster impactful research and innovation but also demonstrates the effective utilization of strategic grant funding alongside private equity investment. Such collaborations are crucial for bringing new products to market and driving significant investment into the UK for emerging technologies, enhancing our national and global standing in cutting-edge fields," she believes.

The goal of the project to industrialize the process involves scaling up ULTRARAM wafer diameters from 3" at Lancaster to 6" at IQE by using the mainstream production technique metal-organic chemical vapour deposition (MOCVD) rather than molecular beam epitaxy (MBE), which is typically used at universities.

"Lancaster will do some initial MBE epitaxy as a control/template for the industrial growth activities of IQE and Cardiff. Our key role will be to characterize the antimonide material grown at IQE and, once sufficient quality is confirmed, we will fabricate and test ULTRARAM memory on small areas of the wafers from IQE," Hayne says. "In parallel with this, Lancaster will continue to work on ULTRARAM scaling, by reducing the size of individual devices (Moore's law) and making larger and larger arrays. Once devices are small enough and arrays are large enough, the following stage will be to demonstrate fabrication on a complete 8" wafer, and then to translate the process to an industrial one, suitable for a semiconductor foundry fab."

https://onlinelibrary.wiley.com/doi/10.1002/aelm.202101103

www.quinas.tech

Veeco's record laser annealing sales compensate for declining compound semiconductor revenue in Q2

Full-year revenue forecast for compound semiconductors reduced to flat to slightly down

For second-quarter 2024, epitaxial deposition and process equipment maker Veeco Instrument Inc of Plainview, NY, USA has reported revenue of $175.9m, up 1% on $174.5m last quarter and 9% on $161.6m a year ago.

"We delivered solid second quarter results in line with our guidance, led by our Semiconductor business," says CEO Bill Miller Ph.D.

The Semiconductor segment (Front-End and Back-End, as well as EUV Mask Blank systems and Advanced Packaging) fell by 9% from Q1's record $120.4m to $109.9m (63% of total revenue), but this was up on $106.3m a year ago. "Demand for our Laser Annealing systems remains strong, highlighted by record revenue," says Miller. "We're also pleased to have received follow-on LSA [laser spike annealing] orders for a leading logic customer's gate-all-around (GAA) process, as well as follow-on business from our tier-1 DRAM customer to support their planned expansion."

The Compound Semiconductor sector (Power Electronics, RF Filter & Device applications, and Photonics including specialty, mini- and micro-LEDs, VCSELs, laser diodes) contributed $18.2m (10% of total revenue), down from $21m last quarter and $24.1m a year ago.

The Data Storage segment (equipment for thin-film magnetic head manufacturing) contributed $34m (19% of total revenue), approximately doubling from $18m last quarter and $13.9m a year ago.

The Scientific & Other segment (research institutions and other applications) contributed $13.8m (8% of revenue), down from $15.1m last quarter and $17.4m a year ago.

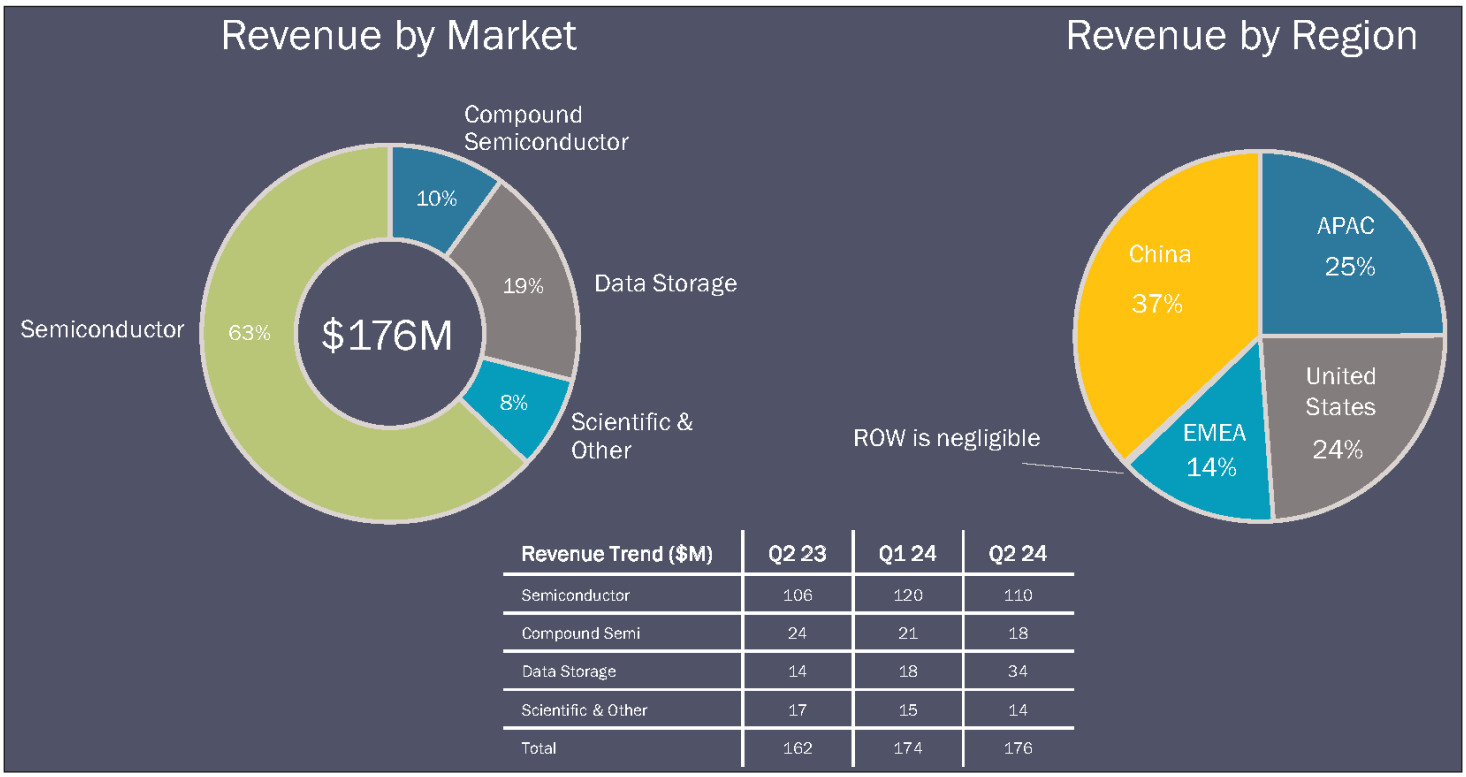
By region, China comprised 37% of revenue (level with last quarter and up from 31% a year ago) led by semiconductor sales. The Asia-Pacific (excluding China) has fallen from 36% of revenue a year ago and 37% last quarter to 25%. The USA comprised 24% of revenue, up from 16% last quarter and 22% a year ago. Europe, Middle-East & Africa (EMEA) rebounded from 6% of revenue a year ago and just 5% last quarter to 14%.

On a non-GAAP basis, gross margin was 43.7%, down from 44.2% last quarter but up from 42.7% a year ago, and toward the high end of the 43–44% guidance range.

Operating expenses have risen further, from $44.8m a year ago and $47.8m last quarter to $48.6m, exceeding the expected $46–48m due primarily to the timing of R&D investments.

Net income was $25.4m ($0.42 per diluted share), down from $26.4m ($0.45 per diluted share) last quarter but up from $20.6m ($0.36 per diluted share) a year ago.

Operating cash flow was $8m. Capital expenditure was $3m. During the quarter, cash and short-term investments rose sequentially



Revenue Trend ($M)	Q2 23	Q1 24	Q2 24
Semiconductor	106	120	110
Compound Semi	24	21	18
Data Storage	14	18	34
Scientific & Other	17	15	14
Total	162	174	176

by $8m to $305m. Long-term debt remains about $249m.

Regarding working capital, accounts receivable fell by $14m to $92m.

Inventory increased slightly, by $2m to $245m. Accounts payable fell by $7m to $47m. Customer deposits included within contract liabilities on the balance sheet declined by $13m to $59m.

Full-year guidance tightened

For third-quarter 2024, Veeco expects revenue of $170–190m. "By market, we expect growth sequentially in semiconductor and similar levels of revenue for the remaining markets," says chief financial officer John Kiernan.

Gross margin is expected to remain 43–44%. With operating expenses of $48–50m, net income should be $24–31m ($0.39–0.49 per diluted share).

For full-year 2024, Qorvo has tightened its guidance for revenue from $680–740m to $690–730m and for EPS from $1.60–1.90 per share to $1.65–1.85 per share.

"Semiconductor is slightly stronger and so we're now thinking for the full year in semi, when we compare it to last year, to be up high single-digits, low double-digits," says Kiernan. "On the flip side, we see slightly lower contribution from compound semi space, where we're now saying, flat to slightly down [versus the prior forecast of flat to slightly up]."

Evaluation program

"We continue to increase investments in our evaluation program for core technologies, focused on solving tier-1 customers' high-value problems. This is a key element in supporting our long-term growth strategy," he adds.

"In the compound semi market, we're focused on long-term opportunities within power electronics and photonics," notes Miller.

"We are very close to meeting all of the market requirements for silicon carbide, and our goal is to place two evaluation systems either end of this year or early in 2025," says Miller.

"We recently shipped a 300mm GaN-on-silicon evaluation system to a tier-1 power device customer in the compound semi market," says Miller. "Installation for the 300mm evaluation is progressing very well and we're in the midst of turning the tool over to the customer for them to start running their qualification wafers," he adds.

"In the semiconductor market, our nanosecond annealing and ion beam deposition evaluation systems at customer sites are progressing well and we're targeting additional evaluation system shipments in early 2025," says Miller. "We're also making progress towards an LSA evaluation shipment to a second leading DRAM customer in early 2025."

www.veeco.com

Riber's first-half revenue up 13% year-on-year to €13.7m

Order book rises 18% to €36m, driven by 27% growth for MBE Systems

For first-half 2024, molecular beam epitaxy (MBE) system maker Riber S.A. of Bezons, France has reported revenue of €13.7m, up 13% on €12.2m in first-half 2023.

MBE Systems revenues was €9.4m, up 10% year-on-year from €8.5m, despite delivering three systems versus four in first-half 2023.

Services & Accessories revenue rose by 19% from €3.6m to €4.3m.

Of total revenue, 67% came from Asia, 28% from Europe and 5% from North America.

Order book up 18% year-on-year

Reflecting the strength of the compound semiconductor market for both research and industrial production, eight MBE systems were ordered during first-half 2024.

The MBE Systems order book hence grew by 27% year-on-year, from €23.7m at end-June 2023 to €30.2m (12 machines, including seven production systems) at end-June 2024.

The Services & Accessories order book is down by 14% from €6.7m to €5.8m, as a result of a high level of invoicing in first-half 2024.

The total order book is therefore up 18% from €30.5m at end-June 2023 to €36m at end-June 2024.

Outlook for full-year 2024

Riber says that, in a semiconductor market driven by innovation, it will record new orders in second-half 2024.

Given the current orders scheduled for delivery in 2024 and the upcoming opportunities for its systems, services & accessories, Riber expects further growth in revenues and earnings for full-year 2024.

www.riber.com

Riber receives repeat order for MBE 412 cluster platform

US customer boosting R&D on IR sensor materials and structures

Riber has sold an MBE 412 cluster platform for delivered in 2025) to a leading US-based manufacturer of infrared imaging sensor materials for ground- and space-based astronomy.

The order is repeat business and will enable the customer to further increase its activities for new IR sensor materials and structures.

Benefiting from a high level of performance, the MBE 412 cluster platform is compatible with 4"-diameter substrates, offering flexibility in terms of equipment, modularity and adaptability for the development and production of compound semiconductors. Riber says that the MBE 412 was selected as this platform is optimized for such applications.

Aixtron's revenue rebounds in Q2/2024, boosted by LED segment

Full-year revenue guidance reduced, as strong power electronics orders in Q2 to generate revenue next year

For second-quarter 2024, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported revenue of €131.8m, down 24% on €173.5m a year ago but 11.4% up on last quarter's €118.3m, and in the upper half of the €120–140m guidance range.

First-half 2024 revenue of €250.1m hence almost matched first-half 2023's €250.7m, performing strongly against the weaker overall market dynamics.

Of total first-half revenue, 79% came from equipment sales (down from 82% a year ago), while 21% came from after-sales service & consumables and spare parts (up from 18% a year ago).

Metal-organic chemical vapor deposition (MOCVD)/chemical vapor deposition (CVD) equipment for making gallium nitride (GaN)- and silicon carbide (SiC)-based power electronics devices comprised 52% of equipment revenue (34% SiC and 18% GaN), falling back from 83% last quarter. This is because MOCVD equipment for making LEDs has rebounded from just 5% of equipment revenue a year ago to 43%, driven by micro-LED developments. MOCVD equipment for making optoelectronics devices (telecoms/datacoms and 3D sensing lasers for consumer electronics, solar, and wireless/RF communications) has fallen further, from 12% of equipment revenue last quarter to just 9%.

We have not only succeeded in acquiring new customers, including one of the top-five suppliers of SiC components, we were also able to secure major follow-up orders from important existing customers... Nexperia is a good example in the field of power electronics

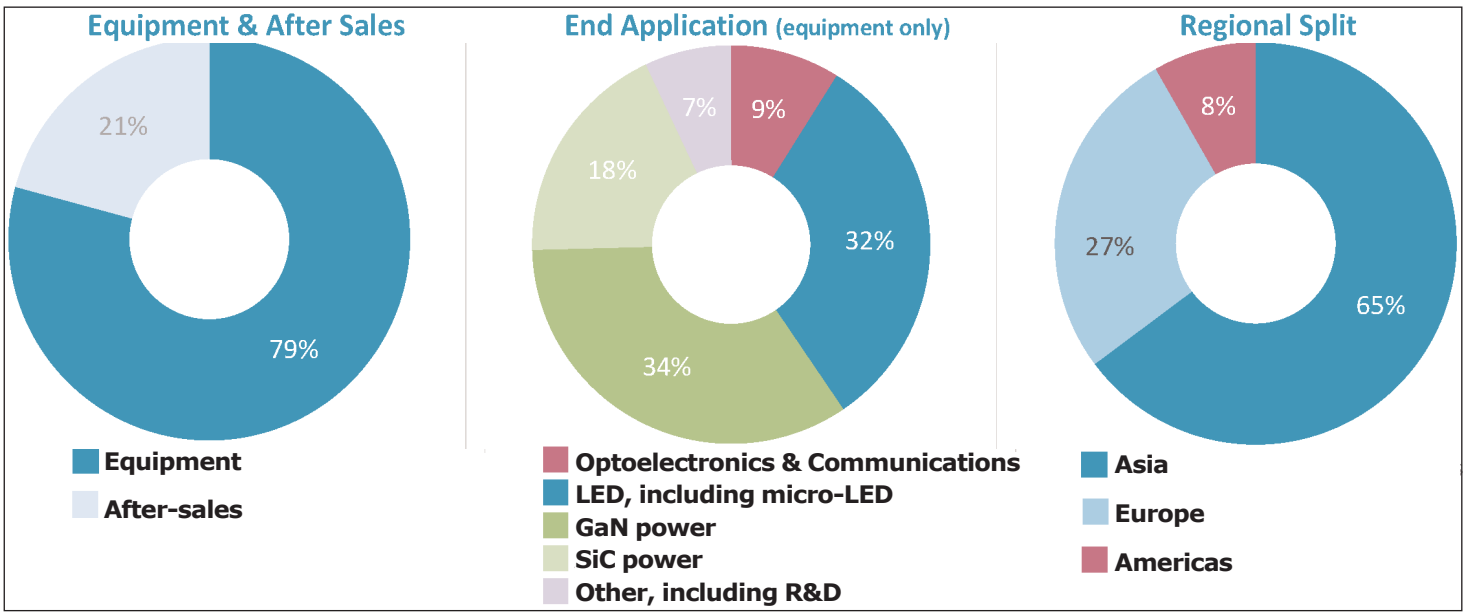
On a regional basis for first-half 2024 revenue, 65% came from Asia (up from 50% in first-half 2023), 27% from Europe (down from 29%) and just 8% from the Americas (up from 21%).

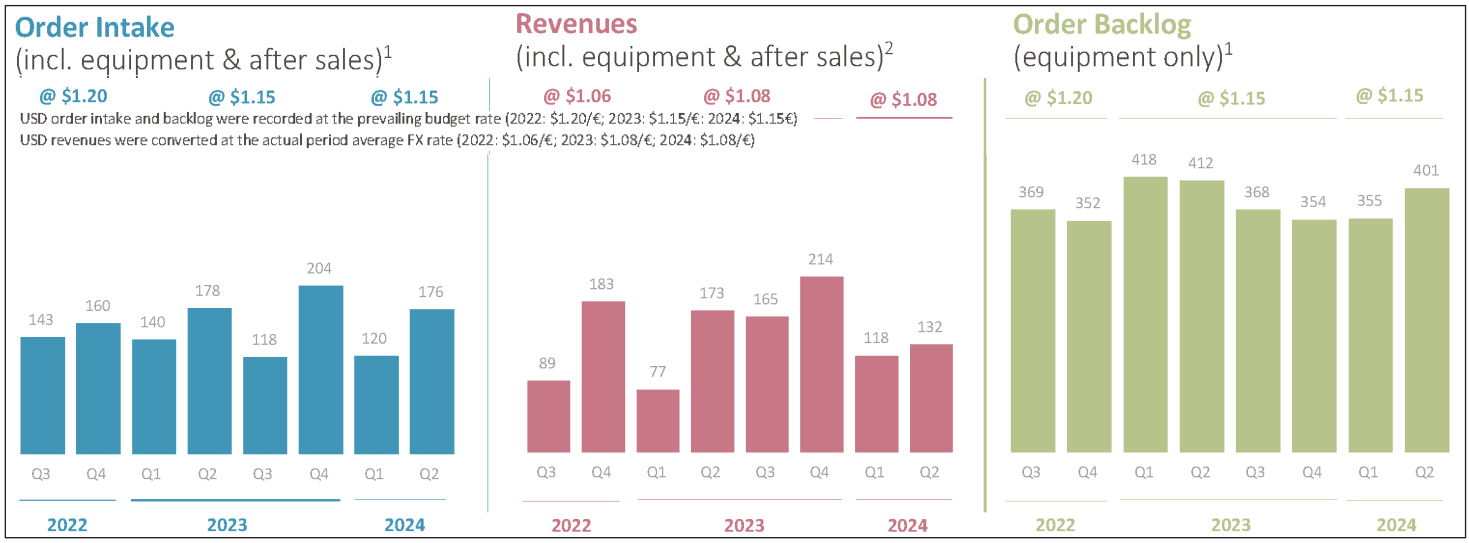
The G10 product family, comprising the G10-SiC, G10-GaN and G10-AsP systems, was the main driver. "The strong demand for our technology continues across all addressed end-markets, particularly in the SiC segment," says CEO & president Dr Felix Grawert.

Quarterly gross margin was 37% in Q2/2024, down from 42% a year ago but level with last quarter, leading to first-half gross margin of 37% in 2024 being down from 42% in 2023. This was due mainly to a shift in the product mix, which included a high proportion of lower-margin LED systems.

Investments in R&D remain high

Quarterly operating expenses have risen further, from €28.9m a year ago and €33.8m last quarter to €36.3m, due mainly to R&D expenses increasing from €19.8m then €22.9m to €24.6m. First-half operating expenses have hence risen from €56.5m in 2023 to €70.1m in 2024, with R&D spending (on existing systems plus the development of new system generations) increasing from €39m to €47.5m. Accordingly, full-time equivalent staffing of 1132 is up by 12% from 1014 a year ago.





The operating profit (earnings before interest and taxes, EBIT) has more than halved from €48.1m (19% EBIT margin) in 2023 to €22.8m (9% EBIT margin) in first-half 2024. However, despite being down on €44.6m (26% margin) a year ago, quarterly EBIT has rebounded from €9.9m (EBIT margin of 8%) last quarter to €12.9m (EBIT margin of 10%) in Q2/2024.

First-half net profit has halved from €43.9m (€0.39 per share) in 2023 to €22m (€0.20 per share) in 2024. However, despite being down on €40.4m (€0.36 per share) a year ago, quarterly net profit has rebounded slightly from €10.8m (€0.10 per share) in Q2/2023 to €11.2m (€0.10 per share) in Q2/2024.

Operating cash flow continues recovery

Quarterly operating cash flow of €20.2m in Q2/2024 was a big improvement on €7.4m last quarter and –€76.3m a year ago. First-half operating cash flow has hence improved from –€70.5m in 2023 to €12.8m in 2024.

However, despite improving from –€82m in Q2/2023 and –€33.1m, quarterly free cash flow in Q2/2024 was still negative at –€23.4m, with first-half free cash flow going from –€80.1m in 2023 to –€56.5m in 2024. This is because quarterly capital expenditure (CapEx) has risen from just €5.7m a year ago then €25.7m last quarter to €43.5m, taking first half CapEx from just €9.6m in 2023 to €69.2m in 2024, due mainly to investments in Aixtron's new Innovation Center and the expansion of production capacities in Italy.

Also, in preparation for the high expected business volume in the upcoming quarters, inventory has been built up further, from €394.5m a year ago and €436.4m last quarter to €447.9m.

New production site in Italy

In June, Aixtron announced the purchase of a new site near Turin, Italy. With an investment in the low double-digit million euro range in an existing building, the firm is creating the opportunity to quickly expand its production capacities — and potentially double its volume in the future after additional investment in the facility's infrastructure. Aixtron is thus addressing the expected increase in demand from major customers and will be able to cover future order peaks at all times.

First systems to be installed in new Innovation Center in second-half 2024

Aixtron is investing about €100m in constructing its Innovation Center in Herzogenrath site, where it will work with customers on the development and testing of the next generation of systems for the future. After breaking ground in Q4/2023, the first systems are scheduled to be installed in the new 1000m^2 cleanroom complex during second-half 2024.

Cash reserves

After paying a dividend of €45m, cash and cash equivalents (including other current financial assets) fell during Q2/2024 from €148.5m to €79.4m (down from €181.7m at the end of 2023 and €210.4m a year ago). However, underlining the firm's continuing financial strength, the equity ratio was 75% at end-June 2024.

High order intake and backlog

First-half order intake was down from €317.7m in 2023 to €296m in 2024. However, second-quarter 2024 order intake was €175.7m, almost matching the record €177.8m a year ago and up on €120.3m last quarter, due particularly to the high demand from the power electronics sector.

Of total equipment order intake, 57% was for silicon carbide (SiC) applications and 29% for gallium nitride (GaN) power electronics. A large proportion of the equipment orders booked in Q2/2024 will be delivered next year.

While important new SiC customers drove business in Q1 — including one of the top-five suppliers of SiC components and customers from China and Japan — Aixtron also secured major follow-up orders from existing SiC customers, among others.

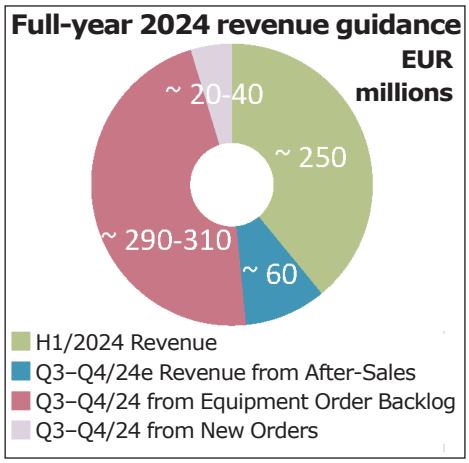
"We have not only succeeded in acquiring new customers, including one of the top-five suppliers of SiC components, we were also able to secure major follow-up orders from important existing customers," says Grawert. "Nexperia is a good example in the field of power electronics, where we were able to

impress with both our SiC and GaN systems. This momentum is reflected in our Q2 order intake," he adds.

The system order backlog has risen significantly from €355m at end-March to €400.6m at end-June, although this is down on €412.5m a year ago.

Full year revenue and EBIT margin guidance lowered

Reflect the current business environment in power electronics and development of the order intake (with a significant proportion of Q2/2024 system order intake not due to be delivered until next year), on 4 July Aixtron lowered its guidance for full-year 2024 revenue from €630–720m to €620–660m. This includes expected third-quarter 2024 revenue of €150–180m.



Aixtron still expects gross margin of 43–45%, but EBIT margin guidance has been reduced from 24–26% to 22–25%.

"The additional site in Italy serves to strategically secure our growth plans. And our new innovation center will further strengthen our research and development activities," says Aixtron's chief financial officer Dr Christian Danninger. "This will enable us to offer technologies that not only meet the current high demands of the semiconductor industry but also anticipate and serve future trends," he adds.

www.aixtron.com

Forge Nano launches TEPHRA 200mm single-wafer atomic layer deposition cluster tool

All-ALD Metal Barrier Seed film enables conformal high-aspect-ratio thin-film coatings at commercial scale

Atomic layer deposition (ALD) equipment provider and materials science company Forge Nano Inc of Thornton, CO, USA has further expanded into the semiconductor market by unveiling its new TEPHRA single-wafer ALD cluster platform. By offering single-wafer ALD coating quality at throughputs similar to the speed of batch systems, TEPHRA enables the production of what are claimed to be best-in-class coatings at commercial scale with unrivaled precursor efficiency and speed.

Powered by Forge Nano's ALD technology, which is said to offer ultrathin, uniform, pinhole-free films with an unprecedented 10x throughput for single-wafer processing, TEPHRA is dedicated to the manufacturing of specialty semiconductor applications on 200mm wafers and below. With 100x efficient chemical use, rapid cycle times, increased yield, and low-risk manufacturing, TEPHRA is claimed to be the only single-wafer cluster tool with commercial throughput speeds serving applications in advanced packaging, power semiconductor, radio frequency devices (RFD), micro-LEDs, micro-electro-mechanical systems (MEMS), and more.

"TEPHRA is designed to unlock new capabilities to meet the growing demand of novel More-than-Moore market device applications that seek high-throughput ALD capabilities without sacrificing film qualities," says CEO Paul Lichty. "Forge Nano will enable advanced device architectures with groundbreaking efficiency in the semiconductor space with our innovative ALD wafer tools that prioritize cost, performance and efficiency," he adds. "With TEPHRA, Forge Nano is opening new coating solutions and opportunities for our proprietary coating techniques that address high-aspect-ratio structures, which have previously been underserved in the semiconductor industry."

Forge Nano says that its ALD technology enables conformal coatings to scale to aspect ratios greater than 10:1. With a flagship all-ALD Metal Barrier Seed film application, TEPHRA offers nitride and metal depositions in high-aspect-ratio structures for advanced 3D integration applications, including through-silicon and through-glass vias. By moving beyond 10:1 aspect ratios, manufacturers can scale their packaging processes and reduce power consumption by overcoming common pitfalls of directional deposition technologies — including plasma-enhanced atomic layer deposition (PEALD) — which struggle with conformality and void formation.

Available in a range of configurations (with the option of four-sided, six-sided and eight-sided cluster platforms), TEPHRA can process wafers up to 200mm between 80°C and 300°C with six process precursor channels and dedicated chambers for oxide, nitride and metal depositions. TEPHRA also features Forge Nano's patented CRISP technology, a suite of catalyzed thermal ALD processes that enable low temperature and hard-to-deposit materials without the need for plasma.

www.forgenano.com/semiconductors
www.semiconwest.org

Nexperia orders Aixtron G10-SiC and G10-GaN systems for Hamburg fab

Nexperia expanding 200mm production for silicon carbide and gallium nitride power devices

Discrete device designer and manufacturer Nexperia of Nijmegen, the Netherlands (which operates wafer fabs in Hamburg, Germany, and Hazel Grove Manchester, UK) is expanding its 200mm-wafer volume production of silicon carbide (SiC) and gallium nitride (GaN) power devices by placing a follow-up order for G10-SiC chemical vapor deposition (CVD) systems, complemented by another order for G10-GaN metal-organic chemical vapor deposition (MOCVD) systems, from deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany.

The Aixtron epitaxy systems will be installed in Nexperia's fab in Hamburg, where the firm produces about 100 billion discrete semiconductors there annually (about a quarter of the global production of these types of components, it is claimed).

Aixtron's equipment produces both GaN and SiC epitaxial layers for developing energy-efficient field-effect transistors (FETs) or metal-oxide field-effect transistors (MOSFETs) used in energy conversion applications such as data centers, solar inverters, electric vehicles or trains.

Nexperia has decades of experience in developing power devices and achieved revenues of more than $2.1bn in 2023. It launched its first GaN FET in 2019, followed by its first SiC MOSFET in 2023.

"With our G10 epitaxy solutions, Nexperia can implement its own growth strategy with the large-scale production of wide-bandgap semiconductors for commercial applications," says Aixtron's CEO Dr Felix Grawert. "Together, we are setting the pace for the industry's transition to more energy-efficient SiC and GaN solutions," he adds.

"Our strategic partnership with Aixtron is of great importance to us as we continue to expand our technological capabilities and market presence in the field of high-performance semiconductor production," says Nexperia's chief operating officer Achim Kempe. "The integration of the G10 systems will significantly improve our development and production capacities for wide-bandgap technology. We are building on Aixtron's proven homogeneity and leveraging the additional productivity gains of Aixtron's G10 systems to increase our production efficiently and cost effectively. With the new G10 systems in our Hamburg fab, we can further expand our production capacities".

www.nexperia.com
www.aixtron.com

Samco sells ICP-RIE etching systems to III–V Lab

Etch systems to be used to enhance performance and integration of III–Vs with silicon

Process equipment maker Samco Inc of Kyoto, Japan has sold two of its RIE-400iP inductively coupled plasma reactive-ion etch (ICP-RIE) systems to III–V Lab of Palaiseau, France (a Alcatel-Lucent, Thales and CEA-Leti joint venture dedicated to industrial R&D on III–V-based optoelectronic and microelectronic components). The systems will be used in ongoing projects aimed at enhancing the performance and integration of III-V semiconductors with silicon. The deal is a milestone for Samco as it continues to expand its presence in the European market.

The RIE-400iP is a load-lock ICP etching system designed to handle wafers with a diameter up to 100mm (4"). The HSTC (Hyper Symmetrical Tornado Coil) ICP source effectively delivers uniform, high-density plasma and ensures excellent etch profiles, it is claimed.

Samco's RIE-400iP inductively coupled plasma reactive-ion etch system.

Robust and reliable hardware aids process control, achieving high productivity for a wide range of etching applications, indium phosphide (InP), gallium nitride (GaN), gallium arsenide (GaAs) and silicon carbide (SiC).

"Dry etching is a key technological building block for the development of III–V semiconductor innovative devices," notes III–V Lab research engineer Dr Alexandre Larrue. "The purchase of RIE-400iP ICP etching systems from Samco will allow III–V Lab to address new challenges in compound semiconductor manufacturing and reinforce both its R&D activities and its small-volume production."

www.3-5lab.fr
www.samcointl.com

Lumileds completes sale of Lamps and Accessories business to First Brands Group

LED product and lighting maker Lumileds LLC of San Jose, CA, USA says that in July it completed the sale of its Lamps and Accessories business to First Brands Group LLC (a global automotive parts maker that serves the worldwide automotive aftermarket).

"Completion of this transaction strengthens Lumileds and enables the company to focus on our core LED business," says CEO Steve Barlow. "Lumileds is committed to continued collaboration with our customers to solve market needs, and to producing innovative LED solutions that drive growth, improve profitability, and generate value for Lumileds, our customers and stakeholders alike."

Citi acted as financial advisor and DLA Piper acted as legal advisor to Lumileds.

www.lumileds.com

Lumileds launches LUXEON HL4Z undomed power LED

High intensity, high light output and high efficacy in industry-standard 3535 package

Lumileds has released the LUXEON HL4Z undomed power LED for applications that require very high intensity and superior efficacy.

Optical designers and engineers must typically make a tradeoff between optimizing optical design and achieving high efficacy. Lumileds addresses this with its LUXEON HL4Z. At the maximum drive current of 3.5A, the undomed LED delivers intensity of over 1400lm from its 2.16mm x 2.16mm light-emitting surface at 85°C.

Also, at 70CRI, 4000K, 85°C and 700mA, typical luminous efficacy is 189lm/W.

Options include correlated color temperatures (CCTs) of 3000K, 4000K, 5000K, 5700K and 6500K, and color rendering indexes (CRIs) of 70, 80 and 90.

The LUXEON HL4Z comes in an industry-standard 3535 package with a 3-stripe footprint. A large thermal pad allows high drive currents and close-packed LEDs.

"There are many applications from stadiums to torches and even forward lighting on bicycles, mopeds, e-bikes and motorcycles that require very high-intensity light and, until now, the pursuit of application efficiency has required a compromise in optical design," says Noman Rangwala, head of product marketing & management. "LUXEON HL4Z resolves the dilemma by delivering the output, intensity and efficacy that simply make the intended application better than has previously been possible."

Luminus launches high-efficacy mid-power MP-5050 LEDs

Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — has launched the mid-power MP-5050-240E and MP-5050-810E LEDs, which deliver what is claimed to be unmatched efficacy of 233 lumens per watt at a correlated colour temperature (CCT) of 4000K at 70 CRI (color-rendering index) and 1 Watt, exceeding the standards in outdoor and industrial lighting applications.

The two new product families meet the stringent requirements of DLC Premium, ensuring top-tier energy efficiency and sustainability. With an L90 rating of over 36,000 hours at high temperature and high current, the new products offer long-lasting performance and reliability for years of operation.

Other key features and benefits are cited as:

- Superior thermal management: Low thermal resistance design enables superior thermal dissipation, enhancing overall efficiency and performance;
- Versatile applications: Suitable for a wide range of outdoor and industrial luminaire applications including streetlights, area lights, parking lights, post-top lights, floodlights, stadium lights, tunnel lights, and high-bay lights;
- Enhanced compatibility: Available in 6V (240E) and 24V (810E) options, providing flexibility and compatibility with economical high-performance drivers;
- Uniform light distribution: Square LES design offers uniform light distribution, optimizing the optical design process for more controlled and directed light beams;
- Color uniformity: Available in 3-step and 5-step MacAdam ellipse binning, guaranteeing superior color uniformity for consistent and high-quality illumination.

"The 5050 package has emerged as the workhorse in many high-lumen applications, and Luminus' customers are already adopting these latest new 240E and 810E products to stay a step ahead of their competitors in major streetlight projects and industrial high bays," notes senior product marketing manager Kenan Chen.

www.luminus.com/products/color/monochromatic-smd

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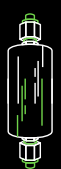
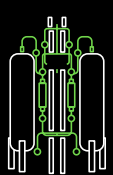
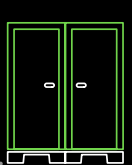


Point-of-Use Purifiers



Frame-Mounted Purifiers



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Cree LED boosts XLamp XE-G LED efficiency by 20%

Improved LED performance and broad color range provide greater design flexibility

Cree LED Inc of Durham, NC, USA (a company of SMART Global Holdings of Milpitas, CA) has launched higher-performance XLamp XE-G LEDs. Through a combination of higher light output and lower forward voltage, the upgraded XE-G LEDs deliver a 20% increase in efficiency for RGBW (red/green/blue/white) color-mixing systems and a 10% or higher efficiency gain for 13 of the 18 colors. Since their debut, XE-G LEDs have provided high functionality, and this latest performance boost will enable customers to further improve their lighting fixtures, says the firm.

"Cree LED's XE-G LEDs offer high performance and comprehensive colors in the small packages we need, without compromising thermal and optical values," comments Thomas Bretgeld, CEO of Bretgeld-Engineering GmbH of Herzogenrath, Germany. "This upgrade will provide a significant increase in efficiency and more design options, enabling us to push the performance boundaries of our LED engines even further," he adds. "Combining the performance of the LEDs, the list of available colors with our state-of-the-art simulation tools gives us the ability to create truly outstanding solutions for the entertainment and theatrical market which haven't been thought possible before."

The XE-G 2.05mm x 1.6mm-footprint package features what is claimed to be an industry-leading combination of characteristics for LEDs in this size class, including a large isolated thermal pad, minimal spacing between the LED chip and the package edge, ESD protection and a consistent optical source across all colors. With 18 different color options including a full range of white variations, the XE-G LEDs offer lighting manufacturers the flexibility to customize and enhance the light output properties of their products.

"Our upgraded XE-G LEDs enable our customers to improve their luminaires with minimal effort, requiring little to no redesign," says Cree LED's president Joe Clark. "This innovation not only enhances product performance but also delivers significant benefits to our customers."

Cree LED's XLamp XE-G LEDs are optimized for directional lighting applications that benefit from multi-color LED designs, such as indoor directional lighting, architectural lighting, entertainment lighting and aftermarket automotive lighting.

Product samples are available now and production quantities are available with standard lead times.

www.cree-led.com

Cree LED launches XLamp XP-L Color LEDs

A 33% smaller light-emitting surface than XM-L Color Gen 2 LEDs enables smaller, lower profile color-mixing luminaires

Cree LED says that its new XLamp XP-L Color LEDs are multi-color RGBW LEDs that deliver a combination of high lumen output and color mixing in a small 3.45mm x 3.45mm package.

The LEDs feature what is claimed to be the least possible distance between LED die, creating a small optical source for excellent optical control and efficient color mixing.

Features of the new XP-L Color LEDs include:

- a new price-performance option for XLamp RGBW LEDs;
- 33% smaller light-emitting surface (LES) than the existing XLamp XM-L Color Gen 2 LEDs, enabling smaller, lower-profile luminaires;
- High Density (HD) and High Intensity (HI) options with the same footprint;
- a maximum drive current per LED die of 1A, yielding maximum power of 12W;
- individually addressable LEDs;
- 6000-hour LM-80 data available to validate long-term reliability.

XLamp XP-L Color LEDs are optimized for all high-performance RGBW lighting applications, including color-changing, stage, architectural and entertainment.

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VueReal doubling manufacturing space

New production line to enable scale-up of MicroSolid Printing for display makers and smaller, custom-focused firms

VueReal Inc of Waterloo, ON, Canada plans to double its manufacturing space, introducing a production line capable of producing displays for customers and serving as a blueprint to be adopted in its partners' facilities.

"We are thrilled to announce our expansion into the consumer market and the growth of our team and facilities," says CEO Dr Reza Chaji. "Doubling our manufacturing capabilities, forging additional partnerships, and significantly expanding our executive team all reflect our commitment to innovation and excellence, positioning us better to serve our customers and partners across multiple sectors," he adds.

VueReal already serves the automotive industry, delivering micro-LED display and lighting solutions for global OEMs. Building on this, VueReal is strategically expanding into the consumer market, targeting wearable devices, TVs, IT applications, and augmented reality (AR) products with its MicroSolid Printing platform.

In addition to also expanding its executive team, VueReal is building partnerships with industry leaders such as Toray International to support this growth and create a global ecosystem for MicroSolid Printing.

Doubling manufacturing space for OEMs and display companies

Two-thirds of VueReal's manufacturing space is dedicated to a new production line that will enable the scale-up of MicroSolid Printing solutions for established display manufacturers and smaller, custom-focused companies. The production line will serve as a blueprint for partners and provide a pathway for them to integrate MicroSolid Printing into their facilities.

Two distinct market opportunities

VueReal says that it is experiencing significant growth through addressing two distinct market opportunities with its MicroSolid Printing technology:

- Well-established display manufacturers: These companies have comprehensive in-house capabilities and require high-volume production of micro-LED displays and other micro-semiconductor applications. VueReal says that its solutions enable them to scale efficiently at significantly lower capital and operational expenditure while maintaining high quality and performance standards.
- Customizable production: These companies aim to produce applications with small-to-mid volume and demand ease of customization. In addition to developing micro-LED displays and other micro semiconductor products for mass audiences, VueReal says that its MicroSolid Printing provides a unique, low/mid-volume production solution. The turnkey blueprint solution provides an end-to-end solution, allowing these companies to start production and scale as needed.

www.vuereal.com

VueReal appoints Shawn Mills as VP of engineering

Mills to oversee development and integration of cartridge technology, backplane design, and micro-LED device engineering

VueReal has appointed Shawn Mills as VP of engineering, overseeing the development and integration of cartridge technology, backplane design, and micro-LED device engineering. "The company's MicroSolid Printing platform is truly transformative," comments Mills.

Mills joins VueReal from Christie Digital, where he was senior director of display engineering, leading a cross-functional team that bolstered the firm's presence in the premium direct-view display market.

Formally trained in mechanical systems engineering and holding an MBA in Strategic Management, Mills has led programs for Boeing, AT&T and Disney. VueReal reckons

VueReal's new vice president of engineering Shawn Mills.

that his diverse background and strategic mindset make him suited to guide its semiconductor engineering team toward advances in micro-LED display, lighting and micro semiconductor fabrication.

"His expertise and innovative vision will be critical as we continue to push the boundaries of what's possible in micro-LED display and micro semiconductor technology," believes founder & CEO Dr Reza Chaji.

Mills will be responsible for providing strategic leadership to the semiconductor engineering team, fostering a culture of innovation and excellence, and ensuring that VueReal's technologies are efficiently integrated into production processes. Day-to-day activities will include overseeing the design, development and optimization of cartridge technology, leading the development of robust backplane designs, and driving the engineering of micro-LED devices from design to scale-up production.

www.vuereal.com

VueReal and RiTdisplay partner on micro-LED displays

Collaboration extended from automotive display and interior/exterior lighting systems to consumer markets and AR

VueReal Inc of Waterloo, ON, Canada is partnering with emissive display manufacturer RiTdisplay Corp (a subsidiary of RITEK group of Hsin Chu Industrial Park, Taiwan) to enable OEMs and vendors to access micro-LED displays that are said to combine unique features, high performance, low power consumption, and high transparency.

Building on years of collaboration in developing automotive display and interior/exterior lighting systems, the firms are now expanding their partnership into consumer markets and augmented reality, leveraging RiTdisplay's backplane process technology and VueReal's MicroSolid Printing platform to bring display solutions to a wider range of applications.

VueReal says that its MicroSolid Printing process enables production-scale capabilities, ensuring that micro-LED displays can be manufactured efficiently and cost-competitively. MicroSolid Printing is said to overcome the industry's primary challenge: the efficient transfer of LEDs from wafer to backplane. The technology addresses the demand for high-quality, scalable micro-LED production, opening new avenues for diverse applications and markets, it is claimed.

The firms are now expanding their partnership into consumer markets and augmented reality

The partnership aims to provide products with high brightness, energy efficiency, and clarity. By leveraging VueReal's proprietary technologies and RiTdisplay's production capabilities, the collaboration is expected to deliver superior performance and cost-effective displays, across applications from consumer electronics to industrial displays.

"Our collaboration with RiTdisplay will not only accelerate the adoption of micro-LED displays but also deliver unmatched performance and value to our customers, setting new industry standards," reckons VueReal's CEO Dr Reza Chaji.

"Together, we are uniquely positioned to deliver cutting-edge displays that not only meet but exceed the evolving needs of our customers, offering innovative and commercially viable solutions that will redefine the display market," says RiTdisplay's general manager Robert Chen.

The announcement follows an expansion of VueReal's operations. In addition to doubling its manufacturing space, VueReal is introducing a production line capable of producing displays for VueReal customers and serving as a blueprint to be adopted in its partners' facilities.

www.ritdisplay.com
www.vuereal.com

VueReal appoints Jason K. Ruppert as VP of operations

Investment in operations driven by MicroSolid Printing momentum in automotive and consumer markets

VueReal has appointed Jason K. Ruppert as VP of operations, leading production and scale-up activities related to cartridge fabrication and MicroSolid Printing, including capacity planning, vendor and supplier management, quality control and production planning.

Ruppert has over two decades of executive leadership experience in technology and manufacturing, with a track record in scaling companies, optimizing operations, and driving innovative product strategies.

"Jason's extensive experience in the semiconductor industry and strong leadership skills will be invaluable as we continue to push the boundaries of micro-LED display and micro semiconductor technologies," says founder & CEO Dr Reza Chaji.

VueReal's new vice president of operations Jason K. Ruppert.

"VueReal's MicroSolid Printing technology has the potential to revolutionize the display industry and catalyze innovative micro semiconductor products across multiple sectors," believes Ruppert.

Before joining VueReal, Ruppert served as chief operating officer at Phononic, significantly increasing revenues for the thermoelectric devices business unit and leading fundraising. Achievements include optimizing factory operations via AI and ML integration and launching products with high-profit margins.

Ruppert has a master's degree in Integrated Manufacturing Systems Engineering from North Carolina State University, a certificate in Finance and Accounting for the Nonfinancial Executive from Stanford University, and a bachelor's degree in Computer Science and Industrial Engineering from Southeastern Louisiana University.

BluGlass highlights progress in June quarter

BluGlass Ltd of Silverwater, Australia has given an update on its progress in its fiscal fourth-quarter 2024 (to end-June), highlighting the following.

IP transfer to European wafer developer

As announced on 8 July, BluGlass secured a AUS$1.93m payment for the transfer of non-laser-based intellectual property (IP) rights to its European wafer developer customer. Developed by BluGlass under a paid foundry services contract since January 2022, the IP relates to gallium nitride growth techniques on the customer's specialty wafers. The agreement excludes BluGlass' proprietary RPCVD, device or laser IP. BluGlass' foundry services agreement with this customer is ongoing, focused on developing GaN applications on specialty wafers.

"Our epitaxy expertise is a key competitive advantage, complementing our laser business and enabling us to partner with a broad range of industry players on custom GaN solutions," says CEO Jim Haden. "We're continuing to establish ourselves as a partner-of-choice, offering the flexibility to scale foundry services for non-laser applications and development projects to meet specific customer product requirements. We look forward to supporting our long-term foundry customer with their ongoing needs," he adds. "This IP licensing agreement is a good example of additional opportunities available to BluGlass, providing non-dilutive capital while we scale our laser device and development project revenues."

CLAWS Hub progress

BluGlass says that it has continued to deliver on all quarterly milestones under its contract with the US Microelectronics Commons' CLAWS (Commercial Leap Ahead for Wide Bandgap Semiconductors) Hub. The firm remains on track or ahead of schedule for its fourth-quarter base-year deliverables.

North Carolina State University (NCSU) CLAWS Hub director Dr Fred Kish was a plenary speaker at the 2024 International Conference on Compound Semiconductor Manufacturing Technology (CS MANTECH), presenting on the CLAWS' wide-bandgap semiconductor development achievements including BluGlass' GaN distributed feedback (DFB) laser.

Work is continuing on the core development program and this year's call for topics. BluGlass reckons its CLAWS participation has increased its visibility with hub members and the quantum sensing and high-speed communication communities.

Customer engagement

BluGlass says that, during the quarter, it continued to engage with its existing laser customer base while also progressing discussions with multiple potential customers, and supporting new orders.

BluGlass is also working with partners on tender applications for large contracts, which could have the potential to generate significant revenue over both the short and long term, initially from product development projects and then from follow-on production contracts.

DFB performance updates

In April, BluGlass published a technical white paper highlighting performance improvements of its GaN DFB lasers, which have demonstrated what is claimed to be industry-leading side-mode suppression ratios (SMSRs) with power output over 100mW, operating at single-frequency over a range of current densities.

GaN-based DFB lasers are not commercially available in the near-UV and visible spectrums. BluGlass' visible DFB laser demonstrations have achieved near-single wavelengths with extremally narrow full width at half maximum (FWHM) wavelength distribution and high SMSR, which is the suppression of undesirable wavelengths. These properties are critical to ensure the precise and stable operation required for atomic stimulations and sensing, notes BluGlass. The compact size and wafer-level fabrication of GaN DFB lasers suit helping quantum applications scale up in volume and scale-down in size, for commercial use in next-generation applications such as quantum computers, in-flight LiDAR, robotics and atomic clocks.

Financials

For fiscal fourth-quarter 2024 (to end-June), BluGlass has reported record quarterly revenue of $2.78m, including revenues from the NCSU CLAWS contract, foundry services and IP transfer for the European wafer developer, and laser orders.

Three consecutive years of revenue growth reflect the early benefits of the firm's growth strategy and growing laser project, foundry service, and laser product revenues.

Including salaries, materials and fabrication costs, BluGlass' quarterly R&D expenses were $2.2m ($2,178,000 for laser diode product development; $29,000 for RPCVD development). Payments to related parties were $108,000, comprising chair and non-executive director fees.

At the end of the financial year, the cash balance was $5.43m, before the receipt of the $1.93m IP transfer received in July, NCSU CLAWS receivable of ~$670,000, in addition to its expected R&D rebate of $5.5–5.7m for development work completed in fiscal year 2024.

Outlook

BluGlass says that it will continue to focus on its commercial and technical roadmaps in fiscal year 2025, growing laser and project revenues, optimizing its Silicon Valley fab, and bringing new products to market. The firm reckons that it is well positioned for growth within the constrained GaN laser market, as it offers greater manufacturing and packaging flexibility as well as novel architectures that improve laser performance and facilitate next-generation applications.

BluGlass is also continuing to collaborate with industry and academic partners to develop new technologies, solve customer challenges, and support increased adoption of GaN across high-growth industries.

www.bluglass.com.au

European wafer developer pays BluGlass US$1.28m for transfer of IP developed under contract

BluGlass to continue providing foundry services to customer, with increased volumes expected

BluGlass Ltd of Silverwater, Australia — which develops and manufactures gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has secured a US$1.28m (AUS$1.93m) payment from a European wafer developer to acquire intellectual property (IP) rights relating to GaN growth techniques on the customer's specialty wafers.

BluGlass developed the specialist IP for the European wafer developer under a paid contract development program that has been underway since January 2022.

It will continue to provide contract foundry services for the customer, developing GaN applications on specialty wafers, with increased volumes expected. The technology has been designed for adoption into high-growth markets.

The exclusive IP transfer, effective on payment, is limited to metal-organic chemical vapor deposition (MOCVD) deposition of GaN on the customer's unique wafer technology. The agreement does not transfer any of BluGlass' RPCVD, device, or laser intellectual property.

"Solving complex customer challenges is a key tenet of BluGlass' value proposition, enabling us to build long-term partnerships. The company's foundry services leverage our more than a decade of GaN epitaxy expertise to assist in developing next-generation applications," says BluGlass CEO Jim Haden. "We're continuing to support this foundry customer under a paid development contract, with the IP acquisition enabling us to expand our collaboration into a commercial manufacturing contract as the customer's opportunity matures. Importantly, the transfer of IP applies only to the use of MOCVD GaN growth on the customer's specialty wafers. BluGlass has retained all other IP rights."

www.bluglass.com.au

NUBURU resumes trading on NYSE American

Continued listing deficiency resolved regarding low selling price

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — says that on 29 July it received a notification from NYSE American LLC informing it that it has resolved the continued listing deficiency with respect to low selling price, as described in Section 1003(f)(v) of the NYSE American Company Guide. NUBURU had previously twice postponed a 1-for-40 reverse stock split.

As a result, the staff of NYSE Regulation has withdrawn its delisting determination and will be lifting the trading suspension on NUBURU's common stock on NYSE American.

The common stock commenced trading on NYSE American on 2 August under the symbol 'BURU' and CUSIP '67021W301'.

www.nuburu.net

Strategic marketing partnership agreed with NexGenAI

NUBURU has announced a marketing agreement with NexGenAI Solutions Group Inc, a provider of AI-driven marketing solutions (offering analytics and automation tools). The agreement aims to enhance NUBURU's marketing efforts, leveraging advanced artificial intelligence and various proprietary marketing tools to drive commercial growth and market penetration.

Applications for NUBURU's blue laser technology range from industrial manufacturing to medical devices. With the increasing demand for efficient and effective marketing strategies, NUBURU has enlisted NexGenAI Solutions to further advance its marketing presence in key markets.

NUBURU reckons that NexGenAI's expertise in AI-driven marketing solutions will provide it with market insights and enable targeted marketing campaigns that resonate with potential customers. The firm adds that the AI-powered tools and strategies will empower it to augment and streamline its marketing processes and improve customer engagement.

"Their expertise in AI-driven marketing solutions will be essential in assisting us in identifying and connecting with customers in key markets," says NUBURU's CEO Brian Knaley.

"Our AI-driven solutions will empower NUBURU to connect with their target audience more effectively and achieve significant market impact," says NexGenAI Solutions Group's president Anshuman Dash.

https://nexgenai.io

Lasers4NetZero and NUBURU collaborate on industrial lasers for sustainable technology

Partnership targets advances in laser technology for EV manufacturing

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — has announced a strategic collaboration with Lasers4NetZero, an initiative dedicated to advancing sustainable practices.

Lasers4NetZero has entered into the partnership with NUBURU for the implementation of their 42-month program, the Project Advisory Group of Lasers for Accelerated Net-zero Transition. The partnership signifies a step towards accelerating the adoption of environmentally conscious technologies.

The training program initiated by Lasers4NetZero aims to cultivate a new generation of forward-thinking doctoral candidates specializing in laser material processing, artificial intelligence for quality control, advanced process simulation, and sustainability analysis for e-vehicle manufacturing. NUBURU's provision of blue lasers at the WMG facility at the UK's University of Warwick underscores their commitment to driving technological innovation and sustainability in key industries.

"Our collaboration with Lasers4NetZero represents a strategic alignment of our shared vision for sustainable technology advancements," says NUBURU's CEO Brian Knaley. "Building upon our prior success with WMG and the upcoming partnership, we are poised to make significant strides in advancing laser technology for EV [electric vehicle] applications," he adds.

Acknowledging the pivotal role of artificial intelligence in driving industry transformation, NUBURU believes that they will be able to leverage insights from their recent AI partnership with NexGenAI to enhance their contributions to this venture.

The Lasers4NetZero initiative has a mission to address the need for reduced CO_2 emissions in the transportation sector. By leveraging advanced laser technologies and scanning optics, the program aims to enhance efficiency, material utilization and overall product quality, leading to a substantial reduction in carbon emissions in e-vehicle manufacturing.

www.lasers4netzero.com
www.nuburu.net

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Sivers to spin off Photonics subsidiary as NASDAQ-traded firm with Silicon Valley HQ

Manufacturing operations to remain in UK

Sivers Semiconductors AB of Kista, Sweden (which supplies ICs and photonic modules for communications and sensor solutions) has entered into a non-binding letter of intent (LOI) to merge its subsidiary Sivers Photonics Ltd of Glasgow, Scotland, UK with byNordic Acquisition Corp, a publicly traded special purpose acquisition company (SPAC).

Upon completion of the de-SPAC process, the proposed transaction aims to create an independent, NASDAQ-traded photonics company, funded by significant cash reserves, with new headquarters in California's Silicon Valley while maintaining manufacturing operations in the UK.

It is reckoned that the transaction should bring Sivers Photonics closer to investors, customers and partners within the US AI ecosystem. Sivers Photonics currently has about 80% of its net revenue in the USA.

Sivers currently comprises two subsidiaries: Wireless and Photonics. With a particular focus on indium phosphide (InP) laser sources, Sivers Photonics develops customizable lasers (such as tunable multi-wavelength lasers for direct on-chip integration) targeting high-growth artificial intelligence (AI) infrastructure and sensing applications for data centers, consumer healthcare and automotive LiDAR.

Underpinned by 25+ years of R&D, Sivers Photonics has developed a portfolio of technologies and has 80 employees, including 12 PhDs. The firm has three issued patents and 16 patents pending across the US, UK, Canada and the World Intellectual Property Organization. Additionally, Sivers Photonics currently has contracts to develop unique, high-performance lasers for several leading silicon photonics (SiPh) providers, such as Ayar Labs, and is in discussion with several leading AI companies, including hyperscalers.

Subsequent to the photonics spin-off, Sivers remaining wireless business will consist of a portfolio of products in mmWave beam-former front-end integrated circuits, RF transceivers, repeaters and software algorithms for optimum mmWave RF performance for satellite and 5G infrastructure. Wireless business net revenue growth was 155% in 2023, reaching about $15m. These markets are developing rapidly, and Sivers has secured a number of contracts and design wins that are projected to drive significant product revenue growth over the next 3–5 years.

"The potential for AI photonics is immense yet overshadowed by the equally exciting Sivers´ Wireless business unit. With the attractive opportunity for silicon photonics in AI infrastructure and the emerging demand for photonic biometric sensors, we feel now is the right time to shine a light on this business unit as a standalone entity to gain access to the US capital markets and create an opportunity for our shareholders to participate in its potential future success," says Sivers Semiconductor' chairman Bami Bastani. "At the same time, we also look to capitalize on the success of the Sivers' Wireless business unit and the demand for our leading-edge mmWave beam-former solutions for satellite and 5G, which has gained substantial traction with customers in these developing markets over the last several years, enabling us to create a fully fabless and less capital-intensive company that will remain listed under Sivers Semiconductors AB.

www.sivers-semiconductors.com

PhotonDelta opens office in Silicon Valley

Photonic chip accelerator taps into the North American market to take advantage of synergies

Photonic chips industry accelerator PhotonDelta of Eindhoven, The Netherlands (which connects and collaborates with an ecosystem of photonic chip technology organizations worldwide), has opened a new office in North America, with the aim of growing the photonic chip industry by promoting collaboration between European and North American organizations.

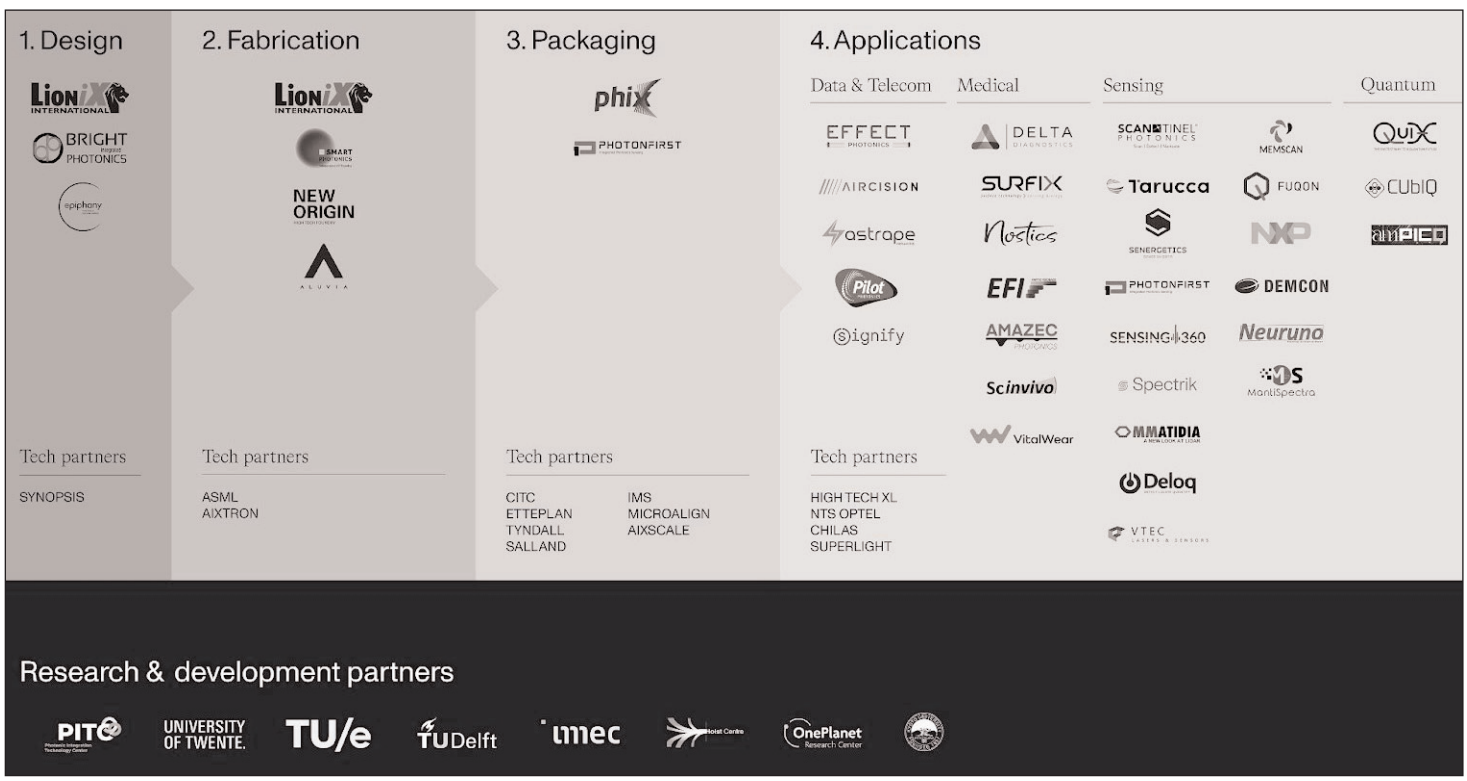
Based in San Francisco's Silicon Valley, the new hub will bring the Netherland's world class photonic chip capabilities to North American organizations, says PhotonDelta. PhotoDelta's ecosystem currently covers over 70 different organizations that form a complete value chain, including design services, multiple foundries for photonic chip fabrication, packaging, assembly and testing, and an increasing number of fabless companies that use PIC technology for innovative solutions.

Jorn Smeets, Managing Director North America at PhotonDelta, said: "We want to tap into the North American market and partner with industry leaders to help accelerate this key enabling technology. As we stimulate the internationalization of our value chain, we need to leverage on each other's strengths and bring our know-how, operations and funding to North America."

Besides the use of PIC technology in datacenters, PhotonDelta says that integrated photonics holds enormous opportunities for quantum computing and sensing solutions for new applications in healthcare, agriculture and automotive. To drive this innovation, PhotonDelta secured $1.2 billion to run numerous R&D programmes, lead international road mapping activities and invest in pioneering startups that apply PIC technology. Over the last five years, PhotonDelta has raised over $500m for companies such as Smart Photonics, EFFECT Photonics, PHIX Photonics Assembly, Astrapé Networks, MantiSpectra, Surfix Diagnostics, Delta Life Science, Scantinel Photonics, Amazec, and many more.

PhotonDelta believes a unified photonic chip industry is essential, because Europe and America have key strengths in complementary integrated photonic chip technologies. Europe has a large concentration of organizations involved in the development of indium phosphide and silicon nitride based photonic chips. In the USA, the development of silicon photonics benefits from extensive infrastructure and greater scale of production due to the compatibility with traditional semiconductor manufacturing. PhotonDelta adds that silicon photonics needs indium phosphide to function, as it's not possible to integrate active components on silicon. Silicon nitride, in turn, is useful for sensing applications and quantum computers, as it benefits from extreme low-loss characteristics.

www.photondelta.com



The PhotonDelta ecosystem.

Lumentum's quarterly revenue falls 16% to $308.3m

Recovery in telecom demand to drive growth in September quarter

For its fiscal full-year 2024 (ended 29 June), 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 reported revenue of $1359.2m, down 23.1% on $1767m in fiscal 2023.

Specifically, Cloud & Networking segment revenue fell by 18% from $1322.5m to $1084.m. Overall demand for telecom products was soft, as expected. Industrial Tech segment revenue fell by 38.3% from $444.5m to $274.3m.

Fiscal fourth-quarter 2024 revenue was $308.3m, down 15.9% on $366.5m last quarter and 16.9% on $370.8m a year ago, albeit above the midpoint of the $290–315m guidance range.

Cloud & Networking segment revenue was $254.7m, down 18.8% on $313.8m last quarter and 11.1% on $286.5m a year ago. Specifically, Telecom revenue fell by $30m sequentially.

Industrial Tech segment revenue was $53.6m, up 1.7% on $52.7m last quarter but down 36.4% on $84.3m a year ago. "Like others in this space, we continue to face challenges due to the weak end-market demand and high levels of customer inventory," notes president & CEO Alan Lowe.

On a non-GAAP basis, gross margin has fallen further, from 36.7% a year ago and 32.6% last quarter to 32.2%. This contributed to full-year gross margin declining from 43.2% in 2023 to 33% for 2024 due to lower overall demand and factory utilization.

Quarterly operating expenses were $100m (32.4% of revenue), down by $2.4m on a year ago. This is despite R&D spending of $64.9m being up on $61.7m a year ago, driving full-year R&D spending up from $249m in 2023 to $260.4m for 2024, focused on Datacom transceivers due to the strong customer traction. Quarterly sales, general & administrative (SG&A) expense has shrunk from $40.7m a year ago to $35.1m, leading to a full-year decline from $175.3m to $150.7m.

"To increase investments in programs that accelerate our exposure to significant new AI opportunities, we decided to stop our in-house development of certain communications ASICs, including coherent DSPs and RFICs," notes executive VP & chief financial officer Wajid Ali. "We can meet customer needs using ASICs from third-party partners while reallocating significant R&D spending towards new cloud and AI customer programs. Hence, in Q4 we recorded $35.8m of restructuring and related charges, including a $29.1m write-off of in-process R&D intangible assets."

Full-year operating profit plunged from $339.2m (19.2% margin) in 2023 to just $37.8m (2.8% margin) for 2024. Compared with an operating profit of $33.7m (9.1% operating margin) a year ago, fiscal Q4 yielded an operating loss of $0.8m (margin of –0.3%, albeit better than the midpoint of the guidance range of between –3% and +1%). Cloud & Networking segment operating margin was 10.1%, down from 17.7% a year ago. Industrial Tech segment operating loss improved from 5.1% last quarter to 0.4%, although this is down on 14.4% a year ago.

Quarterly net income has fallen further, from $40.2m ($0.59 per diluted share) a year ago and $19.6m ($0.29 per diluted share) last quarter to just $4m ($0.06 per diluted share, albeit above the midpoint of the guidance range of between a loss of $0.05 and a profit of $0.10). Full-year net income hence fell from $315.3m ($4.56 per diluted share) in 2023

$ in millions	Q4 FY24	Q3 FY24	Q4 FY23
Revenue	**$308.3**	**$366.5**	**$370.8**
Cloud & Networking	254.7	313.8	286.5
Industrial Tech	53.6	52.7	84.3
Segment Profit (Loss)			
Cloud & Networking	10.1 %	14.6 %	17.7 %
Industrial Tech	(0.4) %	(5.1) %	14.4 %

Revenue and earnings for Lumentum's Cloud & Networking and Industrial Tech segments.

to $68.7m ($1.01 per diluted share) for 2024.

"We exceeded our guidance mid-points for both revenue and EPS in the fourth quarter," notes Lowe.

In fiscal Q4, capital expenditure (CapEx) was $24m, driven mainly by adding high-speed transceiver production capacity at the firm's manufacturing site in Thailand. Cash flow from operations for fiscal full-year 2024 was $24.7m. Total cash, cash equivalents and short-term investments rose by $16.1m during the quarter from $870.9m to $887m, due primarily to improved working capital performance after a $22m sequential reduction in overall inventory levels.

"We booked record orders for datacom chips and are investing in additional production capacity to help us meet customer demand," says Lowe. "We have made excellent progress with multiple new high-speed optical transceiver customer engagements, including securing a major transceiver award with one new customer. We are actively working to secure additional awards from other new customers," he adds. "We saw emerging positive trends in the broader traditional networking market," says Lowe.

For fiscal first-quarter 2025, Lumentum expects revenue growth to $315–335m. Cloud & Networking should rise sequentially, driven mainly by a recovery in telecom networking demand from the low in fiscal Q4/2024. Industrial Tech revenue is expected to be flat to down sequentially, due to decreased industrial laser shipments (continued weak end-market demand and ongoing customer inventory adjustments) offset by a modest seasonal uptick in 3D sensing revenue.

"In future quarters, we anticipate gross margin will sequentially increase as manufacturing utilization improves due to an improved telecom outlook, as well as an increase in datacom laser shipments," says executive VP & chief financial officer Wajid Ali. Operating margin should improve to 0–3%. Diluted earnings per share should rise to $0.07–0.17.

"We are making significant progress executing our strategy to broaden our cloud and AI customer base, which will lead to accelerated growth in calendar year 2025," says Lowe.

"We booked record orders for datacom chips and are investing in additional production capacity to help us meet customer demand," says Lowe. "We have made excellent progress with multiple new high-speed optical transceiver customer engagements."

To achieve its cloud and AI goals, Lumentum is implementing a three-pronged strategy.

1. Expanding its customer base to include multiple data-center operators and AI infrastructure providers as they migrate to higher speeds.

"Within data centers, the shift to 200G lane speeds, particularly in 1.6T optical transceivers, plays to our strengths," says Lowe. "The growing importance of single-mode optics and indium phosphide lasers, driven by the limitations in multi-mode optics, aligns well with our market and technology leadership positions. Our industry-leading 100G EML transmitter components have established a strong reputation for performance, quality and reliability, and are currently shipping in record volumes," he adds. "Our proven capabilities position us favorably as the industry adopts 200G-per-lane technologies. Our 200G EMLs are being qualified by multiple customers for integration into their transceivers and subsequent deployment in a wide range of cloud and AI infrastructures. We anticipate being a key laser supplier in initial 1.6T transceiver deployments as we ramp up 200G EMLs later this fiscal year."

"In Q4, we achieved record volume shipments of EMLs and secured substantial bookings, which we will be working to fulfill throughout fiscal 2025. This includes initial orders for 200G EMLs from leading AI customers. Based on this momentum, we foresee continued strong EML shipments throughout fiscal 2025 and into fiscal 2026."

"Additionally, we are supplying differentiated laser sources for silicon photonics-based transceivers, further broadening our content opportunity within the data-center market. We have also made significant progress on our newest 800G and initial 1.6T transceiver product developments. We are deeply engaged with multiple customers and we have received favorable feedback after providing product samples to these customers. We have secured a major award with one new customer and are actively working to finalize additional awards with multiple customers."

2. Scaling up manufacturing capacity for both optical transceiver modules and components at established Lumentum facilities outside China.

"This expansion is critical to supporting our cloud customers growing AI and cloud workloads while ensuring supply chain security," notes Lowe. "Indium phosphide lasers are essential for scaling data-center infrastructure. Due to overwhelming demand for our critical technology, our indium phosphide capacity is fully subscribed to at least the end of calendar 2025. Therefore, we can only meet this demand by growing capacity," he adds. "In the current fiscal first quarter, we have already invested $43m in our indium phosphide wafer fab facilities and we expect to continue to invest in our indium phosphide capacity over the next several quarters to keep up with the growing demand of these enabling laser technologies. Although the industry faces a broad shortage of indium phosphide lasers, over time our capacity additions will help mitigate these

$ in millions except for EPS, % of revenue	Q4 FY24 Actual	Q1 FY25 Guidance
Revenue	$308.3	$315 - $335
Operating Margin (Loss)	(0.3%)	0% - 3.0%
Diluted EPS	$0.06	$0.07 - $0.17
Diluted Shares – M	68.3	68.8

- **Mid-point of revenue guidance assumes:**
  - Cloud & Networking segment up Q/Q
  - Industrial Tech segment approximately flat Q/Q

constraints. However, we anticipate that our production output will remain on allocation through at least the end of calendar 2025."

"Our significant capacity expansion for optical transceivers in our facility in Thailand is progressing as planned, with the first production line scheduled to start operations [and begin shipping its first sample products] this quarter [with qualifications then volume production ramp-up beginning in calendar first-quarter 2025]. Based on current engagements with multiple hyperscale cloud operators and AI infrastructure customers, we expect to complete additional phases of our manufacturing capacity expansion over the next 18 months to keep up with the expected strong demand."

3. Executing on the firm's differentiated technology roadmaps to support the evolving challenges of data-center compute scaling across future generations of optical interconnect technologies and data-center architectures, encompassing both increased data-link capacity and enhanced energy efficiency.

"We are actively collaborating with leading-edge customers to deliver breakthrough technologies that will support multi-year cloud and AI infrastructure roadmaps," says Lowe. "Optical switching, a critical component of future cloud and AI networking architectures, presents a significant opportunity for us. Our optical switch products in development offer advantages in power efficiency, increased bandwidth, reduced latency, flexibility and agility. We have shipped evaluation units to multiple customers and the initial feedback has been overwhelmingly positive," he adds.

"Another key technology area is enabling the transition to high-density, low-power optical links for future generations. Our ultra-high-power laser technologies have attracted considerable interest from cloud and AI infrastructure customers developing high-density optical interconnects. Our heritage of delivering high-performance, high-reliability lasers in high-volume production environment position us favorably for this emerging market."

"Lastly, we are focused on enabling the shift to speeds beyond 200G per lane, such as the 400G-per-lane generation. Our advanced indium phosphide and photonic integrated circuit capabilities honed through years of experience in data-center and high-performance telecom applications are essential to meeting future demands."

We are focused on expanding our high-speed transceiver capabilities and capacity in Thailand to support 800G, 1.6T and eventually 3.2T transceivers

"While the deployment of these products and technologies is a few years away, these are long-term developments requiring early investment and close customer collaboration," notes Lowe. "We are actively engaged with customers and their R&D teams."

On target to grow quarterly revenue to $500m by end 2025

"As we move through fiscal 2025 and beyond, we are focused on expanding our high-speed transceiver capabilities and capacity in Thailand to support 800G, 1.6T and eventually 3.2T transceivers," notes Ali. "We anticipate an elevated level of capital expenditures in fiscal 2025 to proactively meet the anticipated surge in demand for high-speed transceivers and datacom components," he adds.

"Our robust pipeline of cloud customer engagements and improving trends in the traditional networking market reinforce our confidence in the target to grow quarterly revenue to $500m by the end of calendar 2025," says Lowe. "We foresee continued significant growth into 2026 and 2027. We are executing on new cloud and AI opportunities that we expect will elevate our cloud business to a multi-billion dollar annual run rate in the coming years."

www.lumentum.com

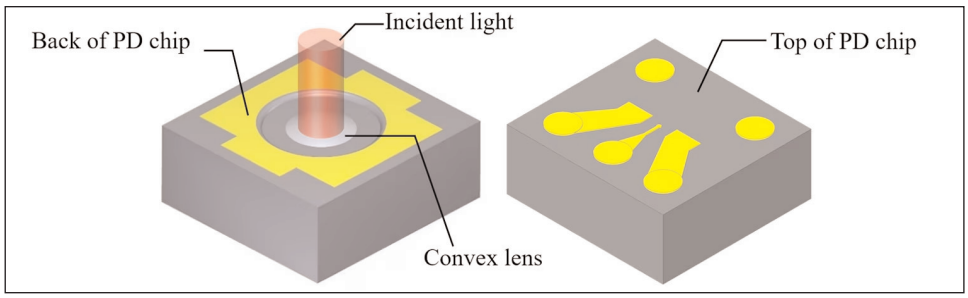
Mitsubishi Electric to ship samples of 200Gbps PIN-PD chip for 800Gbps and 1.6Tbps fiber communication

Integrating backside illumination and convex lens reduces capacitance, doubling transmission speed

Tokyo-based Mitsubishi Electric Corp says that on 1 October it will begin shipping samples of its new 200Gbps PIN-photodiode (PD) chip for use in next-generation optical transceivers to support 800Gbps and 1.6Tbps fiber communication.

The addition of the new PD7CP47 receiver chip to Mitsubishi Electric's optical device lineup will enable existing devices capable of transmitting at 800Gbps/1.6Tbps to now receive optical data at these same speeds, expanding the communication capacity of optical transceivers, including for high-speed, high-capacity communication in data centers.

The introduction of the 200Gbps PIN-PD chip for optical reception follows Mitsubishi Electric's launch of a mass-produced chip for optical transmission, the 200Gbps (112Gbaud four-level pulse-amplitude modulation [PAM4]) electro-absorption modulator laser diode (EML), in April. Leveraging the firm's expertise in optical devices, the new PD chip was developed for high-speed, high-capacity data-center communications by integrating backside illumination and a light-accumulating convex lens that minimizes the photoelectric conversion area within the chip structure, resulting in low capacitance to enable high-speed 200Gbps transmission (112Gbaud PAM4), twice that of conventional mainstream products (100Gbps).



www.mitsubishielectric.com

OIF's 34-member interoperability demo at ECOC showcasing solutions for data centers, AI/ML technologies and disaggregated systems

Demos include 800ZR, 400ZR and multi-span optics, EEI & co-packaging, 224G and 112G CEI, and CMIS

In booth #B83 at the European Conference on Optical Communication (ECOC 2024) exhibition in Frankfurt, Germany (23–25 September), the Optical Internetworking Forum (OIF) is to lead a dynamic interoperability demonstration featuring live collaboration between 34 member companies.

The showcase highlights advances in performance, efficiency and capacity in response to the burgeoning needs of future-oriented data centers, artificial intelligence/machine learning (AI/ML) technologies and disaggregated systems.

The demonstration spotlights interoperability innovations in 800ZR, 400ZR and multi-span optics, Energy Efficient Interfaces (EEI) & co-packaging, 224G and 112G Common Electrical I/O (CEI) and Common Management Interface Specification (CMIS) – all pivotal for shaping the next decade of industry standards.

"OIF's interoperability demonstrations at this year's ECOC are a testament to the collaborative efforts of our member companies in enabling next-generation connectivity solutions," says OIF president Nathan Tracy of TE Connectivity. "Our focus on advanced solutions underscores our commitment to addressing the future networking needs driven by evolving technologies like AI/ML."

The interoperability demonstrations showcase system, component and test-equipment vendors and highlight their roles in driving the adoption of advanced technologies in near-term and next-generation networks.

Participating member companies include Adtran; Alphawave Semi; Amphenol; Anritsu; AOI; Astera Labs; Cadence Design Systems Inc; CICT/Accelink; Cisco; Coherent Corp; EXFO; HG Genuine; Hisense; Infinera; Innolight; Juniper Networks; Keysight Technologies; Lessengers; Linktel Technologies; Lumentum; MACOM Technology Solutions; Marvell; Molex; Multi-Lane; Nokia; O-Net Technologies; Samtec; Semtech; Senko Advanced Components; Sumitomo Electric Industries; Synopsys; TE Connectivity; USConec and Wilder Technologies.

www.ecocexhibition.com
www.oiforum.com/meetings-events/oif-ecoc-2024

First Solar commissions Western Hemisphere's largest solar R&D center

NREL certifies new thin-film record of 23.1%-efficient CdTe cells

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has commissioned a new research & development innovation center in Lake Township, Ohio, which is believed to be the largest facility of its kind in the Western Hemisphere. The Jim Nolan Center for Solar Innovation is dedicated to the late James 'Jim' F. Nolan, a former member of First Solar's board of directors and the architect of the company's CdTe semiconductor platform.

The facility covers 1.3 million square feet and includes a pilot manufacturing line allowing the production of full-sized prototypes of thin-film and tandem PV modules. Previously, First Solar used a manufacturing line at its facility in Perrysburg, Ohio, for its late-stage product development efforts. This arrangement limited the flexibility for development efforts and created constraints when mission-critical tools had to go offline. The new facility is hence expected to accelerate innovation cycles.

"Thin films are the next technological battleground for the solar industry because they are key to commercializing tandem devices, which are anticipated to be the next disruption in photovoltaics," says CEO Mark Widmar. "While the United States leads the world in thin-film PV, China is racing to close the innovation gap. We expect that this crucial investment in R&D infrastructure will help maintain our nation's strategic advantage in thin film, accelerating the cycles of innovation needed to ensure that the next disruptive, transformative solar technology will be American-made."

The Jim Nolan Center is part of an approximately half-billion-dollar investment by First Solar in R&D infrastructure, and the firm expects to also commission a perovskite development line at its Perrysburg campus in second-half 2024. The firm, which has invested almost $2bn in R&D, operates laboratories in Santa Clara, California, and Perrysburg, Ohio, in the USA, and Uppsala in Sweden. Its California Technology Center (CTC) in Santa Clara recently achieved a 23.1%-efficient CdTe cell, a new record certified by the US National Renewable Energy Laboratory (NREL).

Founded in 1999, First Solar claims to be unique among the world's largest solar manufacturers for being the only US-headquartered company and for scaling the production of thin-film solar panels. The firm exited 2023 with 16.6GW of annual global nameplate manufacturing capacity and is expected to exceed 25GW by 2026. First Solar expects to commission new manufacturing facilities in Alabama in second-half 2024 and Louisiana in second-half 2025, bringing its total US nameplate capacity to 14GW by 2026.

First Solar takes ownership of TOPCon technology patents

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has announced its ownership of patents related to the manufacturing of Tunnel Oxide Passivated Contact (TOPCon) crystalline-silicon (c-Si) photovoltaic solar cells.

First Solar secured the US patent and related international counterparts through its acquisition in 2013 of TetraSun Inc of San Jose, CA, USA (which had pioneered proprietary cell architecture and manufacturing processes for large-format crystalline silicon wafers) and the firm's intellectual property portfolio. First Solar has now initiated an investigation of several c-Si solar manufacturers for potential infringement of its patents. The patents include issued patents in the USA, Canada, Mexico, China, Malaysia, Vietnam, Japan and Australia, among other jurisdictions, with validities extending to 2030. It also includes pending patent applications in the European Union and Japan. First Solar says that it firmly believes in the value and strength of the patents and that it plans to conduct a thorough investigation of potentially infringing products.

"These patents are First Solar's intellectual property, which we continue to leverage as part of ongoing efforts to develop the next generation of PV technologies," says Jason Dymbort, First Solar's executive VP, general counsel & secretary. "While First Solar is a world leader in the development and commercialization of advanced thin-film photovoltaics, our R&D and intellectual property portfolio spans several semiconductor platforms, including crystalline silicon, as we pursue multiple pathways towards our goal of developing the next transformative, disruptive solar technology," he adds.

"We are investigating several leading crystalline silicon solar manufacturers for potential infringement of our patents. If infringement is discovered, we intend to challenge the ability of potential infringers to legally manufacture, assemble and sell infringing TOPCon technology by pursuing enforcement, licensing, and/or other measures to safeguard our rights."

www.firstsolar.com

Rocket Lab celebrates CHIPS Act funding preliminary agreement

Congressional leaders and state and local officials visit Albuquerque solar cell manufacturing facility

The executive leadership of launch services and space systems provider Rocket Lab USA Inc of Long Beach, CA, USA welcomed government and community leaders (including Congressional leaders and state and local officials) at its space-grade solar cell manufacturing facility in Albuquerque, New Mexico on 15 July to celebrate its signed preliminary agreement under the US CHIPS and Science Act.

Guests included US Senators Martin Heinrich (D-N.M.) and Ben Ray Luján (D-N.M.), New Mexico Governor Michelle Lujan Grisham, US Representative Melanie Stansbury (D-N.M.), and Albuquerque Mayor Tim Keller was joined by US Deputy Secretary of Commerce Don Graves and White House CHIPS Coordinator Ryan Harper.

Rocket Lab's solar cell facility has been a technology hub in Albuquerque for the past 25 years, employing more than 370 staff manufacturing space solar technology that has powered over 1100 satellites in orbit. To date, Rocket Lab has produced more than 4MW of solar cell energy (equivalent to powering 14,400 miles driven by an electric car). This has enabled critical space missions (such as the James Webb Space Telescope, NASA's Artemis lunar explorations, Ingenuity Mars Helicopter, and the Mars Insight Lander) and served a booming commercial satellite market (including powering the OneWeb broadband internet satellite constellation).

The proposed investment of up to $23.9m will aid Rocket Lab's project to modernize and expand its manufacturing capacity of compound semiconductor space-grade solar cells by 50% within the next three years, creating more than 100 direct manufacturing jobs to Albuquerque. This will help to domestically meet the growing national defense & security and consumer demand for solar cells in spacecraft and satellites (e.g. for critical space programs, missile awareness systems, and exploratory science missions).

Pictured (left to right): Rocket Lab's VP operations Jerry Winton and chief financial officer Adam Spice; US Congresswoman Melanie Stansbury; Deputy Secretary of Commerce Don Graves; New Mexico Governor Michelle Lujan Grisham; Albuquerque City Councilor Renee Grout; US Senator Ben Ray Luján; Dr Brad Clevenger, VP & general manager of Rocket Lab Space Systems; and Navid Fatemi, VP business development Rocket Lab. (Image courtesy of Tiffani Cornish Photo.)

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"The Economic Development Department is proud to support Rocket Lab's expansion," said Mark Roper, Acting Cabinet Secretary for the New Mexico Economic Development Department. "In the last 25 years, they've been committed to investing in New Mexico and their local community, creating manufacturing jobs, and providing internship and educational opportunities for the next generation of New Mexicans," he added.

www.rocketlabusa.com/space-systems/solar

Comparison between MBE and MOCVD technologies

Richard Hogg, III-V Epi chief technology officer and professor of Photonics at Aston Institute of Photonics Technology (AIPT), and Dr Neil Gerrard, III-V Epi director of epitaxy, explore the III-V semiconductor synthesis applications that each epitaxial growth technology best suits.

Both molecular beam epitaxy (MBE) and metal-organic chemical vapour deposition (MOCVD) reactors operate in cleanroom environments and use the same set of metrology tools for wafer characterization. Solid-source MBE uses high-purity, elemental precursors heated in effusion cells to create a molecular beam to enable deposition (with liquid nitrogen used for cooling). In contrast, MOCVD is a chemical vapor process, using ultra-pure, gaseous sources to enable deposition, and requires toxic gas handing and abatement. Both techniques can produce identical epitaxy in some material systems, such as arsenides. The choice of one technique over the other for particular materials, processes, and markets is discussed.

Molecular beam epitaxy

An MBE reactor typically comprises a sample transfer chamber (open to the air, to allow wafer substrates to be loaded and unloaded) and a growth chamber (normally sealed, and only open to the air for maintenance) where the substrate is transferred for epitaxial growth. MBE reactors operate in ultra-high vacuum (UHV) conditions to prevent contamination from air molecules. The chamber can be heated to accelerate the evacuation of these contaminants if the chamber has been open to air.

Often, the source materials of epitaxy in an MBE reactor are solid semiconductors or metals. These are heated beyond their melting points (i.e. source material evaporation) in effusion cells. Here, atoms or molecules are driven into the MBE vacuum chamber through a small aperture, which gives a highly directional molecular beam. This impinges on the heated substrate; usually made of single-crystal materials like silicon, gallium arsenide (GaAs) or other semiconductors. Providing that the molecules do not desorb, they will diffuse on the substrate surface, promoting epitaxial growth. The epitaxy is then built-up layer by layer, with each layer's composition and thickness controlled to achieve the desired optical and electrical properties.

The substrate is mounted centrally, within the growth chamber, on a heated holder surrounded by cryoshields, facing the effusion cells and shutter system. The holder rotates to provide uniform deposition and epitaxial thickness. The cryoshields are liquid-nitrogen cooled-plates which trap contaminants and atoms in the chamber that are not previously captured on the substrate surface. The contaminants can be from desorption of the substrate at high temperatures or by 'over filling' from the molecular beam.

The ultra-high-vacuum MBE reactor chamber enables in-situ monitoring tools to be used to control the deposition process. Reflection high-energy electron diffraction (RHEED) is used for monitoring the growth surface. Laser reflectance, thermal imaging, and chemical analysis (mass spectrometry, Auger spectrometry) analyse the composition of the evaporated material. Other sensors are used to measure temperatures, pressures and growth rates in order to adjust process parameters in real-time.

Growth rate and adjustment

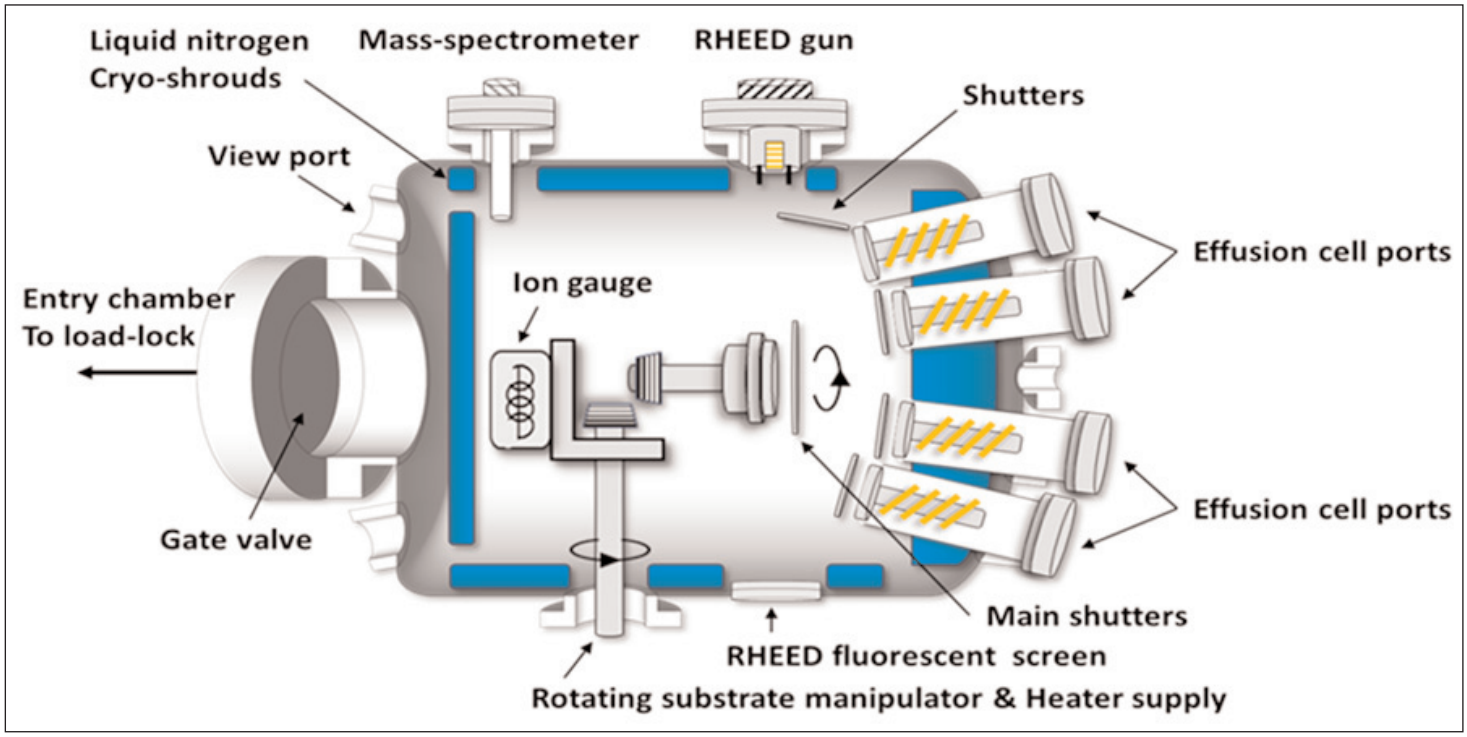
The epitaxial growth rate, which is typically about a third of a monolayer (0.1nm, 1Å) per second, is influenced by the flux rate (the number of atoms arriving at the substrate surface, controlled by the source temperature) and the substrate temperature (which affects the diffusive properties of atoms on the substrates surface and their desorption, controlled by the substrate heat). These parameters are independently adjusted and monitored within the MBE reactor, to optimize the epitaxial process.

By controlling growth rates and the supply of different materials using a mechanical shutter system, ternary and quaternary alloys and multi-layer structures can be grown reliably and repeatedly. After deposition, the substrate is cooled down slowly to avoid thermal stress and tested to characterize its crystalline structure and properties.

Material characteristics for MBE

The characteristics of III-V material systems used in MBE are:

- Silicon: Growth on silicon substrates requires very high temperatures to ensure oxide desorption



(>1000°C), so specialist heaters and wafer holders are required. Issues around the mismatch in lattice constant and expansion coefficient make III-V growth on silicon an active R&D topic.

- Antimony: For III-Sb semiconductors, low substrate temperatures must be used to avoid desorption from the surface. 'Non-congruence' at high temperatures may also occur, where one atomic species may be preferentially evaporated to leave non-stoichiometric materials.
- Phosphorus: For III-P alloys, phosphorous will be deposited on the inside of the chamber, requiring a time-consuming clean-up process which may make short production runs unviable.
- Strained layers, which generally require lower substrate temperatures to reduce the surface diffusion of atoms, reducing the likelihood of a layer relaxing. This can lead to defects, as the mobility of deposited atoms reduces, leaving gaps in the epitaxy which may become encapsulated and cause failure.

Metal-organic chemical vapour deposition

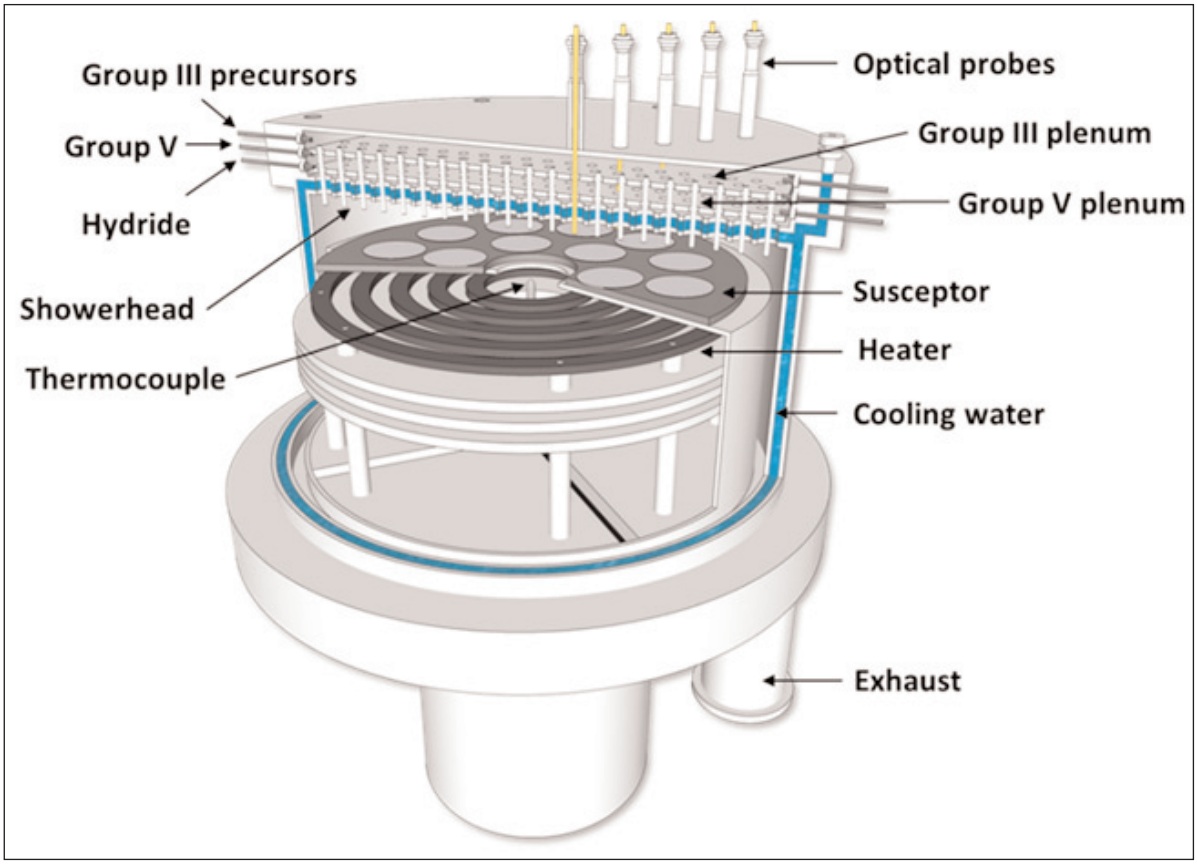
The MOCVD reactor has a high-temperature, water-cooled reaction chamber. Substrates are positioned on a graphite susceptor heated by either RF, resistive or IR heating. Reagent gases are injected vertically into the process chamber above the substrates. Layer uniformity is achieved by optimizing temperature, gas injection, total gas flow, susceptor rotation and pressure. Carrier gases are either hydrogen or nitrogen.

To deposit epitaxial layers, MOCVD uses very high-purity metal-organic precursors such as trimethylgallium for gallium or trimethylaluminium for aluminium for the group-III elements and hydride gases (arsine and phosphine) for the group-V elements. The metal-organics are contained in gas flow bubblers. The concentration injected into the process chamber is determined by temperature and pressure of the metal-organic and carrier gas flow through the bubbler.

The reagents fully decompose on the substrate surface at the growth temperature, releasing metal atoms and organic by-products. The concentration of reagents is adjusted to produce different, III–V alloy structures, along with a run/vent switching system for adjusting the vapour mixture.

The substrate is usually a single-crystal wafer of a semiconductor material such as gallium arsenide, indium phosphide, or sapphire. It is loaded onto the susceptor within the reaction chamber over which the precursor gases are injected. Much of the vapourized metal-organics and other gases travel through the heated growth chamber unaltered, but a small amount undergoes pyrolysis (cracking), creating subspecies materials that absorb onto the surface of the hot substrate. A surface reaction then results in the incorporation of the III-V elements into an epitaxial layer. Alternatively, desorption from the surface may occur, with unused reagents and reaction products evacuated from the chamber. Additionally, some precursors may induce 'negative growth' etching of the surface, such as in carbon doping of GaAs/AlGaAs, and with dedicated etchant sources. The susceptor rotates to ensure consistent composition and thicknesses of the epitaxy.

The growth temperature required in the MOCVD reactor is primarily determined by the required pyrolysis of the precursors, and then optimized regarding surface mobility. The growth rate is determined by the vapour pressure of the group-III metal-organic sources in the bubblers. Surface diffusion is affected by atomic steps



on the surface, with misoriented substrates often being used for this reason. Growth on silicon substrates requires very high-temperature stages to ensure oxide desorption (>1000°C), demanding specialist heaters and wafer substrate holders.

The reactor's vacuum pressure and geometry means that in-situ monitoring techniques vary to those of MBE, with MBE generally having more options and configurability. For MOCVD, emissivity-corrected pyrometry is used for in-situ, wafer surface temperature measurement (as opposed to remote, thermocouple measurement); reflectivity allows surface roughening and the epitaxial growth rate to be analysed; wafer bow is measured by laser reflection; and supplied organometallic concentrations can be measured via ultrasonic gas monitoring, to increase the accuracy and reproducibility of the growth process.

Typically, aluminium-containing alloys are grown at higher temperatures (>650°C), while phosphorous-containing layers are grown at lower temperatures (<650°C), with possible exceptions for AlInP. For AlInGaAs and InGaAsP alloys, used for telecoms applications, the difference in the cracking temperature of arsine makes the process control simpler than for phosphine. However, for epitaxial re-growth, where the active layers are etched, phosphine is preferred. For antimonide materials, unintentional (and generally unwanted) carbon incorporation into AlSb occurs, due to the lack of an appropriate precursor source, limiting the choice of alloys and so the uptake of antimonide growth by MOCVD.

For highly strained layers, due to the ability to routinely utilize arsenide and phosphide materials, strain balancing and compensation are possible, such as for GaAsP barriers and InGaAs quantum wells (QWs).

Summary

MBE generally has more in-situ monitoring options than MOCVD. The epitaxial growth is adjusted by the flux rate and substrate temperature, which are separately controlled, with associated in-situ monitoring allowing a much clearer, direct, understanding of the growth processes.

MOCVD is a highly versatile technique that can be used to deposit a wide range of materials, including compound semiconductors, nitrides and oxides, by varying the precursor chemistry. Precise control of the growth process allows the fabrication of complex semiconductor devices with tailored properties for applications in electronics, photonics and optoelectronics. MOCVD chamber clean-up times are quicker than MBE.

MOCVD is excellent for the regrowth of distributed feedback (DFBs) lasers, buried heterostructure devices, and butt-jointed waveguides. This may include in-situ etching of the semiconductor. MOCVD is, therefore, ideal for monolithic InP integration. Although monolithic integration in GaAs is in its infancy, MOCVD enables selective area growth, where dielectric masked areas help space the emission/absorption wavelengths. This is difficult to do with MBE, where polycrystal deposits can form on the dielectric mask.

In general, MBE is the growth method of choice for Sb materials and MOCVD is the choice for P materials. Both growth techniques have similar capabilities for As-based materials. Traditional MBE-only markets, such as electronics, can now be served equally well with MOCVD growth. However, for more advanced structures, such as quantum dot and quantum cascade lasers, MBE is often preferred for the base epitaxy. If epitaxial regrowth is required, then MOCVD is generally preferred, due to its etching and masking flexibility. ■

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	Epitaxy			
Materials	III-As	III-P	III-Sb	On Si
MBE	Yes	OK	Yes	OK
MOCVD	Yes	Yes	No	OK
Applications	Wireless, Comms, 3D Sensing, Quantum, Biomedical, Pump Lasers	Wireless, Comms, Fibre-sensing, Quantum,	Sensing and imaging	Low Cost Photonics/Electronics convergence
Wavelengths	650~1300nm	1200~2000	1500~6000nm	As epitaxial system
Comments	[1]	[2][3]	[4]	[5]

Material choices: MBE and MOCVD.
[1] Quantum dot lasers made using MBE extend the wavelength options from ~1100nm to ~1300nm.
[2] MBE growth on InP substrates is routine, but the deposition of phosphorous materials requires a chamber clean-up process before opening the chamber safely.
[3] Epitaxial regrowth via MOCVD is routine, with multiple steps possible.
[4] Significant carbon incorporation in AlSb has limited Sb epitaxy options via MOCVD, with MBE being dominant.
[5] Special, high-temperature heating elements are required to desorb native oxide on silicon, so this is not viable for MBE or MOCVD.

III-V Epi's CTO Richard Hogg to chair PCSEL Workshop at Aston University

Photonic crystal surface-emitting laser pioneer Noda giving keynote

Richard Hogg, chief technical officer at III–V Epi Ltd of Glasgow, Scotland, UK — which provides a molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) service for custom compound semiconductor wafer design, manufacturing, test and characterization — and professor of Photonics at Aston Institute of Photonics Technology (AIPT), is chairing this year's PCSEL Workshop 2024 at Aston University (7–8 November).

The workshop's keynote speaker is professor Susumu Noda, a pioneer of PCSEL (photonic crystal surface-emitting laser) research and professor of Electronic Science and Engineering at Kyoto University in Japan.

If successfully commercialized, PCSELs are reckoned to offer many performance and manufacturing benefits over existing laser technologies.

"The workshop brings PCSEL researchers together from around the world to discuss results, device engineering, manufacturing and applications," says Hogg. "Professor Noda is a significant keynote speaker and his laboratory in Japan is at the forefront of PCSEL research, set to transform next-generation smart manufacturing, ICT, LiDAR, face recognition, medical, healthcare, telecoms, and datacoms applications.

"The workshop will also raise the profile of AIPT, one of over 80 photonic research centers worldwide. AIPT actively collaborates with industrial and commercial partners, including Airbus, IBM, Infinera, Thales, BAE Systems, and Nokia Bell Labs," says Hogg. "Additionally, as CTO of III-V Epi, I bring manufacturing experience of PCSEL-based, epitaxial nanostructures, using MBE and MOCVD machines, to the discussions."

www.pcsel.org
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Near size-independent UV-A micro-LED performance

Researchers claim record for on-wafer EQE from sub-10μm device.

University of Wisconsin-Madison in the USA reports on atomic layer deposition (ALD) passivation as a means to overcome the impact of sidewall damage on micron-scale light-emitting diodes (micro-LEDs), resulting in near size-independent performance between 8μm and 100μm [Guangying Wang et al, physica status solidi RRL (2024) 2400119].

The researchers comment on smaller devices: "Micro-LEDs have the potential to show higher stability under high current density while providing a higher light extraction efficiency and output power than regular-sized devices due to improved heat dissipation and reduced strain with decreasing device sizes."

Smaller devices can suffer from greater leakage currents that reduce efficiency, and indicate non-radiative recombination near sidewalls due to plasma-etch damage and dangling chemical bonds.

The researchers point out that, while micro-LEDs in other wavelengths — visible (>420nm) and UV-C (<280nm) — have been extensively studied, there are relatively few on near-ultraviolet (UV-A, 315-400nm) devices.

"UV-A LEDs can be used in various applications such as curing, disinfection, lithography, counterfeit detection, and 3D printing," the team comments. The researchers also see potential for deployment in displays using the UV-A devices to power suitable color-conversion materials for different colored pixels.

The researchers fabricated micro-LEDs using metal-organic chemical vapor deposition (MOCVD)-grown UV-A wafers (Figure 1). The 13x multiple quantum well (MQW) active light-emitting region consisted of indium gallium nitride (InGaN) wells and aluminium gallium nitride (AlGaN) barriers. The p-type contact region included an electron-blocking layer (EBL) to avoid electron overshoot leading to increased non-radiative recombination in the p-contact layers.

The p-electrode consisted first of 100nm nickel (Ni), applied before plasma-etch mesa isolation down to the n-contact layers. The sidewall etch damage was passivated: first using ALD of 30nm aluminium oxide (Al_2O_3), and then using plasma-enhanced CVD of 270nm silicon nitride (SiNx). The n- and p-electrodes were completed with via etching and deposition of titanium (Ti) and Ni.

The fabricated devices were square-shaped with sides in the range 8–100μm. All devices demonstrated a reverse leakage current density less than ~10^{-5}A/cm^2. The smaller devices had higher reverse current density than the larger LEDs.

The injection current density for a given forward bias

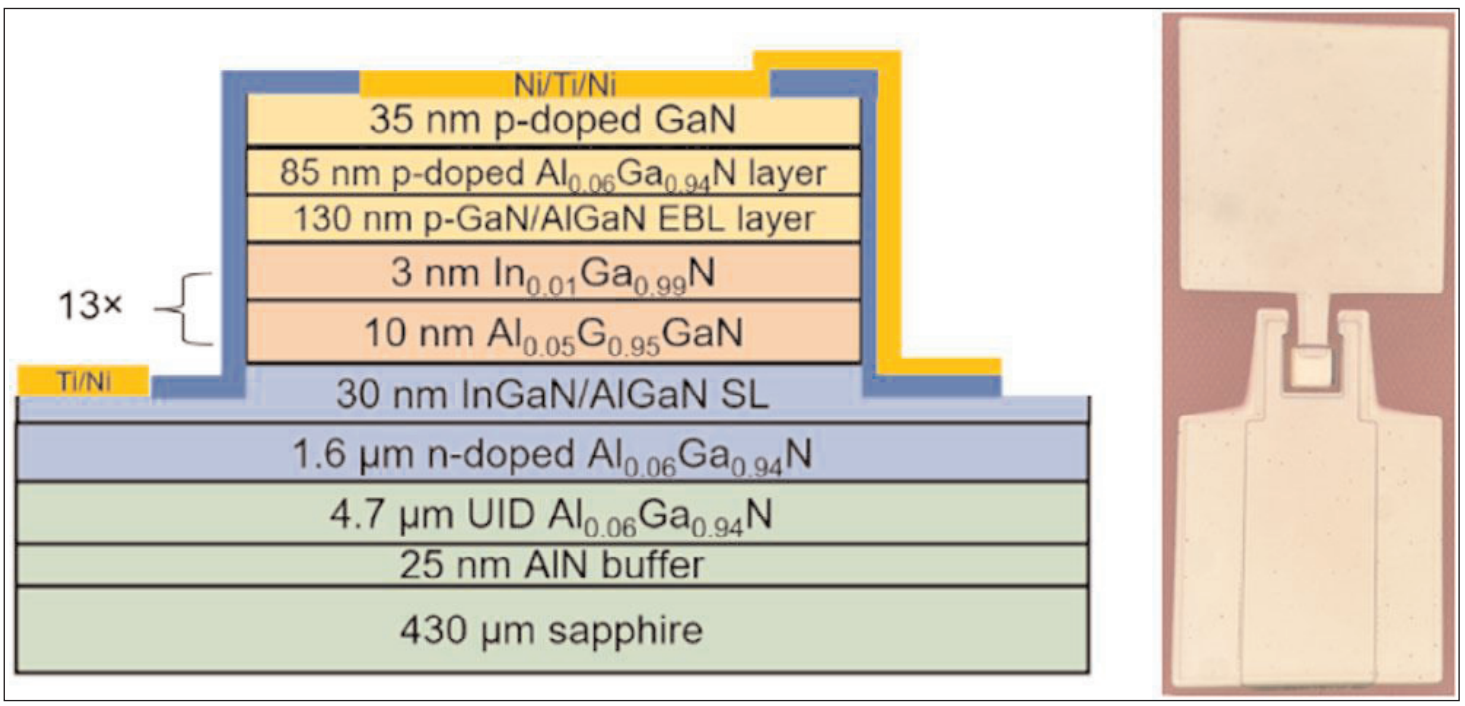

Figure 1. Cross-sectional schematic of UV-A LED with optical microscope image.

was also higher for the smaller devices. The researchers comment: "This behavior might be due to the reduced current crowding and improved heat dissipation in smaller-sized micro-LEDs."

The electroluminescence spectrum showed a peak at 368.5nm with a full-width at half maximum (FWHM) of 14.6nm. Current-dependent shifts in the spectral peak were of order 0.028nm, close to the detection limit of the researchers' equipment.

The team comments: "These UV-A LEDs were designed with minimal indium concentration (<1.5%) in the quantum well. This low indium concentration results in less indium segregation, which increases the composition uniformity of the wafer, hence leading to low FWHM and stable emission wavelength. Low indium concentration also decreases the quantum-confined Stark effect caused by the InGaN/AlGaN interface, which results in a low blue-shift with higher injection current density."

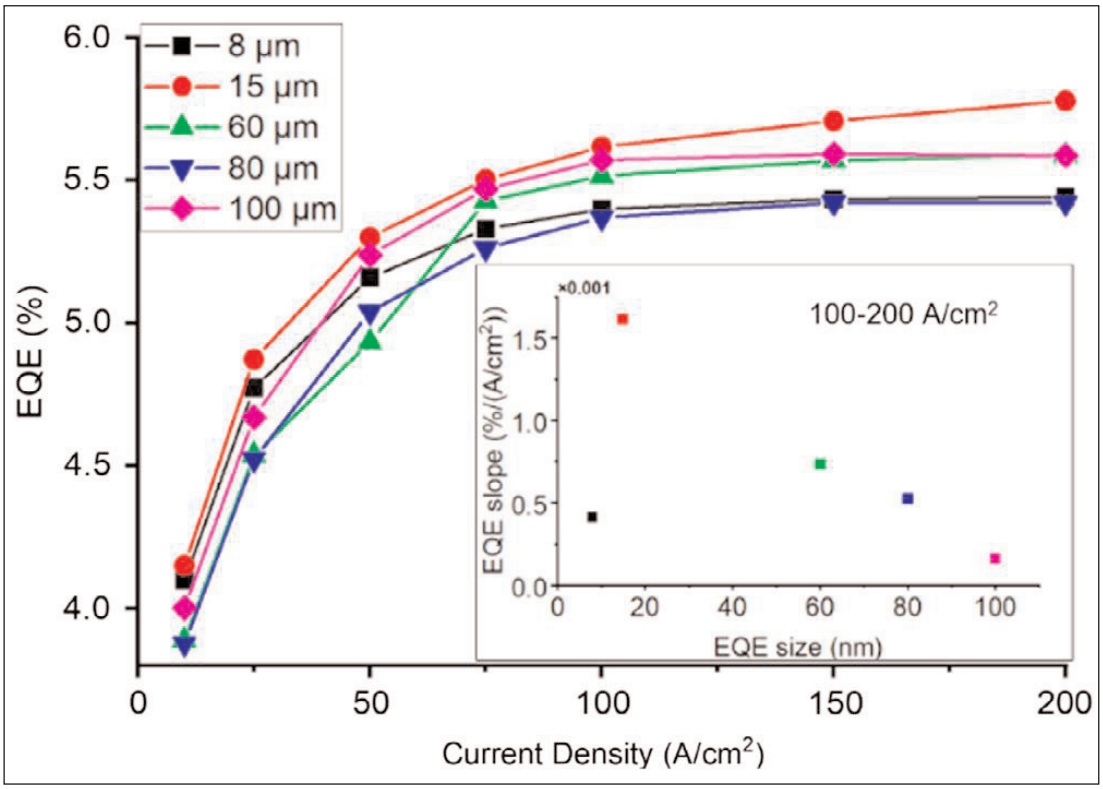

Figure 2. On-wafer EQE measurements of the various LEDs.

The quantum-confined Stark effect (QCSE) refers to electron energy level shifts due to internal electric fields arising from the different charge polarization of the chemical bonds between the different alloys.

The external quantum efficiency (EQE) behavior of the LEDs was similar up to 200A/cm^2 current density (Figure 2). The team reports: "Devices demonstrated high on-wafer EQEs around 5.5%, with less than 0.5% difference among all the sizes at 100A/cm^2. This result indicated that we successfully suppressed the leakage current of smaller-sized micro-LEDs and achieved similar performance of smaller-sized micro-LEDs to the regular-sized micro-LEDs."

On-wafer EQE results tend to be lower than those for fully packaged LEDs measured in an integrating sphere. The team claims the >5% EQE of the 8μm LED as the highest reported on-wafer EQE of UV-A micro-LEDs with a size smaller than 10μmx10μm. The 15μm device showed the highest EQE of 5.78% at 200A/cm^2.

The EQE slope for increasing current in the range 100–200A/cm^2 was positive, indicating that the droop region was pushed to the >200A/cm^2 region. The 15μm device had the greatest slope. The researchers suggest that smaller 15μm device benefited from better heat dissipation and that the effect of sidewall etch damage was adequately handled through the optimized passivation, leading to compensation between these two factors. ■

https://doi.org/10.1002/pssr.202400119

Author: Mike Cooke

Red InGaN micro-LED on silicon prospecting

Pioneers reach ultra-high 4232PPI resolution.

Researchers based in Korea report on size-dependent characteristics of indium gallium nitride (InGaN) red micro-scale light-emitting diodes (micro-LEDs) fabricated on 4-inch silicon (Si) substrates [Juhyuk Park et al, Optics Express, v32, p24242, 2024].

The team from Korea Advanced Institute of Science and Technology (KAIST), Korea Advanced Nano Fab Center (KANC), and Chungbuk National University, sees its work as being pioneering, adding: "This work is the first investigation into the size-dependent characteristics of InGaN/GaN red micro-LEDs grown on Si substrates with dimensions under 100μm."

LED arrays based on the devices reached resolution as high as 4232 pixels per inch (PPI). Relatively poor red LED performance is a roadblock on the route to

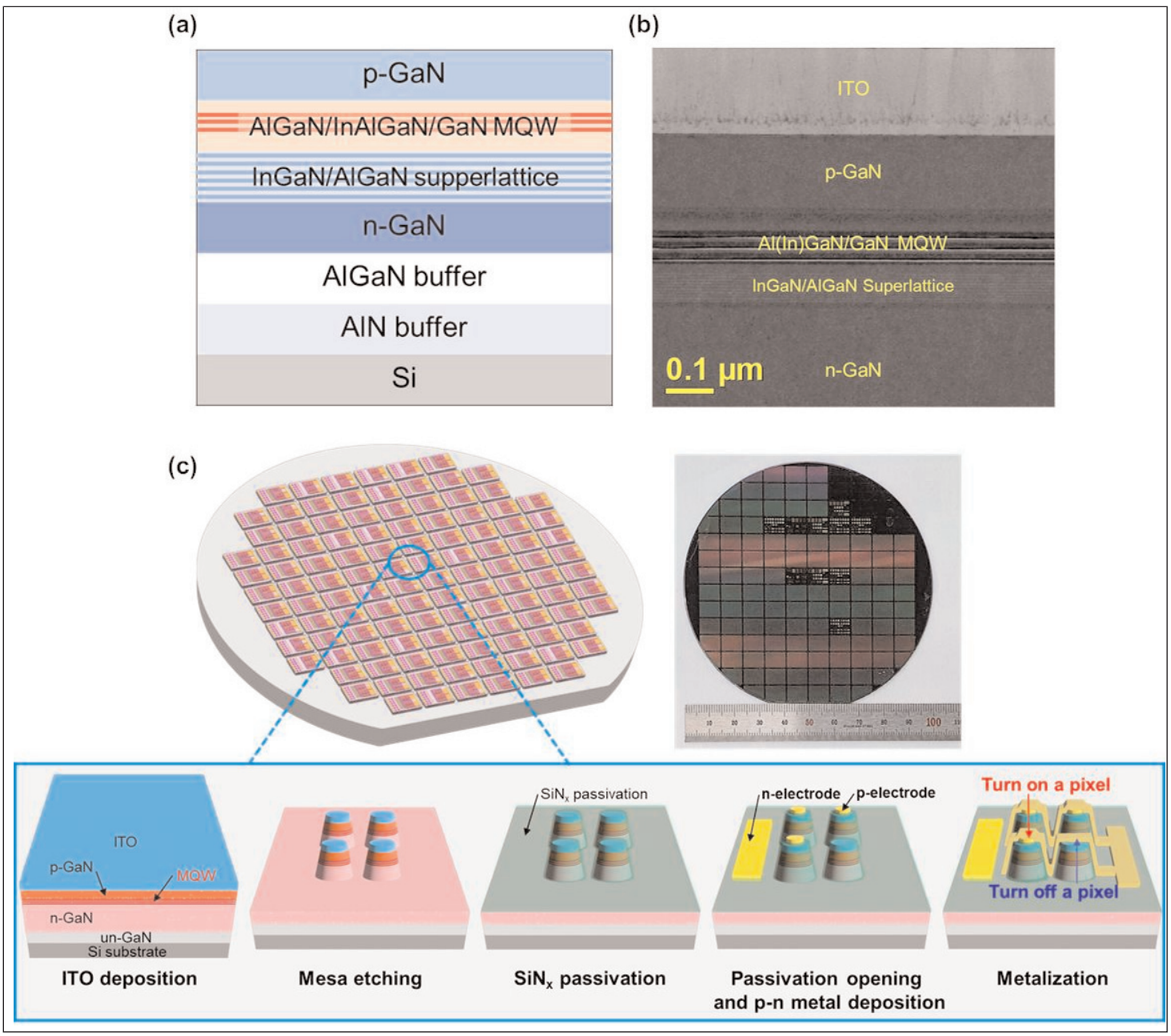

Figure 1. (a) InGaN/GaN red micro-LED epitaxial structure. (b) Transmission electron microscope (TEM) image. (c) Fabrication process flow and photograph inset of InGaN/GaN red micro-LEDs on 4-inch silicon wafer.

full-color displays based on InGaN LED technology. Apart from much lower cost, the advantage of using silicon substrates include better thermal conductivity than the more usual sapphire-based epitaxy.

The epitaxial structure for the red micro-LED arrays was grown by metal-organic chemical vapor deposition (MOCVD) on 4-inch Si (111) wafers (Figure 1). The buffer region was 1.3µm, followed by 2µm n-GaN contact. The superlattice consisted of 10 pairs of 0.9/5nm $Al_{0.04}Ga_{0.96}N/In_{0.05}Ga_{0.95}N$.

The active light-generating region consisted of a three-well multiple quantum well (MQW). The wells were 2.4nm $In_{0.23}Al_{0.05}Ga_{0.72}N$ separated by 10nm GaN barriers. The MQW was capped with 12nm AlGaN varying in Al-content in three steps (13%, 7%, 42%). The structure was completed with 150nm p-GaN as the contact layer.

The researchers used the material to fabricate the red micro-LED arrays. The first step was deposition of 200nm annealed indium tin oxide (ITO) as a transparent ohmic conductor p-electrode. The mesa structures for the individual LEDs were fabricated through a three-step inductively coupled plasma reactive ion etching process. The steps consisted of ITO etching, hydrochloric acid treatment to remove ITO residues, and the final etching down to the n-GaN layer.

The metal contacts with the common n-electrode and ITO p-contact consisted of chromium/gold (Cr/Au), deposited after 500nm silicon nitride (SiNx) CVD passivation. A passive matrix (PM) array format was used to wire the LEDs together in pixels.

The researchers point out that all these processes were carried out at the 4-inch wafer scale. The team comments: "In semiconductor fabrication, the most effective way to lower costs is through large-scale wafer-level fabrication, as it allows for the production of a larger number of devices in a single process."

The dark current density under reverse bias was below 1µA/cm^2 for all devices sizes from 5µm to 100µm.

The LEDs suffered a blue-shift in wavelength as the injection current density increased. For arrays of 12µm LEDs, the wavelength shifted from 648nm to 624nm for injections between 3A/cm^2 and 30A/cm^2, respectively. Standard red 642nm emission occurred at 5A/cm^2.

The full-width at half maximum (FWHM) for the LEDs was around 65nm at low injection, narrowing to 50nm at 30A/cm^2. This put a large chunk of the emissions in the 'orange' range (590–625nm) rather than 'red' (625–750nm).

The researchers comment: "The peak wavelength shift in InGaN quantum wells was attributed to the quantum-confined Stark effect (QCSE) and the band-filling effect."

The QCSE results from shifts in the energy levels due to the different combinations of applied electric field

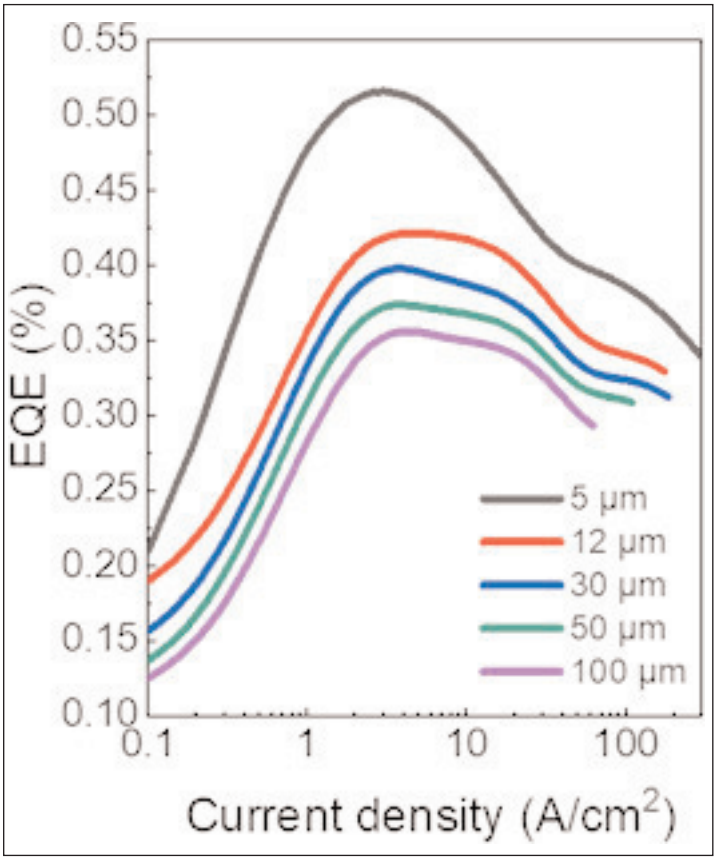

Figure 2. EQE of InGaN/GaN MQW red micro-LEDs with different device sizes.

and electric fields arising from the strain-dependent contrasts in the charge polarization of the different In AlGaN alloys making up the epitaxial structure.

The band-filling effect refers to the filling up of the conduction and valence bands and localized states (as is common in high-indium-content InGaN, which tends to have more non-uniform indium concentrations) at higher current injection — an electron from the top of the conduction band has to transit a larger energy difference to recombine with a hole, creating a higher-energy/shorter-wavelength photon.

The 'dominant' wavelength, taking into account the perception of a normal human eye and reducing it to a single wavelength, was determined, showing that the the LEDs were more orange than red. The largest 100µm LEDs recorded a dominant wavelength between 612nm and 588nm for injections between 10A/cm^2 and 130A/cm^2, respectively. The corresponding dominant wavelength range for the 5µm devices was 610–583nm.

The peak external quantum efficiency (EQE) ranged from 0.52% for the 5µm LED down to 0.36% for 100µm (Figure 2). The injections at which the peak occurred varied between 3A/cm^2 and 5A/cm^2, but without any clear trend, suggesting that the differences were due to process variations. By contrast, the competing red LED technology based on III–phosphide materials suffers a large shift in peak EQE injection

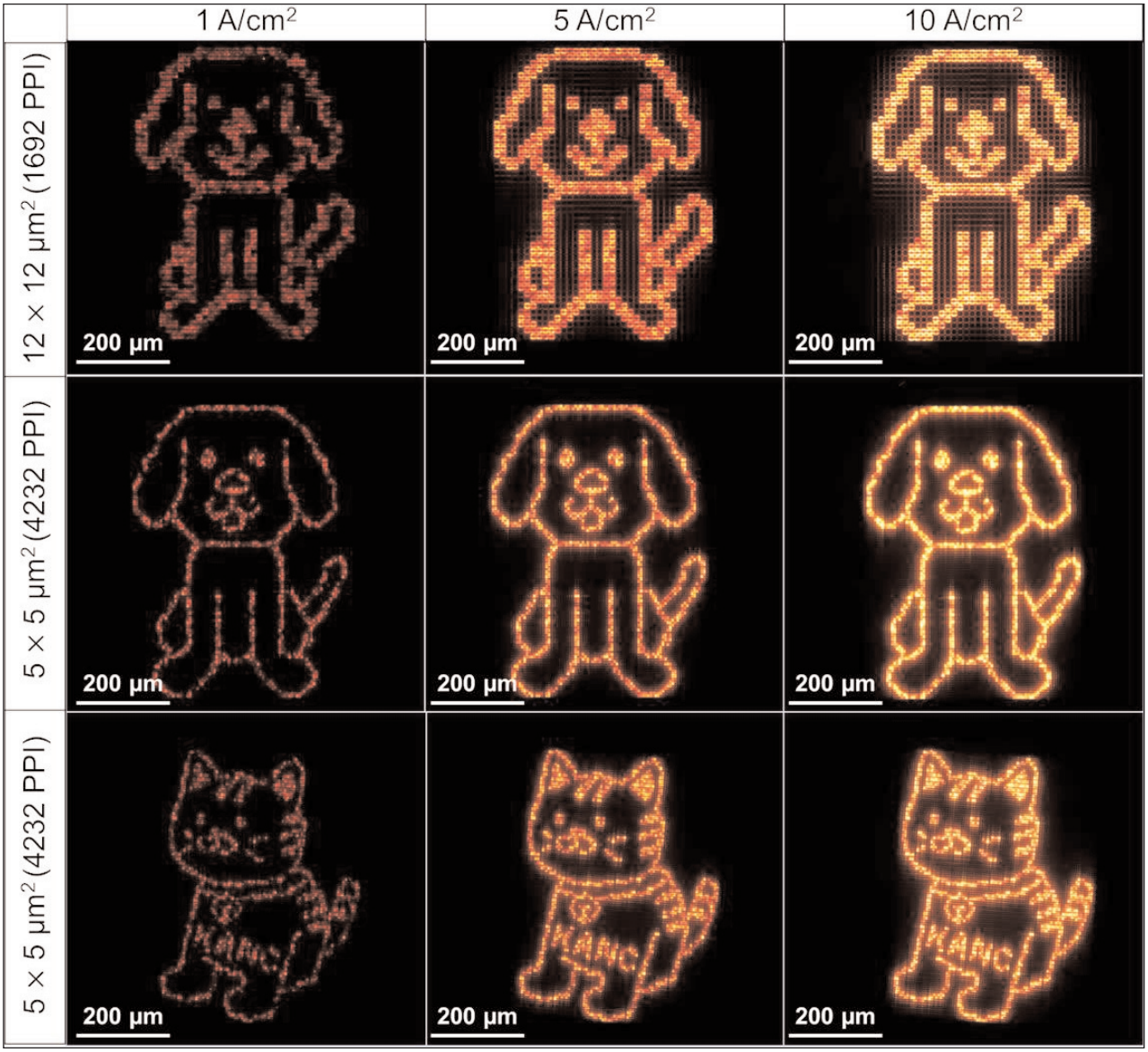

Figure 3. Images of various arrays being driven at various injections.

current with size.

The higher EQE for the smaller InGaN devices is explained as being due both to the reduction of sidewall recombination, relative to phosphide-based LEDs, and higher light-extraction efficiency (LEE).

The carriers in InGaN are more likely to be trapped in localized states, rather than traveling to the sidewalls for non-radiative recombination. The small devices also allow more light to escape rather than being trapped by total internal reflection effects, increasing LEE.

The team also compares their work with recent reports from University of California at Santa Barbara (UCSB) and South China Normal University for red InGaN micro-LEDs on silicon. The USCB and South China data points for peak EQE were 0.021% and 2.3%, respectively.

The team sees the 5µm device as being particularly suitable for displays: the peak EQE occurs around 3A/cm^2, which corresponds to a low drive current of 0.75µA, which could be supplied by mainstream silicon CMOS device drivers.

The researchers suggest that further developments could enhance the EQE such as by removing the silicon substrate through wafer bonding, by optimizing the device structure for higher LEE, and by optimizing the buffer to alleviate strain induced by high indium incorporation.

The team also demonstrate the ability to produce images by selective wiring on 5µm and 12µm LED arrays (Figure 3). The smaller devices naturally achieved a higher resolution.

Given the limitations of InGaN LED devices, the researchers suggest that pulse-width modulation (PWM), rather than pulse-amplitude modulation (PAM) might be a better method to control LED brightness. The said limitations include efficiency and wavelength variations with current injection, hence the desirability of using a fixed current injection amplitude.

The researchers found a linear dependence of light luminance between 476nits and 4148nits (candela/m^2) for pulse duty cycles varying between 10% and 90%, respectively, on a 12µm LED biased at 3.3V, giving current injection of 3A/cm^2.

The researchers comment: "These measurements confirmed that it is possible to represent grayscale with red emission without peak shift using PWM in InGaN/GaN red micro-LED devices." ■

https://doi.org/10.1364/OE.525680

Author: Mike Cooke

Etching-free pixel definition for InGaN micro-LEDs

Selective thermal oxidation proposed as viable alternative to plasma etch.

Researchers at King Abdullah University of Science and Technology (KAUST) in Saudi Arabia propose using selective thermal oxidation (STO) as a means to electrically isolate indium gallium nitride (InGaN) micro-light-emitting diode (LED) arrays rather than the more usual mesa isolation through plasma etch [Zhiyuan Liu et al, Light: Science & Applications, v13, p117, 2024].

A problem with plasma etch is that it creates highly damaged sidewalls with many defects and dangling chemical bonds, which act as sites for non-radiative carrier recombination. Avoiding plasma etching could be one means to remedying this efficiency-sapping mechanism. As devices shrink, the efficiency degradation from this source increases.

"Micro-LEDs fabricated through the STO method can be applied to micro-displays, visible light communication, and optical interconnect-based memories," the researchers comment. Other applications include augmented/virtual reality (AR/VR) and other micro-display formats, which could require micro-LEDs as small as 2μm. The virtually planar STO-processed arrays could also ease the monolithic integration of drive circuitry. The team also suggests potential for other III–nitride device types such as photodetectors, laser diodes, high-electron-mobility transistors, and Schottky barrier diodes.

The researchers fabricated LEDs on InGaN multiple quantum well (MQW) on sapphire LED wafers that had a green photoluminescence peak wavelength of 551nm (Figure 1). The epitaxial structure included two InGaN/GaN superlattices (SLs) in the buffer and an 8-period InGaN/GaN MQW. The 25nm electron-blocking layer (usually aluminium gallium nitride) was surrounded by p-type GaN. The 25nm p-GaN immediately after the MQW active region was grown at low temperature (LT) to avoid damage/degradation of the more delicate InGaN material underneath. High-temperature (HT) p-GaN (125nm) is higher quality in terms of crystallinity and charge transport.

The STO process used plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2) to protect device regions from oxidation in the subsequent

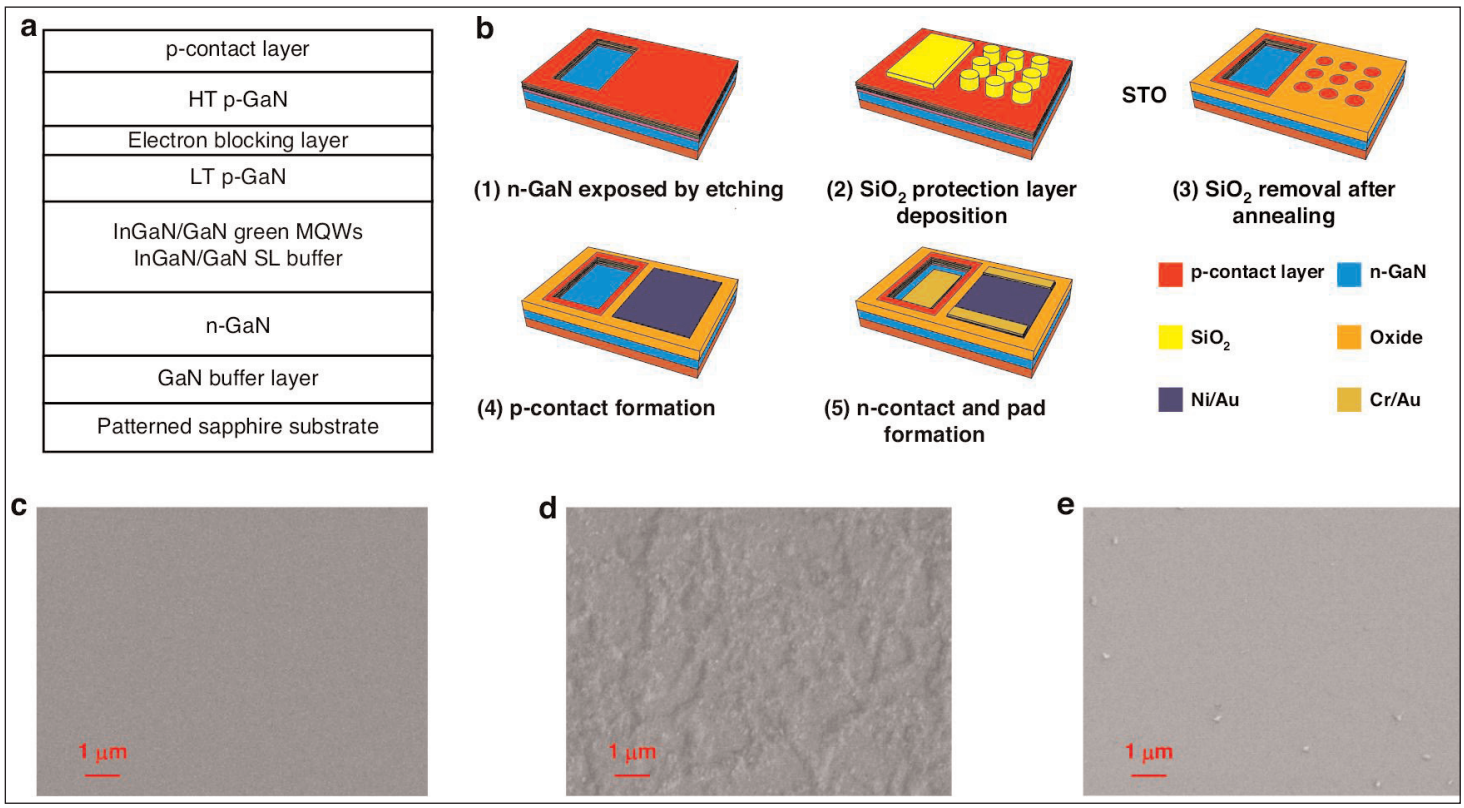

Figure 1. a InGaN-based green LED wafer structure. b STO fabrication process flow of micro-LED arrays. SEM images of the LED surface: c reference sample without thermal oxidization, d 4 hour thermal oxidization without SiO_2 protection, and e 8 hour thermal oxidization with 3.5μm SiO_2 protection and SiO_2 removal by HF vapor.

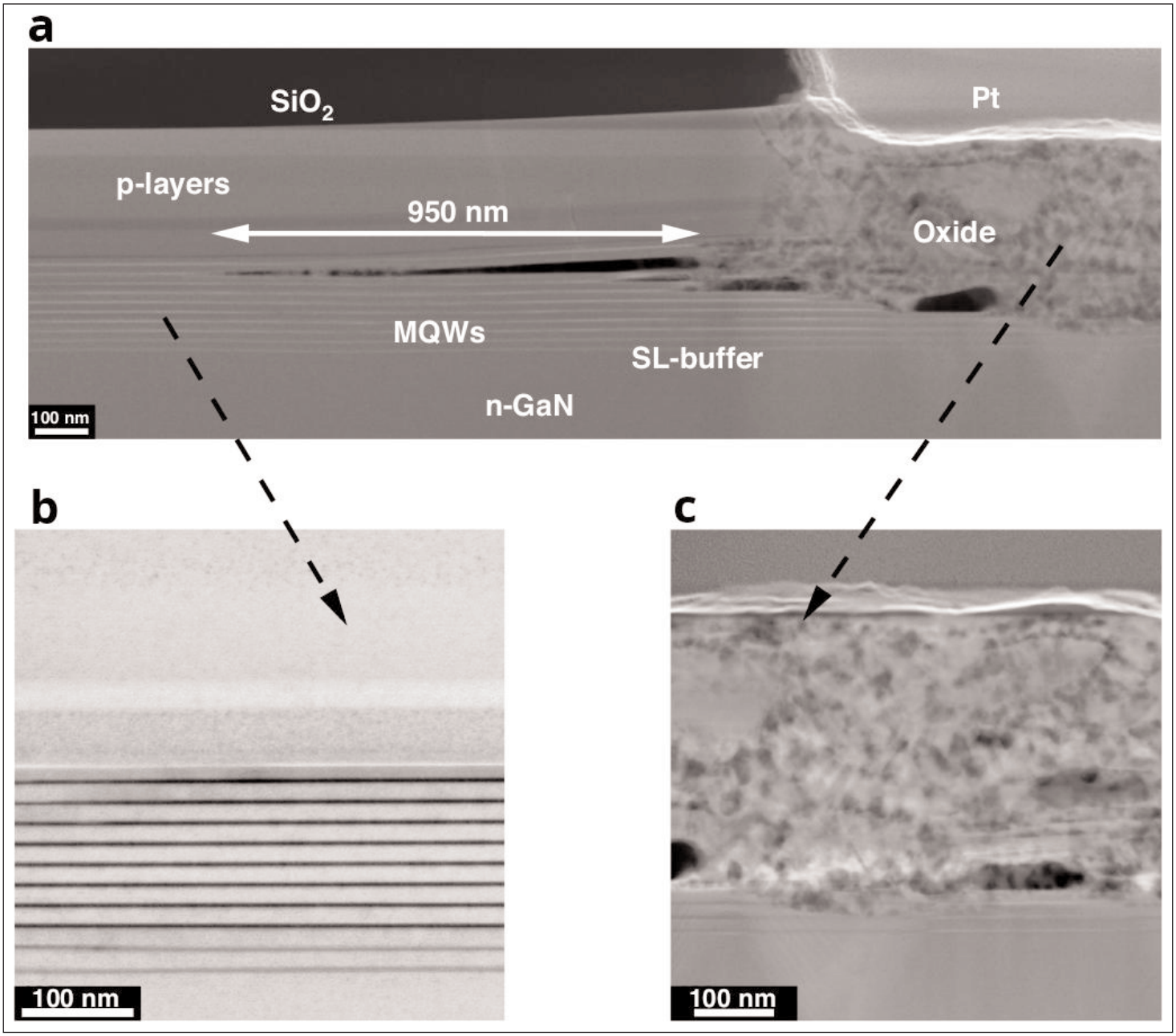

Figure 2. a Cross-section transmission electron microscope (TEM) image at oxide/LED interface with 4 hour annealing. b Magnified image of LED MQW structure under SiO_2 protection. c Magnified TEM image of oxidized material without protection.

thermal annealing step. The device regions included the n-GaN contact area, exposed by plasma etching, and the array of circular LEDs. The wafers used measured 1cmx1cm. The arrays were adjusted to give the same device areas with a current of 1mA representing 5.6A/cm^2.

The SiO_2 was patterned with plasma etch, using a chromium hard mask. The annealing to produce oxidation of the non-active region was carried out in a tube furnace in air. The annealing temperature was a critical parameter.

The researchers comment: "Given the stability of the InGaN MQWs, especially the indium diffusion issue, the annealing temperature should not be excessively high, even with SiO_2 protection. On the other hand, the temperature should be sufficiently high to oxidize GaN and InGaN in the absence of SiO_2 protection."

The team fixed upon 900°C as a suitable annealing temperature. The optimal annealing time for reducing reverse leakage in the final devices was found to be around 4 hours. Longer anneal times also resulted in devices that suffered from diffusion of oxygen from the SiO_2 protection into the device structure. The SiO_2 protection was removed with hydrogen fluoride (HF) vapor at 40°C, which was found to have a high selectivity for removing SiO_2 against the formed STO material.

The electrode metals were nickel/gold (Ni/Au) on the p-contact, and chromium/gold (Cr/Au) on the n-contact. The STO process avoided the need for any further dielectric passivation.

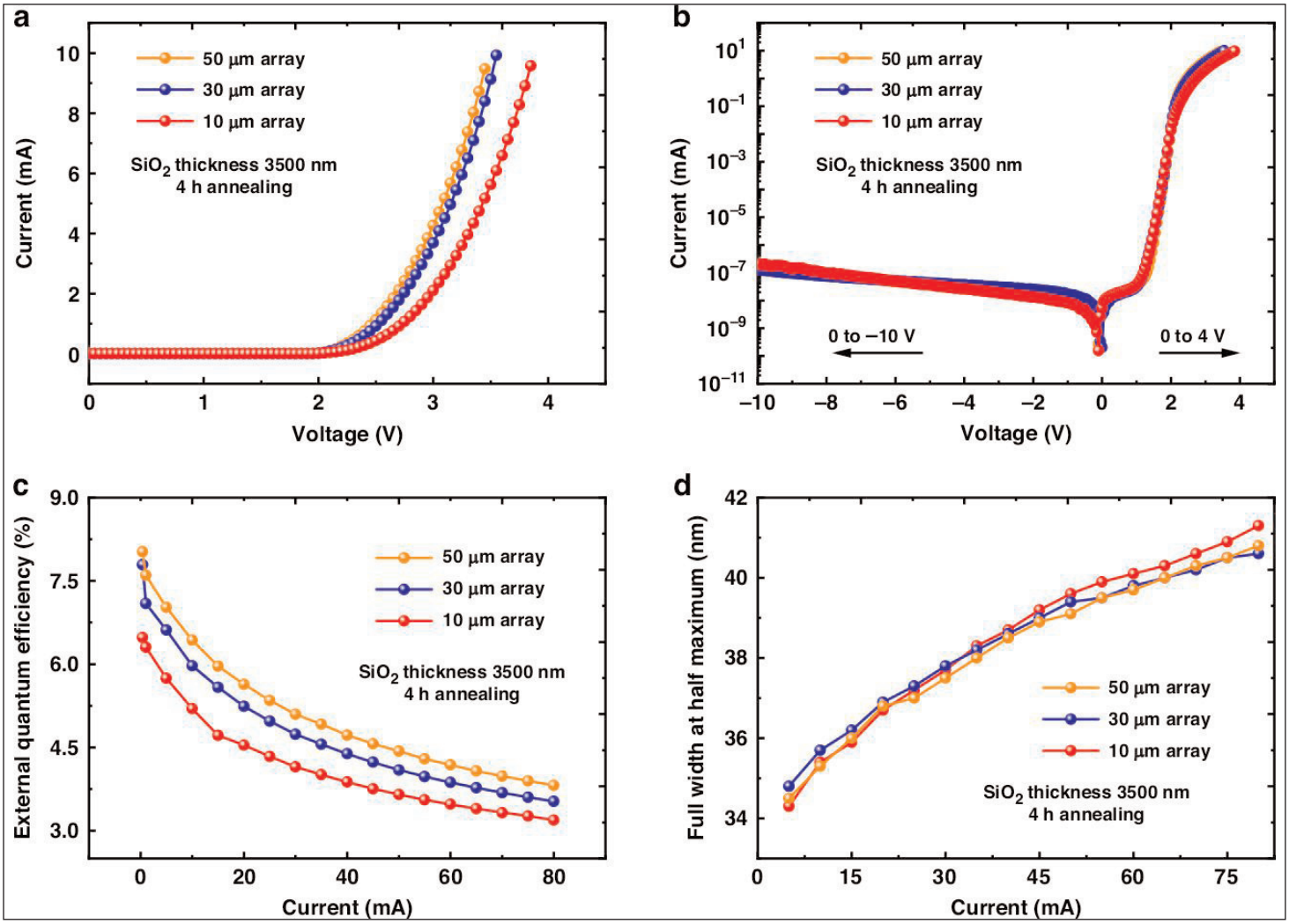

Figure 3. Current-voltage characteristics at forward bias: a, linear and, b, log scale, c EQE, and d spectrum FWHM of devices with 10μm, 30μm and 50μm pixels for 4 hour STO.

The team comments: "Procedures like selective dielectric etching required in traditional micro-LED fabrication for subsequent metal contact and the associated photolithography alignment were no longer necessary. Therefore, the proposed STO process for micro-LED fabrication is a self-aligned technique, reducing the complexity of photolithography for small-size device fabrication."

Inspection of the structures showed some cracking/delamination towards the edge/interface between the STO and LED regions (Figure 2). The oxidized material was polycrystalline. The researchers believe the 950nm crack shown resulted from thermal mismatch between oxide and nitride materials during the heating and cooling stages of the STO process. The team suspects that this could lead to low yields in sub-10μm-diameter devices, but that in the larger-diameter LED arrays that the researchers studied, "the negative impact of the crack was considered to be limited because the pixel size was much larger than the crack width."

The 950nm crack occurred at the top of the MQW, so it had the benefit/silver lining of restricting hole injection/ flow near the MQW/oxide interface, "reducing non-radiative recombination and improving micro-LED efficiency."

The 4 hour annealed 10μm LEDs also demonstrated the highest wall-plug efficiency (WPE)and external quantum efficiency (EQE): 5.72% and 6.48% at 0.4mA, respectively.

After a number of studies varying a number of process parameters, the researchers studied devices protected by 3500nm of SiO_2 in a 4 hour STO anneal process (Figure 3). The smallest 10μm LEDs needed a higher voltage bias to achieve a given current injection level. At 0.4mA, the EQE decreased with reduced pixel size: 8.02%, 7.79% and 6.48% for 50μm, 30μm and 10μm, respectively.

"The efficiency degradation of smaller-sized devices was related to the leakage current and large resistance of the device," believe the researchers. "The latter led to a higher heat generation and junction temperature."

The team reports that it has performed "preliminary investigations" on 2.3μm pixel arrays, but the experimental conditions still need significant optimization to control oxidation and cracks for improved device performance. ■

https://doi.org/10.1038/s41377-024-01465-7

Author: Mike Cooke

Gallium nitride HEMTs on 8-inch sapphire

Researchers seek to reduce production costs for devices with blocking voltages beyond 1200V.

Xidian University and Guangdong Ziener Technology Company Ltd in China claim the first fabrication of gallium nitride (GaN) high-electron-mobility transistors (HEMTs) on 8-inch sapphire substrates [Junbo Wang et al, IEEE Transactions on Electron Devices, vol.71, issue 7 (July 2024), p4429]. The OFF-state breakdown voltages reached beyond 1200V.

The researchers hope that their work will enable sapphire to commercially compete with GaN HEMT devices on large-diameter silicon (8- and 12-inch Si). Previously, GaN HEMTs/sapphire have been produced on 6-inch diameter substrates, increasing cost per unit.

The use of sapphire substrates enables thinner GaN buffers, and simpler epitaxy structures, due to the higher-quality growth, relative to material grown on silicon. The sapphire substrate is also more electrically insulating than silicon, which should enable kiloVolt blocking capability. [Sapphire is also more thermally insulating, which could hamper the heat dissipation needed for high power densities.]

GaN HEMTs with less than 650V ratings have seen deployment in fast chargers, class D-Audio amplifier, power tools, and home appliances. Going beyond 650V, GaN HEMTs/sapphire could open the way to industrial applications such as motor drivers and charging piles.

The researchers performed metal-organic chemical vapor deposition of III-nitride epitaxial material on 1.15mm-thick, 8-inch diameter sapphire substrates (Figure 1). The layer growth sequence was: 35nm aluminium gallium nitride (AlGaN) nucleation, 1.98μm GaN buffer, 420nm GaN channel, 1nm AlN spacer, 21nm $Al_{0.27}Ga_{0.73}N$ barrier, and, 2nm in-situ silicon nitride (SiN) cap.

HEMTs were fabricated with ohmic titanium/aluminium/nickel/gold (Ti/Al/Ni/Au) source/drain (S/D) metal stacks. The gate (G) metal was Ti/Al/Ti. Electrical isolation was provided by nitrogen-ion implantation.

Sheet resistance mapping showed a wafer-level non-uniformity of 4%. The average resistance was 310Ω/square. The warpage of the GaN/sapphire was 30μm.

The ω rocking curves for x-ray diffraction from the (002) and (102) planes demonstrate full-width at half maximum (FWHM) values of 588 arcsec and 1032 arcsec, respectively.

The researchers comment: "Further improvement of the epitaxy uniformity and quality can be made by tuning the buffer stack, gas flow, chamber pressure, temperature field, and so on."

The fabricated HEMTs aimed at 200V ratings. The gate length was 4μm, while the gate–source (GS) and gate–drain (GD) distances were 1.5μm and 6μm, respectively. The gate width was 100μm.

The device operated in 'normally-on' depletion mode with a negative threshold voltage of –4.2V. The specific on-resistance (R_{ON}) was 6.5Ω-mm. The R_{ON} was higher in devices near the center of the wafer, reaching 8.6Ω-mm. The team says that this was the result an "intrinsic problem" of the MOCVD chamber, along with a variation of contact resistance in the range 0.7–1.5Ω-mm.

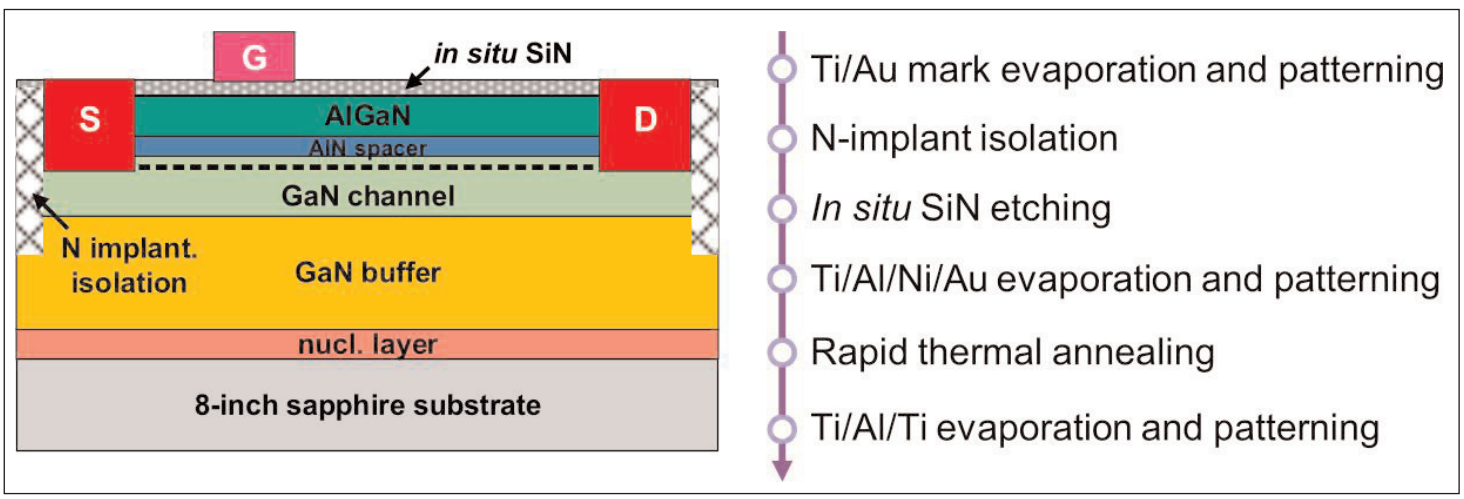

Figure 1. Cross-sectional schematic of fabricated GaN HEMTs on 8-inch sapphire and processing flow.

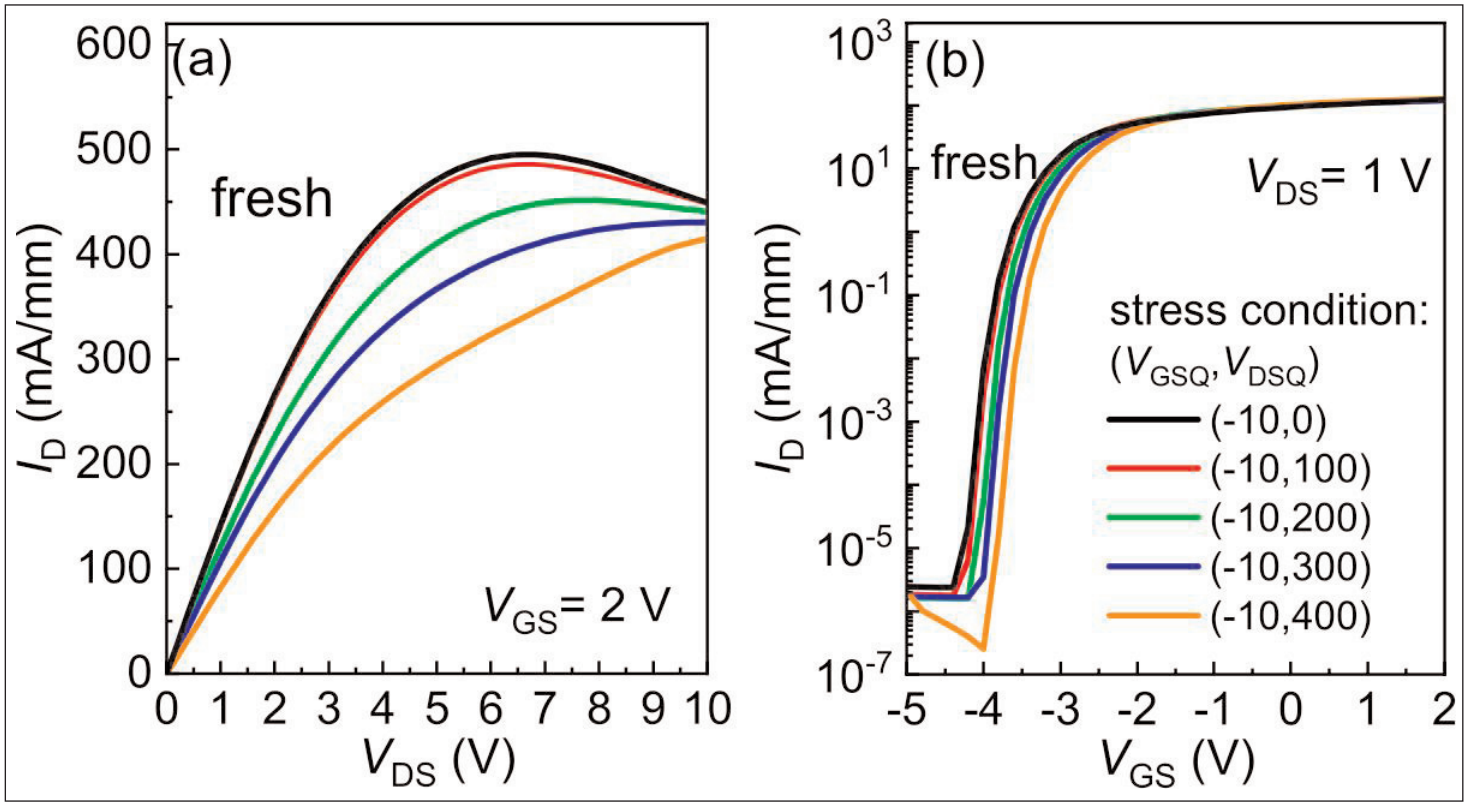

Figure 2. (a) Drain current–voltage (I_D–V_D) and (b) I_D–gate voltage (V_G) curves of the 200V GaN HEMTs on sapphire with 6µm GD distance after various OFF-state stresses.

The OFF-state breakdown of the HEMT devices with 6µm GD distance occurred at more than 500V, meeting the requirements of 200V ratings. Extending the GD distance to 16µm increased the breakdown beyond 1200V, meeting 650V requirements. The researchers believe that field plates and passivation improvements could boost performance further.

Under 400V stress the 200V HEMTs suffered a current collapse of 41% (Figure 2). For 200V stress, the collapse was reduced to 15%. The researchers see the collapse as being due to a combination of a threshold shift and charge trapping effects. Again, field plate structures could alleviate collapse/dynamic R_{ON} impacts, the team suggests. ■

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https://en.wikipedia.org/wiki/Class-D_amplifier

Author:
Mike Cooke

Fraunhofer IAF uses MOCVD to fabricate aluminum yttrium nitride

Alternative to magnetron sputtering of AlYN opens up commercial applications of AlYN/GaN heterostructures.

Fraunhofer Institute for Applied Solid State Physics (IAF) of Freiburg, Germany has used metal-organic chemical vapor deposition (MOCVD) to fabricate and characterize aluminum yttrium nitride (AlYN), enabling the development of new, diverse applications.

AlYN has attracted the interest of many research groups worldwide due to its material properties and adaptability to gallium nitride (GaN), enabling potential use in energy-efficient high-frequency and high-performance electronics for information and communications technology. However, growth of the material has been a major challenge. Until now, AlYN could only be deposited by magnetron sputtering.

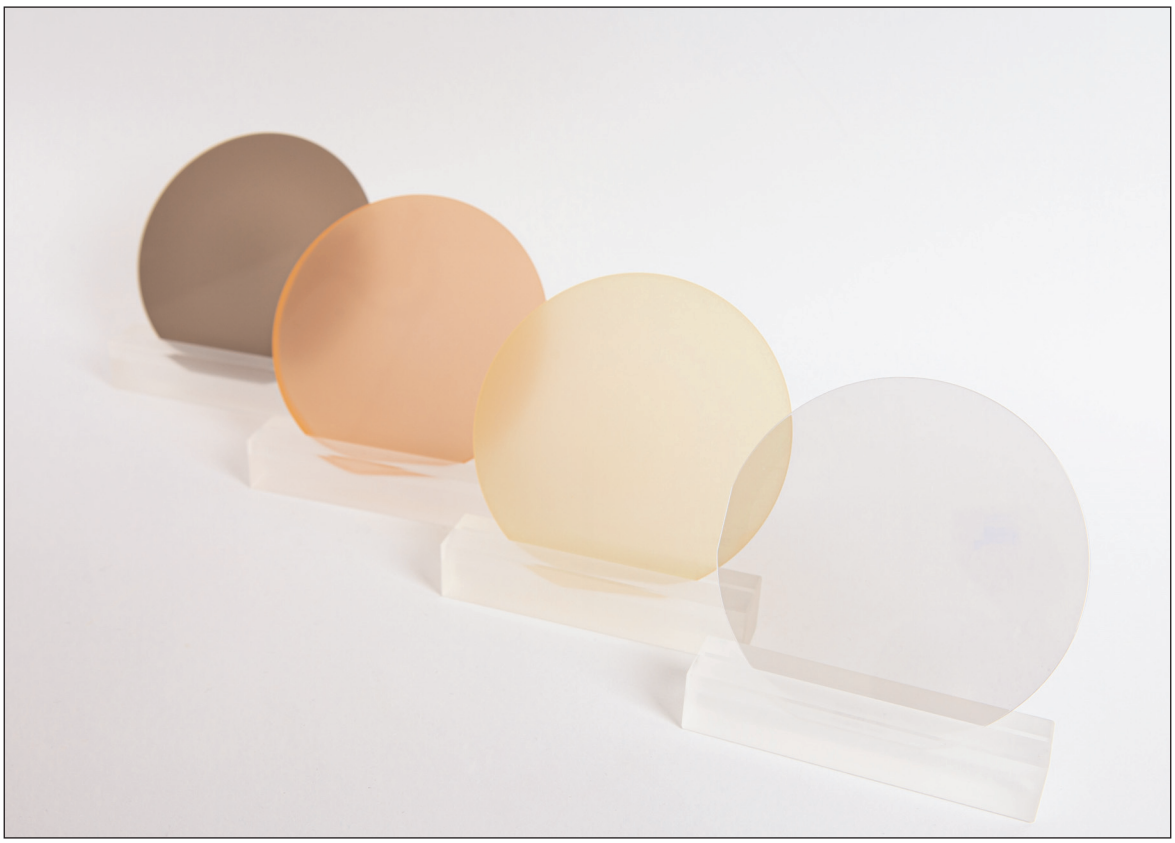
"AlYN is a material that enables increased performance while minimizing energy consumption, paving the way for innovations in electronics," says epitaxy scientist Dr Stefano Leone.

Recent research had already demonstrated the material properties of AlYN, such as ferroelectricity. In developing the new compound semiconductor material, the researchers at Fraunhofer IAF focused primarily on its adaptability to GaN. The lattice structure of AlYN can be optimally adapted to GaN, and the AlYN/GaN heterostructure promises significant advantages for the development of future-oriented electronics.

From layer to heterostructure

In 2023, the Fraunhofer IAF research group deposited a 600nm-thick AlYN layer for the first time. The layer with wurtzite structure contained an unprecedented yttrium concentration of more than 30%. Now the group has fabricated AlYN/GaN heterostructures with precisely adjustable yttrium concentration that are characterized by excellent structural quality and electrical properties. The heterostructures have an yttrium concentration of up to 16%. The structural analysis group, led by Dr Lutz Kirste, continues to perform detailed analyses to further the understanding of the structural and chemical properties of AlYN.

The Fraunhofer researchers have already measured promising electrical properties of AlYN that are of interest for use in electronic components. "We were able to



The different color nuances of the AlYN/GaN wafers result from different yttrium concentrations and growth conditions. © Fraunhofer IAF.

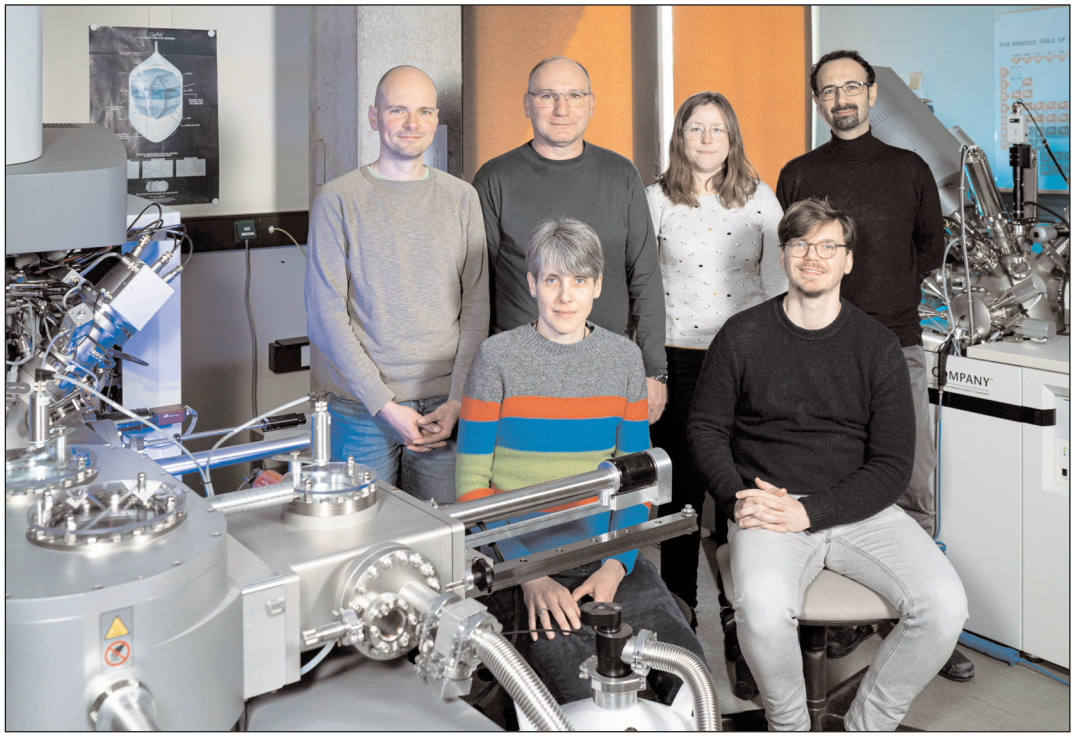
observe impressive values for sheet resistance, electron density and electron mobility," says Leone. "These results showed us the potential of AlYN for high-frequency and high-performance electronics."

AlYN/GaN heterostructures for high-frequency applications

Due to its wurtzite crystal structure, AlYN can be adapted very well to the wurtzite structure of gallium nitride with a suitable composition. An AlYN/GaN heterostructure promises to enable the development of semiconductor components with improved performance and reliability. In addition, AlYN has the ability to induce a two-dimensional electron gas (2DEG) in heterostructures. Recent research results from Fraunhofer IAF show optimal 2DEG properties in AlYN/GaN heterostructures at an yttrium concentration of about 8%.

The material characterization results also show that AlYN can be used in high-electron-mobility transistors (HEMTs). The researchers observed a significant increase in electron mobility at low temperatures (more than 3000cm^2/Vs at 7K). The team has already made significant progress in demonstrating the epitaxial heterostructure required for fabrication, and continues to explore the new material for the development of HEMTs.

The researchers are also optimistic about industrial applications. Using AlYN/GaN heterostructures grown on 4-inch silicon carbide (SiC) substrates, they demonstrated the scalability and structural uniformity of the heterostructures. The creation of AlYN layers in a commercial MOCVD reactor enables scaling up to larger substrates in larger MOCVD reactors, underlining the potential of AlYN for the mass production of semiconductor devices.



The Fraunhofer IAF team that worked on the epitaxy and characterization of AlYN/GaN heterostructures. © Fraunhofer IAF.

The material characterization results also show that AlYN can be used in HEMTs. The researchers observed a significant increase in electron mobility at low temperatures (more than 3000cm^2/Vs at 7K). The team has already made significant progress in demonstrating the epitaxial heterostructure required for fabrication, and continues to explore the new material for the development of HEMTs

Development of non-volatile memories

Due to its ferroelectric properties, AlYN is highly suitable for the development of non-volatile memory. Another advantage is that the material has no limitation on layer thickness. Therefore, the research team at Fraunhofer IAF encourages further research into the properties of AlYN layers for non-volatile memories, as AlYN-based memories can drive sustainable and energy-efficient data storage solutions. This is particularly relevant for data centers, which have to cope with the exponential growth in computing capacity for artificial intelligence and have significantly higher energy consumption.

The challenge of oxidation

A major obstacle to the industrial use of AlYN is its susceptibility to oxidation, which affects its suitability for certain electronic applications. "In the future, it will be important to explore strategies to reduce or overcome oxidation. The development of high-purity precursors, the use of protective coatings, or innovative manufacturing techniques could contribute to this. The susceptibility of AlYN to oxidation is a major research challenge to ensure that research efforts are focused on areas with the greatest chance of success," concludes Leone. ■

https://doi.org/10.1002/pssr.202300091

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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

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4 Barton Lane, Woburn, MA 01801, USA
Tel: +1 781 933 3570
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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

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

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

21 Computer hardware & software

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

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

22 Used equipment

Brumley South Inc
422 North Broad Street,
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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

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

event calendar

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

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

11–13 September 2024
25th China International Optoelectronic Exposition (CIOE 2024)
Shenzhen World Exhibition & Convention Center, China
E-mail: cioe@cioe.cn
www.cioe.cn/en

16–18 September 2024
2nd Bi-annual IEEE Workshop on Wide Bandgap Power Devices & Applications in Europe (WiPDA-Europe 2024)
Royal Welsh College of Music and Drama, Cardiff, UK
E-mail: admin@wipda-europe.org
www.wipda-europe.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

29 September – 4 October 2024
2024 International Conference on Silicon Carbide and Related Materials (ICSCRM)
Raleigh Convention Center, Raleigh, NC, USA
E-mail: registration@icscrm-2024.org
www.icscrm-2024.org

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

23–25 October 2024
OPTO Taiwan 2024: 33rd International Optoelectronics Exposition
TWTC Nangang Exhibition Hall 1, Taipei City, Taiwan
E-mail: exhibit@mail.pida.org.tw
www.pida.org.tw/main2

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

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

advertisers' index

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

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

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

19–21 February 2025
SEMICON Korea 2025
Korea World Trade Tower, Seoul, South Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org/en

5–7 March 2025
Asia Photonics Expo (APE 2025)
Level 1, Sands Expo & Convention Centre (Marina Bay Sands),
Singapore
E-mail: visitors-ape@informa.com
www.asiaphotonicsexpo.com

16–20 March 2025
IEEE Applied Power Electronics Conference (APEC 2025)
Atlanta, GA, USA
E-mail: apec@apec-conf.org
www.apec-conf.org

30 March – 3 April 2025
Optical Fiber Communication Conference and Exhibition (OFC 2025)
Moscone Convention Center, San Francisco, CA, USA
E-mail: custserv@optica.org
www.ofcconference.org

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

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

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

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

Microwave Week

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

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

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

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

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