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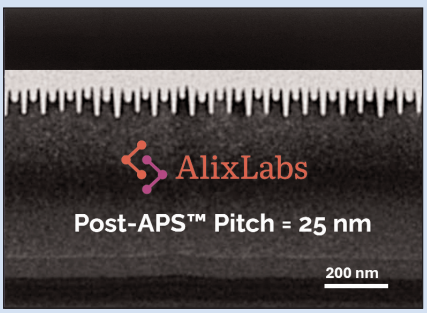
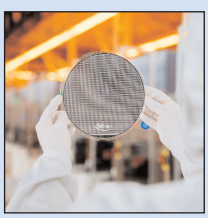
p26 Cambridge GaN Devices has closed a $32m Series C funding round led by a strategic investor joined by British Patient Capital and supported by existing investors.



p36 AlixLabs has used its ALE Pitch Splitting technology to etch structures corresponding to commercial 3nm semiconductor processes on test silicon from Intel.

p48 ST's new silicon photonics and BiCMOS technologies for cloud optical interconnect in data centers and AI clusters is being made in its Crolles 300mm fab.



Cover image: Infineon is releasing its first silicon carbide products based on 200mm SiC wafers to customers in first-quarter 2025. Manufactured in Villach, Austria, the products provide SiC power technology for high-voltage applications including renewable energies, trains, and electric vehicles. **p24**

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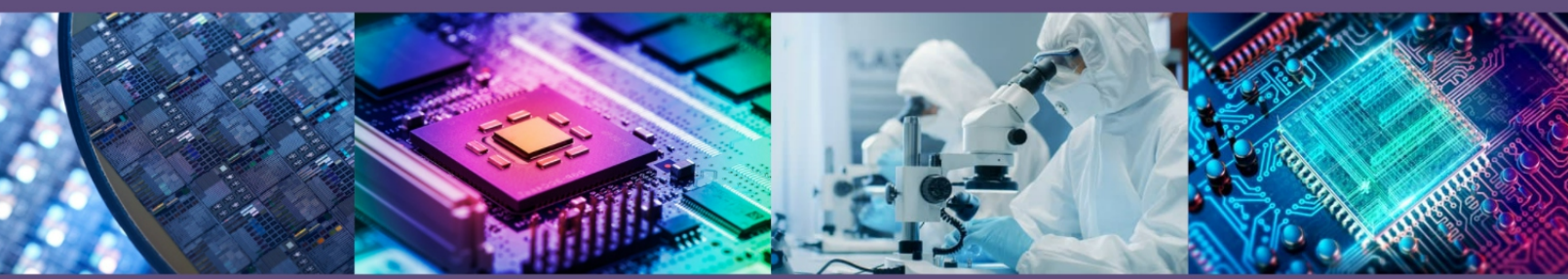

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Compound semiconductor market growing at 10.9% CAGR from $44.5bn in 2023 to $111.6bn in 2032

Gallium nitride segment growing to $25bn

According to a study by Global Market Insights Inc, the compound semiconductor market was $44.5bn in 2023 and is estimated to rising at a compound annual growth rate (CAGR) of 10.9% to $111.6bn by the end of 2032. This is driven by the distinct advantages of compound semiconductors, which provide superior performance in high-frequency, high-power and energy-efficient applications. These materials excel in telecoms, electric vehicles, renewable energy, and aerospace, where their ability to handle extreme conditions, higher power and heat resistance surpasses traditional silicon semiconductors.

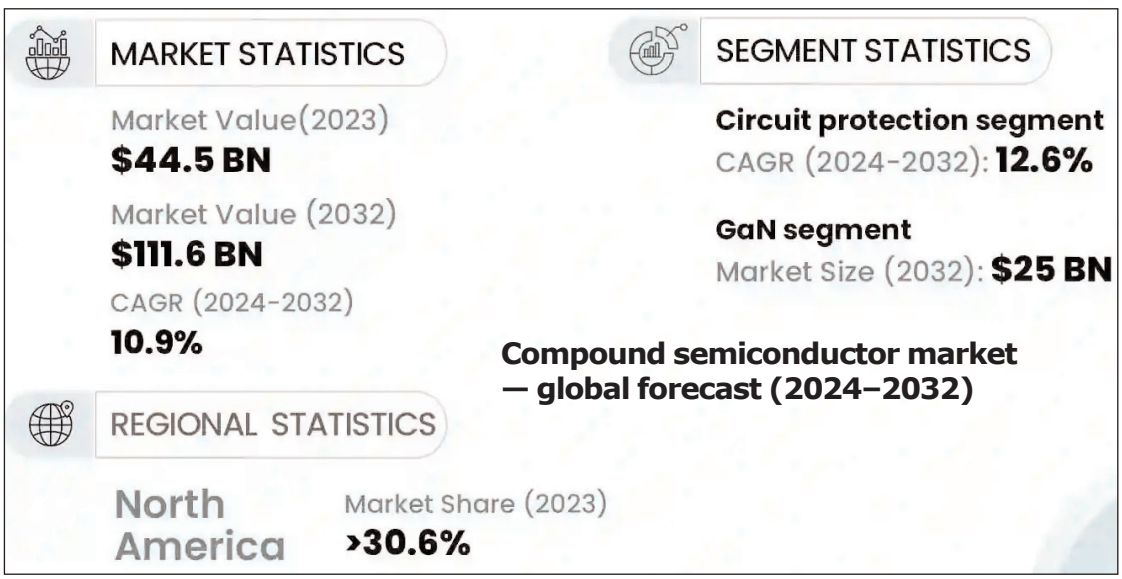
A key driver of the compound semiconductor market is the growing demand for advanced technologies that require high-performance materials. Compound semiconductors outperform silicon in terms of power efficiency and heat resistance, making them well suited to next-generation applications. In telecoms, they are critical for 5G infrastructure and satellite communications, where high frequencies and minimal energy loss are essential. Additionally, their ruggedness makes them ideal for use in harsh environments, such as defense and aerospace, where reliability is paramount.

The gallium nitride (GaN) segment is expected to grow significantly, to $25bn by 2032, since GaN's wide bandgap enables it to handle high voltages, high frequencies and high temperatures, making it a key material for power electronics, radio frequency (RF) devices, and high-efficiency systems, particularly in applications such as 5G.

Regarding compound semiconductor deposition technologies, which include chemical vapor deposition (CVD), molecular beam epitaxy (MBE) and hydride vapor phase epitaxy (HVPE), MBE is gaining traction due to its ability to precisely control thin-film deposition at the atomic level, ensuring the production of high-quality, defect-free layers. This is particularly valuable in fields such as quantum computing, optoelectronics and high-frequency devices, where material purity is crucial.

The USA comprised a 30.6% share of the compound semiconductor market in 2023. The region is seeing rapid growth, driven by investments in high-performance applications such as 5G networks, electric vehicles and renewable energy technologies. The USA is also a leader in semiconductor R&D, bolstered by initiatives aimed at enhancing domestic manufacturing and reducing the dependence on imports.

www.gminsights.com/industry-analysis/compound-semiconductor-market November 2024



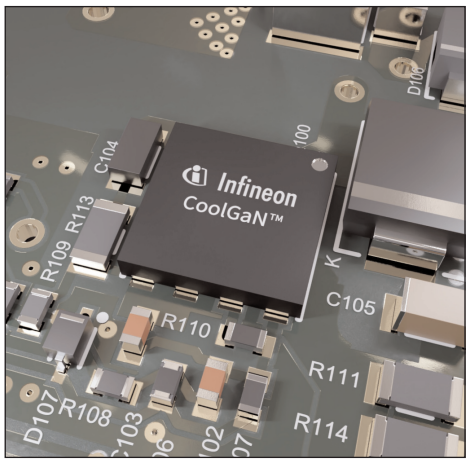
Gallium nitride power semiconductors to reach adoption tipping points in multiple industries in 2025

GaN is driving energy efficiency and decarbonization across consumer, mobility, residential solar, telecoms and AI data-center sectors

In its 2025 predictions for gallium nitride (GaN) power semiconductors, Infineon Technologies AG of Munich, Germany highlights that GaN will be a game-changing material for energy efficiency and decarbonization across the consumer, mobility, residential solar, telecoms, and AI data-center sectors, as GaN enables efficient performance, smaller size, lighter weight, and lower overall cost. While USB-C chargers and adapters have been the forerunners, GaN is now on its way to reaching tipping points in its adoption in further industry sectors, driving the market for GaN-based power semiconductors.

"Infineon is committed to driving decarbonization and digitalization through innovation based on all semiconductor materials Si, SiC and GaN," says Johannes Schoiswohl, head of Infineon's GaN business line. "The relevance of comprehensive power systems will increase, with GaN manifesting its role due to its benefits in efficiency, density and size," he adds. "Given that cost-parity with silicon is in sight, we will see an increased adoption rate for GaN this year and beyond."

Powering AI will be highly dependent on GaN. The rapid increase of the required computing power and energy demand in AI data centers will drive the need for advanced solutions capable of handling the substantial loads associated with AI servers. Power supplies that once managed 3.3kW are now evolving towards 5.5kW, with projections moving towards 12kW or more per unit. By leveraging GaN, AI data centers can improve power density, which directly influences the amount of computational power that can be delivered within a given rack space. While GaN presents clear advantages, hybrid approaches combining GaN with Si and SiC are ideal for meeting the requirements of AI data centers and achieving the best trade-offs between efficiency, power density and system cost, says Infineon.



In the home appliance market, Infineon expects GaN to gain significant traction, driven by the need for higher energy efficiency ratings in applications like washing machines, dryers, refrigerators and water/heat pumps. In 800W applications, for example, GaN can enable a two percent efficiency gain, which can help manufacturers achieve the coveted A ratings. According to Infineon, GaN-based on-board chargers and DC–DC converters in electric vehicles will contribute to a higher charging efficiency, power density and material sustainability, with a shift towards 20kW+ systems. Together with high-end SiC solutions, GaN will also enable more efficient traction inverters for both 400V and 800V EV systems, contributing to an increased driving range.

In 2025 and beyond, robotics will see widespread adoption of GaN supported by the material's ability to enhance compactness, driving growth in delivery drones, care robots and humanoid robots, believes Infineon. As robotics technology integrates AI advancements like natural language processing and computer vision, GaN will provide the efficiency required for compact, high-performance designs. Integrating inverters within the motor chassis eliminates the inverter heatsink while reducing cabling to each joint/axis and simplifying EMC design.

Infineon says that it is further pushing investment in GaN R&D to overcome the challenges of cost and scalability. With innovations such as 300mm GaN wafer manufacturing and bidirectional switch (BDS) transistors, Infineon is bolstering its role in driving decarbonization and digitalization based on all relevant semiconductor materials including gallium nitride.

Infineon's '2025 GaN predictions' ebook can be downloaded here.
www.infineon.com/gan

Silicon carbide patent activity grows strongly in Q4/2024

Technology intelligence and IP strategy consulting company KnowMade says that, for fourth-quarter 2024, its quarterly SiC Patent Monitor shows robust growth, with over 900 new patent families and 400 newly granted patents. This period saw over 100 patents expire or be abandoned and involved seven notable patent transfers.

The industry was also devoid of any new IP litigation in the US or patent opposition in Europe. However, the sector is abuzz with 10 notable patent collaborations and an influx of over 25 IP newcomers entering the field.

Focus on leading industry players

Leading companies such as Rohm, Infineon, STMicroelectronics and Wolfspeed have significantly influenced the SiC technology domain, notes KnowMade. Their innovations and strategic moves have been pivotal in advancing technological frontiers and enhancing their position in the competitive landscape.

Innovations and collaborations

Continuous innovation in the SiC industry, particularly in the bulk wafer and bare wafer segment, has led to the emergence of enhanced substrates and reliable power devices, notes KnowMade.

In Q4/2024, for example, NGK Insulators disclosed a composite SiC substrate with a biaxially oriented SiC layer that helps to reduce warpage by controlling a Raman shift value and to prevent breaking and cracking in the substrate during processing by controlling the volume density of base plane dislocations (BDP).

Another notable player in the quarter is SICC, which published inventions improving 3D stress distribution and reducing internal stress in large-diameter (>150mm) SiC wafers.

Sumitomo Electric continues to lead IP activities in the epitaxial wafer segment, with four new inventions disclosed during Q4/2024. One new invention relates to issues in the epitaxial reactor, such as the presence of SiC particles on the susceptor, causing recesses in the rear surface of SiC epiwafers. Another invention focuses on the reduction of certain defects (bump, pit, carrot, triangular defect, downfall) that can be imaged using a confocal scanning device. Another invention is more closely related to device reliability and aims to improve recombination efficiency while reducing the required thickness of SiC epilayers, in order to prevent stacking faults from transferring from the buffer layer to the drift layer.

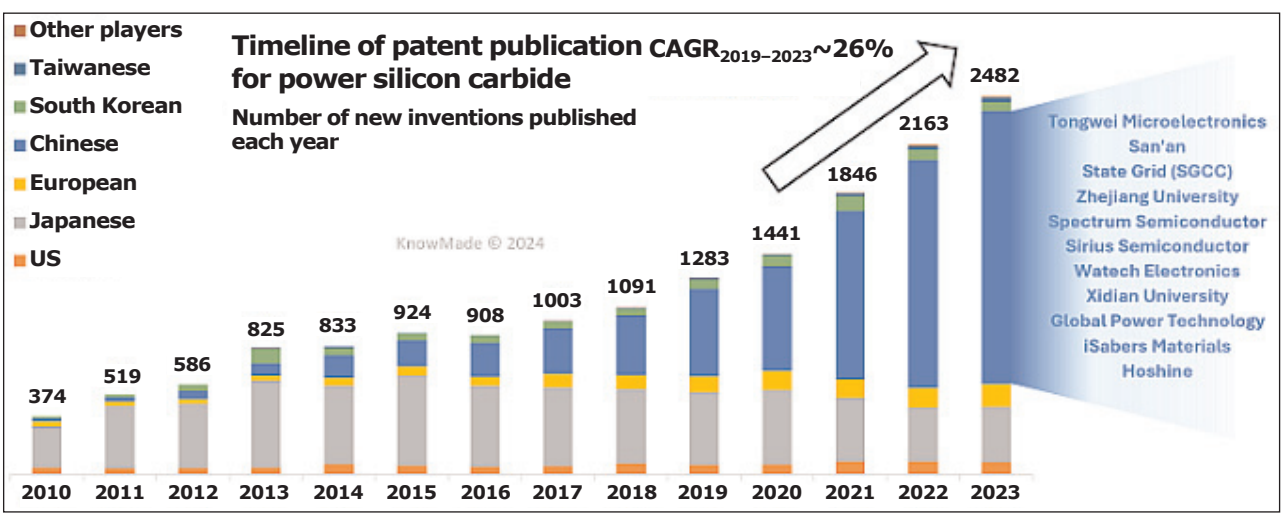
In the device segment, among the patenting activity of several Chinese automotive players such as NIO and FAW, NIO stands out with a European patent publication related to SiC trench MOSFETs. Other players in the automotive supply chain that have been actively filing patents during Q4/2024 include Bosch (e.g. to improve the short-circuit robustness of SiC FETs) and Nexperia (e.g. to improve on-resistance and surge performance of SiC Schotty diodes).

In the module and packaging segment, onsemi has disclosed electroless plating methods and systems suitable for SiC devices. Also, Mitsubishi Electric is still present with two new inventions, including one to suppress heat occurring in a SiC MOSFET connected in parallel with a Si IGBT, without providing a temperature detection circuit and a current detection circuit. Furthermore, Navitas Semiconductor, a leading player in the power GaN market, aims to strengthen its patent portfolio for power SiC with a new invention that provides balanced current flow in SiC power modules.

In the circuits and applications segment, ZF is also continuing tom play its part, with a method of driving parallel-connected SiC MOSFETs and Si IGBTs based on the rapid detection of the current load of the active (switched-on) device. Furthermore, a collaboration between BMW and CSA Catapult and the University of Warwick in the UK has led to a new patent publication describing a monitoring device to measure the temperature or current in SiC devices under high current load even under harsh mechanical conditions (e.g. strong vibration, in automotive applications etc).

KnowMade concludes that this is one of the noteworthy collaborations highlighting the strategic alliances that are essential for maintaining technological leadership and fostering innovation.

www.knowmade.com/



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Qorvo hit by drop in mass-tier Android 5G demand

Focus narrowed to higher-value flagship and premium tiers

For its fiscal third-quarter 2025 (ended 28 December 2024), Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) has reported revenue of $916.3m, down 12.4% on $1046.5m last quarter and 14.7% on $1073.9m a year ago, albeit slightly above the midpoint of the $900m±$25m guidance.

Of Qorvo's six primary end markets: automotive, consumer, defense & aerospace, industrial & enterprise, infrastructure, and mobile, the firm saw sequential strength in defense & aerospace, industrial & enterprise, and infrastructure.

Revenue by business segment was:

● **Advanced Cellular Group** (ACG) $635.1m, down 15.5% on $751.4m last quarter and 24.9% on $846.1m a year ago. "We are focused primarily on delivering 5G advanced products [e.g. discrete placements such as tuners as well as integrated placements like ultra-high-band PADs] for (1) our largest customer [Apple, which comprised just over half of Qorvo's total revenue, supporting their flagship launch] and for (2) the flagship and premium tiers of Android," notes president & CEO Bob Bruggeworth. "Within our Android 5G product portfolio, we are narrowing our focus to the higher-value flagship and premium tiers, where customers value Qorvo's differentiated products."

● **Connectivity & Sensors Group** (CSG) $109.5m, down 25.4% on $146.8m last quarter – matching the seasonality of the last three years because of the profile of the largest customer – but up 0.6% on $108.9m a year ago. In infrastructure, revenue rose significantly year-on-year in both broadband and cellular base-station markets, which are now past the bottom and seeing stabilization. Qorvo increased shipments of high-frequency BAW (bulk acoustic wave) filters in support of enterprise WiFi deployments across geographies and expanded power management engagements with new and existing customers and enterprise SSDs (solid-state drives). In automotive, revenue declined sequentially as end-market softness continues. In consumer markets, revenue declined sequentially, reflecting market headwinds. "We are building upon our strong position in RF solutions across markets while investing in diverse growth businesses, including an expanding portfolio of automotive solutions and SOCs for ultra-wideband, BLE, Thread, and Matter," says Bruggeworth.

● **High-Performance Analog** (HPA) $171.7m, up 15.8% on $148.3m last quarter and 44.4% on $118.9m a year ago, including record Defense & Aerospace (D&A) revenue (driven by multi-year tailwinds including upgrades to non-terrestrial networks and the transition from mechanical radar systems to active electronic scanning radar systems). "We continue to grow our Defense & Aerospace business while expanding our business in power management," says Bruggeworth.

On a non-GAAP basis, gross margin was 46.5%, down from 47% last quarter but this was due mainly to (1) a headwind of 300 basis points from the silicon carbide business (subsequently divested, in January); (2) the mass-tier Android 5G revenue (which Qorvo is now exiting). "While we continue to serve mass-tier programs previously awarded, we expect these lower-margin programs to go end-of-line in fiscal 2026 and into fiscal 2027," says Bruggeworth. Despite revenue falling year-on-year, gross margin was up on 43.8% a year ago, and above the expected 45%.

"The opportunity in mass-tier Android 5G declined at a faster rate than anticipated," notes Bruggeworth. "Android build plans changed to reflect higher consumer demand for entry-tier 5G devices. In response, during the December quarter we implemented changes across the organization in how we support Android 5G… We narrowed our focus to the premium and flagship tiers to increase profitability and reduce variability," he adds.

"On operating expenses, we implemented a significant workforce reduction, primarily targeting our mass-market Android business as well as supporting areas to enhance our cost structure," says chief financial officer Grant Brown.

Also, to align its scope with the anticipated economic benefits, Qorvo has cancelled elements of its digital transformation project (a three-year initiative to modernize its 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). Spending on this had been scheduled to double to about $15m in the December quarter — totaling about $40m full-year fiscal 2025 — but this has been reduced.

Operating expenses are still up on $234m a year ago, but have hence been cut from $279.8m last quarter to $248.4m (better than the expected $265m), with selling, general & administrative expenses reduced from $85.3m to $78.8m and R&D spending cut from $187.6m to $165.5m. "Our 5G product development spend is now focused solely on premium and flagship tiers," notes Bruggeworth.

By operating segment (compared with last quarter), operating margin was 19% for HPA (up from 8.8% last quarter and just 1.3% a year ago), 25.4% for ACG (down from 28.6% last quarter and 31.2% a year ago) and −10.7% for CSG (worsening from −6.1% last quarter but better than −23.5% a year ago).

Net income has fallen further, from $205.9m ($2.10 per diluted share) a year ago and $179.8m ($1.88 per diluted share) last quarter to $152.8m ($1.61 per diluted share, above the expected $1.10–1.30).

"Qorvo exceeded the midpoint of our December quarter non-GAAP

guidance in revenue, gross margin, and EPS," notes Brown.

Operating cash flow was $214.1m (up from $127.8m last quarter, but under half the $492.9m a year ago). Capital expenditure was $37.8m. Free cash flow was hence $176.3m (up from $94.8m last quarter, but down on $466.5m a year ago).

"Qorvo is executing on a broad set of strategic initiatives to expand margin, generate strong free cash flow, and increase shareholder value," says Bruggeworth.

During the quarter, Qorvo repurchased about $100m of stock (at an average price of $73 per share). The firm also spent $412m to retire its remaining 2024 notes.

Cash and cash equivalents hence fell from $1096.5m to $769.4m. Long-term debt remains $1549m.

Qorvo ended the quarter with a net inventory balance of $656.2m (the lowest in over three years, due to ongoing inventory reduction), down by $38m sequentially and by more than $70m year-on-year.

Outlook

For fiscal Q4/2025 (to end-March), Qorvo expects revenue to fall by 5–10% to $850m±$25m, driven by being the lowest seasonal quarter for Qorvo's largest customer (although the sequential drop will be less than the seasonal drop in the last couple of years). Android-related revenue will be up sequentially, given the flagship platform launches.

In HPA, Qorvo expects even better strength in the March quarter, driven again by D&A business. This is due mainly to the timing of US Department of Defense contracts, but Qorvo still expects that, for full-year fiscal 2025, D&A revenue will grow faster than that for the rest of HPA, becoming a $400m annual business.

Silicon carbide revenue will be negligible in the March quarter (versus $9m in the December quarter and about $30m for full-year fiscal 2025) following January's sale of the business, which is accretive to both gross and operating margins.

Gross margin should fall seasonally in the March quarter, to 43–44%. Including $1–2m from the remaining portion of the digital transformation project, operating expenses are expected to be about $250m (and to average about $250m per quarter in fiscal 2026). Diluted earnings per share should be $0.90–1.10.

For fiscal first-quarter 2026 (to end-June), revenue is expected to fall by 10–15% sequentially, due to the Android ramp at a large customer for their flagship smartphone model ramping down at the same time that Qorvo's largest customer also ramps down. Also: "Like prior years, our D&A business will be down meaningfully in June on a sequential basis [by up to $75m] due to program timing, while expected to grow double-digits for the full year," says Brown.

Cost savings to drive margin growth despite flat revenue in fiscal 2026

"During the [December] quarter, we took proactive steps to change how we support our Android business. These actions will reduce operating expense and are expected to benefit gross margin in our fiscal 2026," says Brown. "Subsequent to the quarter, we divested our silicon carbide business. These actions, in aggregate, are expected to support a high-40%'s gross margin in seasonally strong quarters of fiscal 2026 and additional gross margin improvement in fiscal 2027," he adds.

"These actions are reflected in our Q4 guidance and will extend into fiscal 2026. Overall, we anticipate achieving over $100m in gross annualized savings across COGS and OpEx. A portion of these savings will be reinvested in the key growth areas such as D&A, power management, ultra-wideband and programs for our largest customer, as well as to offset inflationary pressures," he adds.

"As we continue to execute on our growth and diversification strategy, we expect HPA and CSG to deliver double-digit growth in fiscal 2025 and next fiscal year."

In full-year fiscal 2026, Qorvo expects gross margin to expand by about 150 basis points on roughly flat revenue. This reflects growth of 10–12% in CSG and HPA (excluding SiC) but a single-digit drop in ACG revenue, as Android 5G declines gradually from about $875m in fiscal 2025 by $150–200m annually in fiscal 2026 and again in fiscal 2027, mostly due to China, with the rest being mid-tier at Qorvo's second-largest customer Samsung. "Beginning in fiscal 2027, we expect ACG to return to growth, where our updated long-term revenue target is for mid-single-digit growth," says Bruggeworth. "Our largest growth opportunity in ACG is with our largest customer, and we are investing today to continue increasing our share with them in subsequent programs over multiple years," he adds.

"With ACG, we expect to enhance margins and reduce [seasonal] variability as our portfolio management efforts and pricing strategies reduce our exposure to legacy mass-tier Android 5G," says Brown.

"In HPA, the divestiture of our SiC business is margin accretive. In addition, our strategic investments supporting continued growth in D&A will also be accretive."

"In CSG, gross margin will increase with the relocation of gallium arsenide [GaAs] production from our underutilized North Carolina facility to our high-volume Oregon site. We continuously evaluate further opportunities to reduce our capital intensity and product costs, including process technology advancements and die-size reductions. The complexity of our solutions, coupled with the global RF compliance requirements faced by our customers, results in multi-year design cycles. We're working closely with our customers as we align our factory footprint to address only the most differentiated elements of our products and increasingly leverage the scale, capabilities and cost-effectiveness of our outsourced partners," Brown adds.

"All of these factors in aggregate are expected to support high 40% gross margin in seasonally strong quarters during fiscal 2026 and up to 50% gross margin in a seasonally strong quarter during fiscal 2027," concludes Brown.

www.qorvo.com

Skyworks' Broad Markets revenue returns to year-on-year growth

Dual-sourcing by Apple to reduce Skyworks' content share by 20–25%

For fiscal first-quarter 2025 (ended 27 December 2024), Skyworks Solutions Inc of Irvine, CA, USA (which manufactures analog and mixed-signal semiconductors) has reported revenue of $1068m, down 11% on $1201.5m a year ago but up 4% on $1025m last quarter and slightly above the midpoint of the $1050–1080m guidance range. This was despite the muted demand environment and ongoing inventory digestion across selective end markets.

Mobile products revenue grew 6% sequentially, comprising 67% of total revenue, as the firm supported multiple new product launches across its top mobile customers.

Skyworks' largest customer (Apple) grew 9% sequentially to 72% of total company revenue. About 85% of that revenue from Apple related to its smartphones, as Skyworks supported the ramp of the latest model. The other 15% related to other products (the watch, tablet, PC, HomePod, the Vision Products, etc). In contrast, the Android-related segment [Google, Samsung, and China-based OEMs] was flat sequentially.

Skyworks' Broad Markets products comprised 33% of total revenue, growing modestly for a fourth consecutive quarter (since the fiscal Q1/2024 bottom) and returning to year-on-year growth (of 2%). "We have observed consistent improvement in demand indicators within Broad Markets," says chairman, president & CEO Liam K. Griffin. Specifically, Skyworks is seeing growth in wireless gaming, home audio and headsets, where customers are adopting its RF connectivity and audio technology. Also, despite a soft demand environment, the automotive segment grew as design wins in the connected car, onboard charging and infotainment are gradually converting into revenue. However, the industrial and infrastructure segments remain subdued due to persistent inventory challenges.

Highlights of the quarter include:

- securing 5G content for premium Android smartphones, including Samsung Galaxy, Xiaomi, ASUS and several others;
- supporting Gemtek's launch of the first AI router with voice-enabled AI-powered healthcare service;
- enabling ASUS's award-winning quad-band Wi-Fi 7 gaming routers;
- expanding the design-win pipeline in automotive with cellular connectivity and power management solutions.

On a non-GAAP basis, gross margin was 46.5%, level with last quarter but up slightly on 46.4% a year ago.

Operating expenses have risen from $191m (15.9% of revenue) a year ago to $212m (19.9% of revenue), reflecting strategic investments in technology and product roadmaps.

Net income is down on $317m ($1.97 per diluted share) a year ago but rebounded from $249.9m ($1.55 per diluted share) last quarter to $258.3m ($1.60 per diluted share, $0.03 above the $1.57 guidance).

"Revenue, gross margin and EPS met or exceeded the midpoint of guidance," notes Griffin.

Operating cash flow has fallen further, from the record of $774.9m (operating cash flow margin of 64.5%) a year ago and $393.2m (38.4% margin) last quarter to $377.2m (35% margin). Capital expenditures was $39m (up from $22.2m a year ago). Free cash flow has hence fallen further, from the record $752.7m (free cash flow margin of 62.6%) a year ago and then $393.2m (38.4% margin) last quarter to $338.2m (31.7% margin).

We are seeing positive momentum in booking trends, backlog and sell-through patterns across Broad Markets. However, [excess] inventory headwinds remain acute in industrial and infrastructure

During fiscal Q1/2025, Skyworks distributed $112.5m in dividends. Overall, cash and marketable securities hence rose, from $1574.1m to $1754.8m (up from $1029.7m a year ago).

Debt remains about $994m, providing "ample financial flexibility".

Dividend payment and stock repurchase program

Skyworks' board of directors has declared a cash dividend of $0.70 per share, payable on 17 March, to stockholders of record at the close of business on 24 February.

Also, as part of a "disciplined capital allocation strategy", Skyworks' board has authorized the repurchase of up to $2bn of the firm's common stock, through to 3 February 2027. This succeeds in its entirety the stock repurchase program approved by the board on 31 January 2023. The firm aims to fund the repurchase program using working capital.

Outlook

During Q1/2025, Skyworks cut its internal inventory for an eighth consecutive quarter, from $784.8m to $699.7m, down from $927m a year ago. "We are seeing positive momentum in booking trends, backlog and sell-through patterns across Broad Markets. However, [excess] inventory headwinds remain acute in industrial and infrastructure," notes senior VP & chief financial officer Kris Sennesael. "The inventory and the distribution channel has been cleared out, but there is still inventory at the customer level."

For fiscal second-quarter 2025 (to end-March), Skyworks expects rev-

enue to fall to $935–965m (driving gross margin down to 45.5–46%), due to a seasonal mid-to-high-teens sequential decline in Mobile revenue.

"In Broad Markets, we anticipate further sequential and year-over-year growth as demand signals and backlog improve," says Griffin. "In certain segments, supply and demand dynamics are in equilibrium and channel inventories have normalized."

Operating expenses will increase to $220–228m, driven mostly by a reset of the social charges at the beginning of the calendar year as well as an increase in R&D project expenses. Diluted earnings per share are expected to fall to $1.20.

"Overall, we are encouraged by the recent momentum in Broad Markets and are energized about new product cycles in automotive, electrification, Edge IoT and AI data center fueling long-term growth," says Griffin. "In Edge IoT, we are observing higher levels of intelligence and, combined with more nodes being added to the edge of the network, driving higher levels of RF complexity. Artificial intelligence and machine learning increases the range of functionality, running models like voice and computer vision. RF connectivity is the conduit for secure, robust and lower-power AI applications. Moreover, the adoption of WiFi 6E and 7 systems by customers is contributing to the improvement in demand. These systems, characterized by enhanced complexity and utilization of additional bands enable transmission of higher-value content. We are currently in the emerging stages of a multi-year upgrade cycle with WiFi 7 shipments experiencing a ramp-up," he adds. "In automotive, we expect our RF content per vehicle to grow driven by 5G cellular, WiFi, Bluetooth, and V2X."

Regarding Mobile: "Over the last 18 years, we have benefited from a truly collaborative partnership with our largest customer [Apple], which has resulted in significant content and revenue growth over the years," notes Sennesael. "However, the last couple of years have been challenging, in part because the competition has been intensifying, in part because of the multi-year baseband or modem transition, which has created some turbulence among the RF players. As it relates to the upcoming phone cycle expected to be launched in the fall of 2025, the Skyworks team developed a suite of high-performance RF solutions. Most of the sockets that we targeted, we actually were able to keep [including several highly integrated RF modules], but instead of being single-sourced [still] on one particular socket, it is being dual-sourced… Our content position is expected to be down 20–25%. This decline will start impacting our revenue in the fourth quarter of fiscal 2025 and throughout fiscal 2026. So, we are going to remain with under-utilization in our factories for a little bit longer than we initially anticipated. That is not going to help in gross margins improvement. We are going to continue and actually double down on trying to find operational efficiencies in our factories as we deal with this situation," he adds.

The last couple of years have been challenging, in part because the competition has been intensifying, in part because of the multi-year baseband or modem transition, which has created some turbulence among the RF players

Instead of being single-sourced on one particular socket, it is being dual-sourced… Our content position is expected to be down 20–25%. This decline will start impacting our revenue in the fourth quarter of fiscal 2025

"We have already started the development of a new suite of solutions for the next-generation [Apple] phone [due to launch in Fall 2026] with an expanding set of products and addressing more opportunities than ever before. The customer is demanding and asking for better and higher RF products, in part because they're bringing AI capabilities to the phone, which is increasing the technological burden inside the phone. They're asking for smaller footprint, lower power consumption, lower latency and higher throughput, and overall higher performance, and we are stepping up. We demonstrated that our technology and products can do it," Sennesael says.

"Global adoption of generative AI on smartphones is still in its nascent stage," notes Griffin." We anticipate this to be a multi-year trend that will catalyze smartphone upgrades and increase the complexity and requirements for RF solutions."

"In addition, we will continue to pursue growth opportunities with our other mobile customers… We continue to have a strong relationship with Google. We have already won substantial design wins for next year and the year after. With Samsung and China, we will remain selective, focusing on those segments of the market that demand high-performance RF. But there is design-win momentum that is starting to turn into revenue. We can grow our Android business as a whole this year and the year after and beyond," says Sennesael.

"We will continue to drive our diversification strategy, supported by multiple secular growth trends in Broad Markets. Our Broad Markets business should be growing double digits, more than 10% year-over-year," continues Sennesael. "We expect those opportunities to partially offset the revenue decline at a large customer in fiscal 2026 and position us for growth in fiscal 2027."

www.skyworksinc.com

Philip Brace succeeds Liam K. Griffin as president & CEO of Skyworks

Lead independent director Christine King appointed chair

Skyworks Solutions Inc of Irvine, CA, USA (which manufactures analog and mixed-signal semiconductors) has appointed Philip Brace as president & CEO and a member of the board of directors, effective 17 February.

Brace succeeds Liam K. Griffin, who is stepping down as president & CEO but remaining in an advisory role for three months to help ensure a smooth transition.

Griffin has also stepped down as a member of the board of directors, and Christine King, who has served as lead independent director since 2019, has been appointed chairman of the board.

Brace has extensive experience in the semiconductor, server, IoT and storage industries and has held roles across software, hardware, engineering, marketing and sales. He has been executive chairman of Inseego Corp since February 2024, also serving as interim principal executive officer until this January. Previously, he was president & CEO of Sierra Wireless Inc from July 2021 to January 2023, leading the firm through significant operational improvements. Prior to this, Brace was executive VP of Veritas Technologies from 2019 to 2021 and president of Cloud Systems and Electronic Solutions at Seagate Technology from 2015 to 2017. Brace began his career at Intel Corp and LSI Corp, holding various engineering and management roles. He currently serves on the boards of directors of Inseego, Blackberry Ltd and Lantronix Inc. He received his bachelor's degree of applied science in computer engineering from the University of Waterloo and his master's degree in electrical engineering from California State University, Sacramento.

"Phil is an accomplished technology executive who brings strategic insight and exemplary leadership. We are at an inflection point in the wireless networking revolution, and Phil's expertise adds to our confidence that he will execute on our long-term initiatives," comments King. "Phil has deep knowledge of the semiconductor industry and extensive experience in helping businesses enhance their product lines and achieve market penetration and profitable growth. The board is confident that Phil is the right leader for Skyworks as we work to deliver operational excellence, diversify our offerings, and seek to capture new opportunities across a range of markets," she adds.

"Skyworks has the ability to support customers with highly curated and cutting-edge solutions across many different industries," comments Brace. "I have long admired Skyworks for its breakthrough communications platforms and strong solutions that enable the true potential of 5G and IoT," he adds.

www.skyworksinc.com

Mitsubishi joins Horizon Europe's FLAGCHIP project

'Flagship Advanced Solutions for Condition and Health Monitoring in Power Electronic' to estimate junction temperature and related degradation of power modules

Tokyo-based Mitsubishi Electric Corp is to begin developing a prototype to demonstrate a junction-temperature estimation technology for power modules, which it is pursuing as a partner in the European Union's Horizon Europe project aimed at developing advanced power modules and improving the cost efficiency of renewable energy power generation. The firm is participating through its European subsidiary Mitsubishi Electric R&D Centre Europe B.V., which has now joined the project 'Flagship Advanced Solutions for Condition and Health Monitoring in Power Electronics' (FLAGCHIP).

In the global effort to expand the introduction of renewable energy to support carbon neutrality, the need to upgrade the reliability and maintenance of electronic devices for power conversion has become increasingly important, notes Mitsubishi Electric. In particular, attention is being focused on technological innovations aimed at strengthening power module reliability and improving data acquisition and analysis methods to accurately determine degradation conditions in order to facilitate more timely maintenance.

The FLAGCHIP project currently involves 11 companies and academic institutions from nine European countries engaged in developing advanced power modules, condition and health monitoring technologies, and devising methods for calculating cost efficiency of renewable energy power generation systems and reducing associated costs.

Demonstrations of wind power and solar power generation systems using these technologies and methods will be conducted at test facilities owned by project partners in Norway and France.

https://flagchip-project.eu
www.mitsubishielectric.com/semiconductors/powerdevices

APC Electronics chooses Luminus as worldwide sales channel and go-to-market partner

Initial launch of 650V and 1200V SiC Schottkys and industrial SiC MOSFETs to be followed by SiC MOSFETs with high switching speeds and matched isolated gate drivers and electrically isolated packages

APC Electronics (APC-E) of Bend, OR, USA — which researches, develops and manufactures wide-bandgap power semiconductor products — has announced Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — as its exclusive world-wide sales channel and go-to-market partner.

Led by power semiconductor veterans CEO Dr W Albert Gu and CTO Dumitru G. Sdrulla, APC-E's team has invested several years developing IP around unique silicon carbide (SiC) power devices and gate drivers, and several of these products will be introduced to the market in 2025. APC says that its technologies serve to improve reliability, switching speed and energy efficiency, and enable new system architectures in diverse applications such as industrial power supplies, wind turbines, energy storage, motor driving, data centers, server farms, HVAC, electric vehicle (EV) charging, high-speed rail, and photovoltaics. APC-E and Luminus are targeting these high-power industries where the benefits of APC-E's SiC field-effect transistor (FET) devices can be leveraged to help the industry meet the rapidly growing global demand for electrical power, driven largely by AI data centers and EVs.

APC-E's initial product launch includes 650V SiC Schottky barrier diodes (SBDs) with remarkably low forward voltage to enhance energy savings in power supplies across a wide range of applications. Also included in the first wave of products are 1200V SiC SBDs with high surge capability and general purpose industrial SiC MOSFETs. Second-half 2025 will bring unique products such as SiC MOSFETs with high switching speeds and matched isolated gate drivers and electrically isolated packages to enable more efficient thermal system solutions.

"We are excited to leverage the global Luminus sales and marketing team, especially their USA regional manufacturers reps and distributors to launch our new line of products and work closely with customers in helping them leverage the many advantages of our proprietary devices as the industry rises to meet the seemingly insatiable appetite for electrical power while calling for efficiency improvement as well as system size and weight reduction," says Gu.

"Our partnership with APC-E brings value to our customers that will expand widely in the coming years as they will see the unique, elegant solutions that APC-E has been developing," says Luminus Devices' CEO Mark Pugh. "While the power grid struggles to keep up with growing demand from power-hungry AI data centers and EVs, the APC-E product line enables new levels of efficiency to help the industry bridge gaps and reduce waste."

www.luminus.com

University of Michigan awarded up to $7.5m to bring heat-resistant silicon carbide sensing and computing chips from lab to fab

Open-source effort supports durable silicon carbide circuits that can operate at record high temperatures

University of Michigan researchers are leading a multi-million dollar collaborative effort to develop heat-resistant sensing and computing chips made of silicon carbide (SiC) that could advance aircraft, electric and gas-powered vehicles, renewable energy, defense and space exploration.

The project 'Improving Engine Reliability and SWAP with 350–500°C SiC Electronic Systems' is one of 34 technical projects funded in 2024 by the US Department of Defense through the Microelectronics Commons program, established by the US CHIPS Act. Funded specifically by the Silicon Crossroads Microelectronics Commons (SCMC) Hub, the project is launching with $2.4m in initial funding, and could receive up to $7.5m over three years.

The University of Michigan is a founding member of the SCMC Hub which, led by the Applied Research Institute, is an innovation ecosystem of diverse partners driven to accelerate expansion of America's microelectronics base by leveraging strong collaborative practices that strategically support innovation, workforce development and infrastructure needs to achieve domestic microelectronics excellence.

Engineers at NASA's Glenn Research Center have been exploring the potential of silicon carbide as a high-performance semiconductor for decades. SiC devices can handle higher voltages, temperatures and radiation levels than silicon alone. With an eye toward exploring the surface of Venus, they built a SiC circuit that can withstand 930F (500°C) for thousands of hours. NASA Glenn has also shown packaged device operation over a 1800F (1000°C) temperature span from –310F (–190°C) to 1490F (812°C), with relevance across aerospace.

SiC is already increasingly being used in power electronics for electric vehicles and solar and wind energy systems. However, these applications aren't making the most of its resilience to extreme conditions.

The new project will scale up NASA's technology and manufacturing process to a modern wafer size and democratize SiC chip design. Along with NASA, collaborators include GE Aerospace Research; Ozark Integrated Circuits; and Wolfspeed

The new project will scale up NASA's technology and manufacturing process to a modern wafer size and democratize SiC chip design. Along with NASA, collaborators include GE Aerospace Research in Niskayuna, New York; Ozark Integrated Circuits (Ozark IC) in Fayetteville, Arkansas; and North Carolina-based SiC manufacturer Wolfspeed.

While the technology could be useful in a broad range of sectors, the project will focus on aerospace, including electronics and sensors that make aircraft engines more reliable and help to optimize their size, weight and power. A key goal is the demonstration (for aerospace or engine applications) of a packaged actuator, converting electrical signals to mechanical motion (and hence playing an important role in control systems).

Partnering with industry and government

"NASA, GE Aerospace and Ozark IC have done an amazing job of developing this technology, which is very impactful for a variety of applications," comments principal investigator Becky Peterson, associate professor of electrical and computer engineering and director of the U-M Lurie Nanofabrication Facility. "This project will provide a critical pathway to advance and commercialize that technology," she adds. "We need advanced semiconductors produced domestically that can perform in these challenging high-temperature environments."

In the project, NASA Glenn and GE Aerospace will work together to scale the high-temperature SiC junction field-effect transistor (JFET) fabrication process from 100mm- to 150mm-diameter wafers.

"SiC-based high-temperature electronics will be a key enabler for delivering new sensor and actuator functionality that improves the capability of future DoD engine platforms," notes Aaron Knobloch, platform leader, controls and electrical systems at GE Aerospace Research. "Beyond jet engines, the ability to handle more extreme temperature capabilities could open exciting new applications in control and sensing for hypersonic applications."

Ozark IC, which has worked with NASA Glenn through the NASA Small Business Innovation Research program and licensing offices for many years, will support packaging, integration and process commercialization. Ozark IC has shown a path for the technology working to over 1400F (800°C) integrated with advanced packaging.

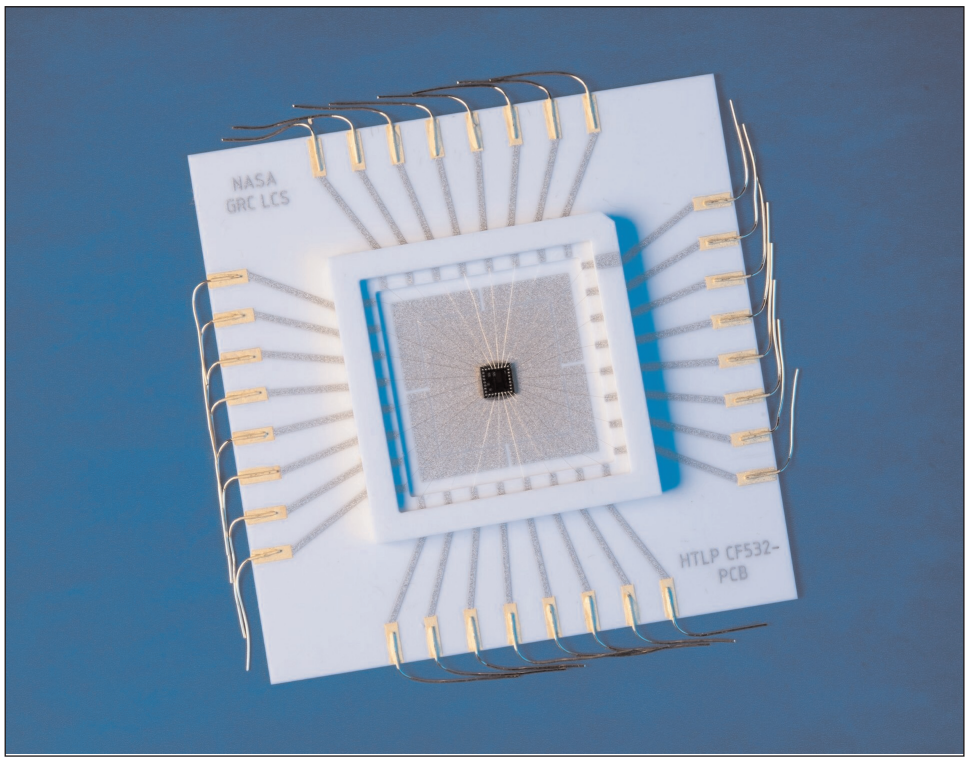
The program builds on Ozark IC's existing Department of Defense work with NASA, where DARPA has supported SiC JFET-R technology transition to GE Aerospace's 100mm facility in New York, and its application to aerospace sensing through the DARPA High Operational Temperature Sensors (HOTS) program.

Wolfspeed will provide the specialized SiC wafers necessary for these devices, building on its expertise and capacity in SiC epitaxy. Wolfspeed and the US Department of Commerce are finalizing a proposed $750m direct funding package to support the expansion of Wolfspeed silicon carbide production in North Carolina and New York. In addition, Wolfspeed will consult with the team on design for commercialization.

"Ozark IC has been working with NASA and GE Aerospace in bringing SiC technology into aerospace and energy for many years," says the firm's CEO & founder Matt Francis. "We couldn't be more thrilled to work with Michigan and Wolfspeed to help scale the technology up to 150mm with advanced packaging and integration."

Michigan Engineering researchers will refine and standardize a process development kit (PDK) and transistor models. They will create libraries of commonly used circuit blocks to make the SiC technology more accessible to integrated circuit designers.

"We'll test the devices and circuits made by NASA and GE Aerospace and packaged by Ozark IC and work together to standardize those pieces," Peterson says. "And we'll use the data to create process development kits and open electronic design automation (open EDA) software that can help automate the design of integrated circuits, and model their performance. We want to develop advanced refined models so that future users have all the tools they need to design and manufacture commercial products in this exciting technology."



A silicon carbide chip in a high-temperature ceramic package. Image courtesy: NASA Glenn Research Center.

To do this, a team led by U-M professor of electrical and computer engineering David Wentzloff will add to the unique open-source tools they've developed for designing analog and mixed-signal circuits. These circuits are crucial for tasks such as managing power, converting real-world data from sensors to digital information for processing, and driving actuators and controllers in jet engines. Analog circuits complement the digital ones that perform processing and memory tasks, for example. While open-source design tools for digital circuits are becoming increasingly common, U-M brings them into the analog realm to implement analog and digital systems on a SiC chip.

"Our system is unlike other prior analog circuit design automation tools," Wentzloff says. "The primary difference is we build on top of very mature digital design automation tools — in short, analog circuits designed with digital design automation tools. This speeds up the design of analog and mixed-signal circuits and makes it more accessible to a wide range of designers. You no longer need highly specialized analog circuit design skills."

Improving aerospace engine reliability

Existing silicon-based electronics used in engine control systems are limited to 257F (125°C) and must be protected from heat through complex and heavy cooling systems or located in cooler areas of the engine. SiC electronics can function in hot areas within engines and their exhaust systems. The technology established in this project will enable new sensor and actuator functionality, flexible modular control systems, lower weight and simpler engine electrical system architectures. Due to SiC's ability to handle extreme temperatures, SiC electronics can also advance emerging hypersonic aircraft systems which operate at temperatures far beyond the capabilities of silicon.

www.ozarkic.com
ece.engin.umich.edu
www.siliconcrossroads.us
www1.grc.nasa.gov/research-and-engineering/silicon-carbide-electronics-and-sensors

Wolfspeed's revenue falls 7% in December quarter

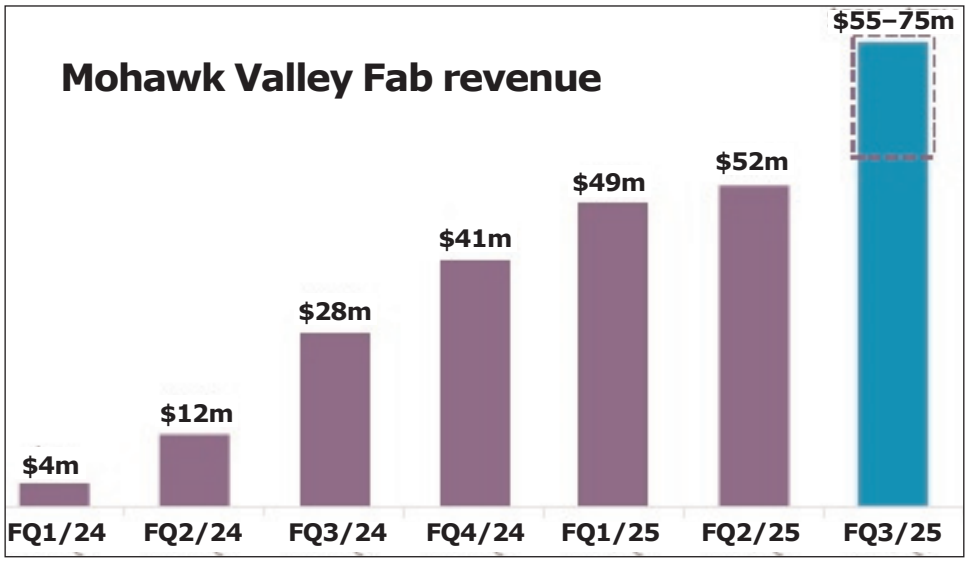
Cost cutting, better revenue linearity, stricter cash management and inventory reduction to improve profitability

For fiscal second-quarter 2025 (for continuing operations, to 29 December 2024), Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — has reported revenue of $180.5m, down 7% on $194.7m last quarter and 13% on $208.4m a year ago, but slightly above the midpoint of the $160–200m guidance range.

Materials Product revenue was $89.7m, down 8% on $97.6m last quarter and 10.6% on $100.7m a year ago, driven by customers reducing their inventories to reflect weaker industry demand outlook.

Power Device revenue was $90.8m, down 6% on $97.1m last quarter and down 15.5% on the record $107.7m a year ago, driven largely by ongoing weakness in industrial and energy (I&E) end markets. Of this, the Mohawk Valley Fab in Marcy, NY (the world's largest 200mm SiC wafer fab) contributed $52m, up just 6% on $49m last quarter but still more than quadrupling from $12m a year ago as it continues to ramp up utilization (after starting revenue-generating production at the end of the fiscal Q4/2023 June quarter). Specifically, revenue from electric vehicle (EV) applications grew year-on-year for a second consecutive quarter by more than 90% (92%).

On a non-GAAP basis, gross margin was just 1.8%, down from 3.4% last quarter and 16.4% a year ago (but above the midpoint of the guidance range of –6% to +6%). This includes a 1600-basis-point impact from under-utilization costs of $28.9m (primarily from production start-up at the Mohawk Valley Fab), down from $35.6m (a 1700-basis-point impact) a year ago, and less than the expected $35m (1900-basis-point impact). Gross margin was also impacted by lower factory production rates in the Durham wafer fab and Durham materials operations as Wolfspeed executed a maintenance shutdown and lowered factory output in line with a lower demand outlook.



Operating expenses have been cut further, from $125.9m a year ago and $120m last quarter to $108m (better than the $110m guidance) as Wolfspeed continues to reduce costs as part of its restructuring and simplification efforts. Factory start-up costs, mainly from constructing the John Palmour Manufacturing Center for Silicon Carbide (The JP) materials production facility in Siler City, North Carolina, have risen further, from $10.5m a year ago and $19.7m last quarter to $22.8m. Excluding start-up costs, operating expenses have been cut by $23m (or 21%) in fiscal first-half 2025.

Net loss has risen further, from $69.6m ($0.55 per diluted share) a year ago and $115.8m ($0.91 per diluted share) last quarter to $122.6m ($0.95 per diluted share), although this is better than the midpoint of the $114–145m guidance range.

Gross margin was also impacted by... lowered factory output in line with a lower demand outlook

Operating cash flow was –$195.1m, up from –$132m last quarter, impacted by higher net working capital due to the timing of shipments in the quarter, cash restructuring charges and higher cash interest costs. This was partially offset by improved profitability, driven by cost-reduction efforts. Capital expenditure (CapEx) has been cut from $572.3m a year ago to $403m, primarily comprising investment into The JP Materials facility. Free cash outflow has hence improved, from –$755.2m a year ago to –$598.1m.

During the quarter, cash, cash equivalents and short-term investments have hence fallen further, from $2635.7m a year ago and $1687.6m last quarter to $1404.8m. This included about $91m of the total $200m at-the-market (ATM) equity offering that was completed in January. Including the remaining $109m raised in January after the quarter closed, starting quarterly cash balance is now over $1.5bn to support the firm's ramp and growth plans.

Fiscal Q2/2025 saw $1.475m of design-ins and $795m of design-wins. Cumulative design-ins are now over $30bn and design-wins are now $12.2bn.

Start-up & under-utilization costs

Factory start-up costs have risen further, from $10.5m a year ago and $19.7m last quarter to $22.8m in fiscal second-quarter 2025. However, under-utilization costs of $28.9m are down on $35.6m a year ago, and less than the expected $35m.

For fiscal third-quarter 2025 (to 30 March), operating expenses are expected to include about $26m of factory start-up costs primarily in connection with materials expansion efforts at The JP. Cost of revenue (net) should include about $31m of under-utilization costs from the Mohawk Valley Fab.

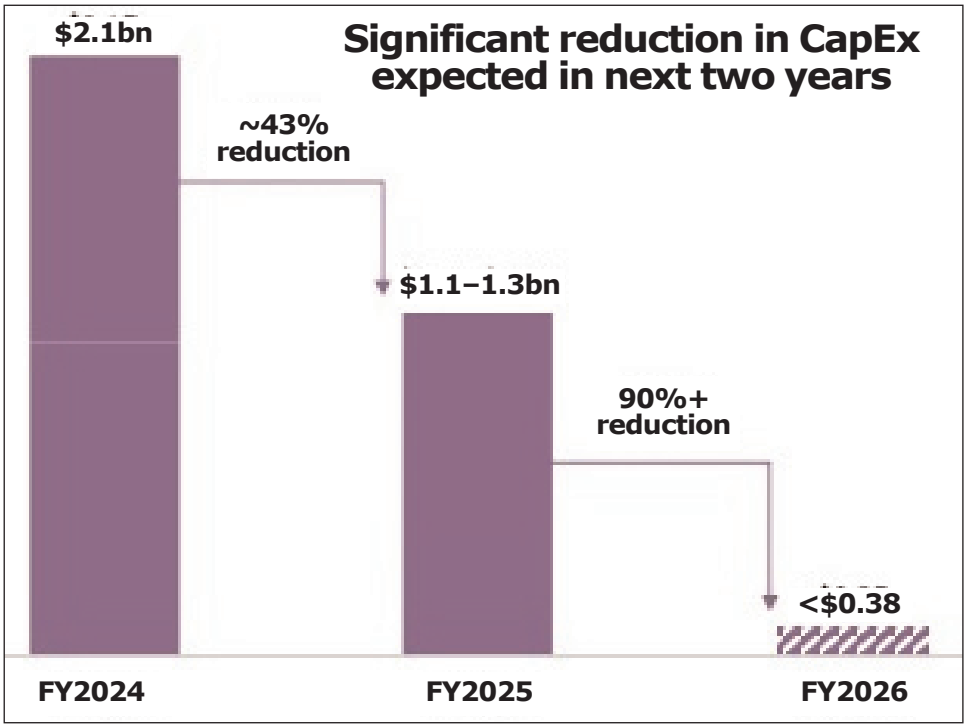
Business outlook

For its fiscal third-quarter 2025 (to 30 March), Wolfspeed targets revenue of $170–200m. This includes Mohawk Valley Fab revenue rising by 25% sequentially to $55–75m, driven by continued growth in EV-related revenue (of 20–30% quarter-to-quarter and again over 90% year-on-year) and the ramp of previously announced design wins. Power device revenue will continue to grow through fiscal second-half 2025, driven largely by companies such as General Motors investing in their EV programs to support the long-term transition taking place in automotive. However, Materials revenue is expected to fall over the next several quarters until end-market demand improves.

Gross margin should be between –3% and +7%. Operating expenses are expected to be cut to $99–104m, despite the start-up costs from The JP.

Net loss is expected to be $138–119m ($0.88–0.76 per diluted share). However, this includes the impact of issuing about 27.8 million shares of common stock under the firm's ATM program.

"On the CHIPS Act, an important milestone is the certificate of occupancy for Siler City [The JP], which we expect to happen by middle of this year. Despite close to zero new capital commitments, we will complete Siler City," notes Werner. "We are extremely pleased with the yields of our 200mm wafers and the performance of our devices from these wafers. This is a key competitive advantage as we are the first to begin commercial production on 200mm substrates," he adds.



Wolfspeed expects to continue to reduce start-up costs during fiscal second-half 2025. "As these new facilities mature, and we see less impact from start-up and under-utilization costs on our financials, unit economics will improve significantly."

"As we wind down the construction phase [of The JP], we expect capital expenditures to fall-off sharply in the second half of fiscal 2025," says chief financial officer Neill Reynolds. Full-year CapEx should fall by about 43% from $2.1bn in fiscal 2024 to about $1.2bn in fiscal 2025, then more than halve to $200–600m in fiscal 2026. "We're at the low end of that range or lower from a gross perspective, and we have the flexibility to continue to take that down," adds Reynolds. "These levels provide us adequate runway to deliver sustained revenue growth [to over $1bn in fiscal 2025, including 70% Power Device revenue growth]," he adds. "Existing capital commitments we made can satisfy meaningful demand increase and can satisfy our customers' demand," says Werner. "We expect further CapEx commitments to be close to zero."

As we wind down the construction phase [of The JP], we expect CapEx to fall-off sharply in the second half of fiscal 2025. Full-year CapEx should fall by about 43% from $2.1bn in fiscal 2024 to about $1.2bn in fiscal 2025, then more than halve to $200–600m in fiscal 2026

Financing

"Since stepping into the executive chairman role in November, I have been acutely focused on aggressively pursuing our plans to achieve our financial and operational targets," says executive chair Thomas Werner. "Myself, the board and the management team have aligned on an operating plan driven by three key immediate priorities designed to put us on a path toward long-term growth and profitability: improving the financial performance of the company to accelerate

the path to operating free cash flow generation, taking aggressive steps to strengthen our balance sheet, and raising cost-effective capital to support our growth plan. We have already made significant progress on these initiatives, evidenced by our completion of our $200m at-the-market equity offering, which puts us one step closer to finalizing our CHIPS funding."

Last quarter, Qorvo outlined its financing and liquidity plans in conjunction with the announcement of a $2.5bn funding package in line with preliminary memorandum of terms for a grant under the US CHIPS Act. This included a $750m grant, $750m of additional private secured term loan financing, and about $1bn in 48D tax credits. "To receive the funding tranches of the grants, we are required to achieve both financial and operational milestones," notes chief financial officer Neill Reynolds. "We are required to raise $300m of non-debt capital and a portion of that to receive the first funding tranche, which we achieved by executing the $200m ATM equity offering. In addition, we will need to address our convertible debt, which will be our next primary focus. Also, we will need to achieve operational milestones, which we remain on track to achieve," he adds.

"As it relates to the 48D tax credits, we have already accrued $865m as of fiscal Q2, and we have already submitted returns for $186m of cash refunds from the federal government. We expect to request significantly more cash tax refunds under the 48D program in calendar 2025 when The JP goes into service this year, which we expect to receive in calendar 2026," continues Reynolds.

"Also tied to improving financial performance, we continue to execute on our company's simplification and restructuring efforts that we expect to contribute to $200m of annual cash savings as well as driving approximately $150m of liquidity in conjunction with non-core asset sales."

Restructuring and facility closure

During fiscal Q1/2025, Wolfspeed initiated a facility closure and consolidation plan to optimize its cost structure and accelerate its transition from 150mm to 200mm silicon carbide devices.

The Durham 150mm wafer fab remains on track to close in calendar second-half 2025. The Farmers Branch 150mm epitaxy facility was closed at the end of December and is being prepared for sale. The non-factory workforce reductions contributing to a 20% reduction in total company employment, along with the factory closures, remains on track, with most of the reductions already completed at the end of fiscal Q2. "Lastly, we continue to work on our divestiture of non-core assets, which we expect to generate approximately $150m of cash proceeds in calendar 2025," says Reynolds.

Restructuring costs are expected to total $400–450m in fiscal 2025, including $188.1m in fiscal Q2/2025 (comprising employee severance and benefit costs, voluntary termination benefits and asset impairment costs including write-offs related to the Farmers Branch facility and the proposed Saarland facility [in Germany], accelerated depreciation, and asset disposition costs), plus a forecasted $72m in fiscal Q3.

"We continue to expect restructuring activities to be cash neutral in fiscal 2025 and start generating a significant amount of the annualized $200m of cash savings in fiscal 2026," says Reynolds. "Collectively, these measures allow us to improve our unit economics, deliver substantial annualized cash savings and enhance cash-generation capabilities, reducing our non-GAAP EBITDA breakeven point to under $1bn on an annualized revenue basis."

"We expect to see significant improvement in our operating cash flow as we move into the second half of fiscal 2025 as we anticipate our cost-cut measures, improved revenue linearity, stricter cash management and inventory reduction efforts will result in improved profitability and working capital performance," says Reynolds.

www.wolfspeed.com

India's Archean investing £12m in Scotland's Clas-SiC

Strategic move towards building India's first SiC power device fab

Clas-SiC Wafer Fab Ltd of Lochgelly, Fife, Scotland — which was founded in 2017 and the UK's only commercial wafer fabrication facility dedicated to silicon carbide (SiC) — has secured a £12m inward investment from Archean Chemical Industries of Chennai, India. In return for the equity investment, Archean will gain representation on Clas-SiC's board of directors, with Ranjit Pendurthi appointed as a director.

Clas-SiC Wafer Fab focuses on providing rapid prototyping for early design concepts, reducing time to market with short cycle-time and low-rate production in Scotland.

"This investment secures next-generation technology development and manufacturing," says Clas-SiC's chief executive Jen Walls. "We already export power semiconductors globally, partnering with customers from North America, Europe and Asia," she adds.

"Attracting investment from around the world is vital in growing the UK's compound semiconductor sector and supporting the work of innovative companies like Clas-SiC," commented UK Science Minister Lord Vallance.

For Archean Chemical Industries, the investment is seen as a strategic move towards potentially building India's first dedicated silicon carbide power device manufacturing facility in the coming months.

www.clas-sic.com

Former Wolfspeed CEO Gregg Lowe joins Power Integrations' board of directors

PI gains analog and power semiconductor experience, particularly in sales & distribution and customer relationships in the automotive and industrial end-markets

Power Integrations Inc of San Jose, CA, USA (which provides high-voltage integrated circuits for energy-efficient power conversion) says that Gregg Lowe is joining its board of directors on 15 February.

From 2017 until 2024, Lowe was CEO of Wolfspeed Inc of Durham, NC, USA, where he led its transition to a pure-play manufacturer of silicon carbide solutions for high-power applications. Previously, he was CEO of Freescale Semiconductor from 2012 until its 2015 merger with NXP Semiconductors. Earlier, he had a 27-year career at Texas Instruments, serving in leadership roles across field sales, automotive sales, marketing and integrated circuits, culminating in the role of senior VP & manager of its analog business, where he helped to direct the acquisition of National Semiconductor.

New board member Gregg Lowe.

Lowe currently serves on the boards of Silicon Labs and North Carolina A&T University, and is chairman of the board of the Rock and Roll Hall of Fame Museum. He holds a Bachelor of Science degree in electrical engineering from the Rose-Hulman Institute of Technology and has completed the Stanford Executive Program at Stanford University.

"Gregg is an ideal fit thanks to his decades of experience in analog and power semiconductors, particularly his expansive knowledge of the sales and distribution landscape and deep customer relationships in key end-markets including automotive and industrial," comments Power Integrations' chairman & CEO Balu Balakrishnan.

Power Integrations' CEO Balu Balakrishnan to retire

To continue as executive chairman until transition, then remain on board of directors

Power Integrations Inc of San Jose, CA, USA (which provides high-voltage integrated circuits for energy-efficient power conversion) says that Balu Balakrishnan, CEO since 2002, is retiring from that role once a successor is in place. The board of directors has retained an executive search firm to assist in identifying its next CEO. Balakrishnan, 70, intends to serve as executive chairman of the board for as long as is needed to ensure a smooth transition to his successor, and is expected to remain on the board of directors thereafter.

Balakrishnan joined Power Integrations in 1989, shortly after its formation, from National Semiconductor, where he was a product line manager. He is the inventor of many Power Integrations products including TOPSwitch, its first commercial product, followed by TinySwitch, the first product to feature the firm's EcoSmart technology for reducing standby-power waste. Balakrishnan served in a succession of executive roles before being named president & chief operating officer in 2001. In 2002 he was named CEO and joined the board of directors. He has been awarded more than 200 US patents. Awards include the Discover Award for Technological Innovation in recognition of the environmental benefits of EcoSmart technology.

Balu Balakrishnan.

"While it is time for me to turn over leadership of the company to a new CEO, I remain as passionate as ever about the work we are doing," says Balakrishnan. "We have a talented, dedicated workforce and a promising array of products and technologies with which to pursue growth opportunities in a broad range of end-markets."

"Balu is not only one of the great inventors in the history of the power semiconductor industry, but also an outstanding leader who has built a durable franchise with strong intellectual property, a deep reservoir of engineering talent and a culture that nurtures innovation," says lead independent director Bala Iyer.

www.power.com

Vishay launches 650V and 1200V silicon carbide Schottky diodes in SOT-227 package

Forward voltage drop down to 1.36V enables high speed and efficiency for high-frequency applications

Discrete semiconductor and passive electronic component maker Vishay Intertechnology Inc of Malvern, PA, USA has introduced 16 new 650V and 1200V silicon carbide (SiC) Schottky diodes in the industry-standard SOT-227 package.

Designed to deliver high speed and efficiency for high-frequency applications, the Vishay Semiconductors devices are claimed to offer the best trade-off between capacitive charge (QC) and forward voltage drop for diodes in their class.

The new devices consist of 40–240A dual-diode components in a parallel configuration, and 50A and 90A single-phase bridge devices. Built on thin wafer technology, the diodes' low forward voltage drop down to 1.36V dramatically reduces conduction losses for increased efficiency. Further increasing efficiency, the devices are said to offer better reverse recovery parameters than silicon-based diodes and have virtually no recovery tail.

Typical applications include AC/DC PFC and DC/DC ultra-high-frequency output rectification in FBPS and LLC converters for photovoltaic systems, charging stations, industrial UPS, and telecom power supplies. In these applications, the diodes' low QC down to 56nC allows for high-speed switching, while their industry-standard package offers a drop-in replacement for competing solutions.

The diodes deliver high-temperature operation to +175°C and a positive temperature coefficient for easy parallelling. UL-approved to file E78996, the devices feature a large creepage distance between terminals and a simplified mechanical design for rapid assembly.

Samples and production quantities of the new silicon carbide diodes are available now, with lead times of 18 weeks.

www.vishay.com

SemiQ launches 1200V SiC full-bridge modules to simplify development of solar inverters, energy storage and battery charging applications

Two low-loss high-speed switching SiC MOSFETs with reliable body diode deliver up to 333W with continuous drain up to 102A

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 announced a family of three 1200V SiC full-bridge modules, each integrating two of the firm's rugged high-speed switching SiC MOSFETs with reliable body diode.

The modules have been developed to simplify the development of photovoltaic inverters, energy storage, battery charging and other high-frequency DC applications.

Available in 18mΩ, 38mΩ and 77mΩ (R_{DSon}) variants, the modules have been tested at voltages exceeding 1350V and deliver a continuous drain current of up to 102A, a pulsed drain current of up to 250A and a power dissipation of up to 333W.

Operational with a junction temperature of up to 175ºC, the rugged B2 modules have exceptionally low switching losses (E_{ON} 0.13mJ, E_{OFF} 0.04mJ at 25ºC – 77mΩ module), low zero-gate voltage drain/gate source leakage (0.1µA/1nA – all modules) and low junction-to-case thermal resistance (0.4ºC per watt – 18mΩ module).

"By integrating high-speed SiC MOSFETs with exceptional performance and reliability, our new QSiC 1200V family of full-bridge modules sets a new standard for power density and efficiency in demanding DC applications," says Seok Joo Jang, director of module engineering. "This family of modules simplifies system design, and enables faster time-to-market for next-generation solar, storage and charging solutions."

Available immediately, the modules can be mounted directly to a heat-sink, are housed in a 62.8mm x 33.8mm x15.0mm package (including mounting plates) with press-fit terminal connections and split DC negative terminals.

www.semiq.com

Infineon wins German Sustainability Award

Infineon Technologies AG of Munich, Germany has won the German Sustainability Award in the 'Electrical Engineering and Electronics' category. "Infineon has assumed a leading role in the field of sustainability and serves the sector as a 'beacon' for successful transformation," the judges stated. The German Sustainability Award recognizes companies that make effective and exemplary contributions to transformation and that function as role models within their industry.

Working together with the German Chamber of Industry and Commerce (DIHK), WWF Germany, PwC Germany, Leuphana University Lüneburg (CSM Lüneburg) and other industry associations to design and implement the competition, the German Sustainability Award is Europe's largest award for ecological and social commitment. The jury selected winners in 100 different sectors from among around 2000 competing companies.

"This award is recognition, as well as an incentive to be a role model in sustainability and to continue rigorously implementing our ambitious sustainability strategy — together with our employees, customers and partners," says Elke Reichart, management board member & chief digital and sustainability officer at Infineon, who accepted the award in Duesseldorf.

Pursuing a comprehensive decarbonization strategy, Infineon says it is making good progress towards the goal it defined in 2020: achieving climate neutrality by 2030. Since then, emissions have been reduced by more than two-thirds while revenue has almost doubled. Moreover, Infineon is intensifying its collaboration along the entire supply chain. Infineon this year began reporting emissions at the individual product level (the Product Carbon Footprint). The data is already available for half of all Infineon products today.

Infineon says that its semiconductors contribute to making the generation, transmission, storage and use of energy more efficient. A recent example of sustainable product innovation is a new type of energy-saving silicon carbide (SiC) module, whose developers were nominated for the 2024 Deutscher Zukunftspreis. The solution increases the energy efficiency of existing high-performance electrical applications such as solar and wind power plants and train drives. Among other things, the module also facilitates the efficient electrification of large drives such as those found in agricultural and construction machinery, ships and aircraft. A single electric locomotive equipped with the new drive system saves around 300MW-hr per year (equivalent to the annual energy requirements of 100 single-family homes).

www.nachhaltigkeitspreis.de
www.infineon.com/coolsic

Infineon's new CoolSiC Automotive MOSFET 1200V selected by FORVIA HELLA

Automotive supplier chooses top-side-cooled devices for next-generation 800V DC–DC charging solutions

Infineon's new CoolSiC Automotive MOSFET 1200V has been selected by Germany-based international automotive supplier FORVIA HELLA for its next-generation 800V DC–DC charging solution.

Designed for on-board charger and DC–DC applications in 800V automotive architectures, Infineon's CoolSiC MOSFET comes in a Q-DPAK package and is available now. The device uses top-side cooling (TSC) technology, which enables what is claimed to be excellent thermal performance, easier assembly and lower system costs.

"We are excited to continue our partnership with FORVIA HELLA, leveraging our high-efficiency SiC products based on TSC packages," says Robert Hermann, VP of automotive high-voltage chips and discretes at Infineon.

"Together with Infineon, we will continue to offer sustainable and innovative products and comprehensive services that exceed our customers' expectations and drive the development of advanced mobility," says Guido Schütte, a member of the Electronics Executive Board at FORVIA HELLA.

Infineon's new CoolSiC Automotive MOSFET 1200V in the Q-DPAK package is based on Gen1p technology and offers a drive voltage in the range of $V_{GS(off)}$= 0V and $V_{GS(off)}$= 20V. The 0V turn-off enables unipolar gate control, which simplifies design by reducing the number of components in the PCB. With a creepage distance of 4.8mm, the package achieves an operating voltage of over 900V without the need for additional insulation coating. Compared with backside cooling, the TSC technology ensures optimized PCB assembly, reducing parasitic effects and resulting in significantly lower leakage inductances. As a result, customers benefit from lower package parasitics and lower switching losses, says Infineon. Heat dissipation is further improved by diffusion soldering the chip with .XT technology.

www.hella.com/en
www.infineon.com/Q-DPAK

Infineon releases first silicon carbide products to customers based on 200mm SiC wafers

Villach fab providing SiC power chips for high-voltage applications

Infineon Technologies AG of Munich, Germany says that it has made significant progress on its 200mm silicon carbide (SiC) roadmap, and is releasing the first products based on the 200mm SiC technology to customers in first-quarter 2025. Manufactured in Villach, Austria, the products provide SiC power technology for high-voltage applications, including renewable energies, trains, and electric vehicles.

Also, the transition of Infineon's manufacturing site in Kulim, Malaysia, from 150mm wafers to the larger and more efficient 200mm-diameter wafers is fully on track. The newly built Module 3 is poised to commence high-volume production aligned with market demand.

"The implementation of our SiC production is progressing as planned, and we are proud of the first product releases to customers," says chief operations officer Dr Rutger Wijburg. "By ramping up

SiC production in Villach and Kulim in phases, we are improving cost-efficiency and continuing to ensure product quality. At the same time, we are making sure our manufacturing capacities can meet the demand for SiC-based power semiconductors."

Infineon says that its SiC products let customers develop energy-efficient solutions for electric vehicles, fast-charging stations and trains as well as renewable energy systems and AI data centers. The firm says that the release to customers of the first SiC products based on the 200mm wafer technology marks a substantial step forward in its SiC roadmap, with a strong focus on providing a comprehensive portfolio of high-performance power semiconductors that promote green energy and contribute to CO_2 reduction.

As 'Infineon One Virtual Fab' for wide-bandgap (WBG) technologies, Infineon's production sites in Villach and Kulim share technologies and processes that are said to allow for fast ramping and efficient operation in SiC and gallium nitride (GaN) manufacturing.

www.infineon.com/coolsic

Infineon adds Q-DPAK and TOLL packages to industrial CoolSiC MOSFETs 650V G2 range

Portfolio of discrete CoolSiC MOSFETs 650V expanded for greater compactness and power density

To support the electronics industry's shift towards more compact and powerful systems and to further drive innovation at the system level, Infineon is expanding its portfolio of discrete CoolSiC MOSFETs 650V with two new product families housed in Q-DPAK and TOLL packages.

The diverse product families, with top- and bottom-side cooling, are based on CoolSiC Generation 2 (G2) technology and offer significantly improved performance, reliability and ease of use. They target high- and medium-power switched-mode power supplies (SMPS) including AI servers, renewable energy, chargers for electric vehicles, e-mobility and humanoid robots, televisions, drives and solid-state circuit breakers.

The TOLL package is said to offer outstanding thermal cycling on board (TCoB) capability, enabling compact system designs by reducing the printed circuit board (PCB) footprint. When used in SMPS, it can also reduce system-level manufacturing costs. The TOLL package now fits an extended list of target applications, enabling PCB designers to further reduce costs and better meet market demands.

The introduction of the Q-DPAK package complements the ongoing development of Infineon's new family of Topside Cooled (TSC) products, which includes CoolMOS 8, CoolSiC, CoolGaN and OptiMOS. The TSC family enables customers to achieve excellent robustness with maximum power density and system efficiency at low cost. It also enables direct heat dissipation of 95%, allowing the use of both sides of the PCB for better space management and reduction of parasitic effects.

Teradyne and Infineon partner on power semi testing

Teradyne to acquire Infineon's automated test equipment technology and development team

Automated test solutions provider Teradyne Inc of North Reading, MA, USA and Infineon Technologies AG of Munich, Germany have entered into a strategic partnership to advance power semiconductor test.

As part of the strengthened relationship, Teradyne will acquire part of Infineon's automated test equipment team (AET) in Regens burg, Germany, providing mutual benefits for both companies, it is reckoned.

With the additional resources and expertise, Teradyne will accelerate its roadmap in the power semiconductor segment while collaborating on new solutions with a key market leader.

By entering into a service agreement, Infineon secures continued manufacturing support as well as enhanced flexibility to respond to internal demand for this specialized test equipment, and benefits from Teradyne's economy of scale.

Teradyne says that it is fully committed to the 80-person team at Infineon's Regensburg site and plans to build upon these capabilities as it integrates together with its Power Semiconductor business unit.

"Acquiring and integrating Infineon's technology and team in Regensburg will extend our leadership in the power semiconductor market," says Rick Burns, president of Teradyne's Semiconductor Test Group. "Infineon's technology will enhance our market-leading ETS product portfolio, demonstrating our commitment to continue to provide innovative solutions that meet the evolving needs of our customers," he adds.

"Together with Teradyne, we are advancing our power semiconductor test capabilities," says Alexander Gorski, executive VP, Frontend Operations at Infineon. "Integrating our experienced workforce with Teradyne will help to accelerate innovation and address the dynamic test challenges in new technologies like silicon carbide and gallium nitride at the scale and flexibility needed by our markets and customers. At the same time, we provide our employees a long-term perspective in a highly specialized company."

www.teradyne.com

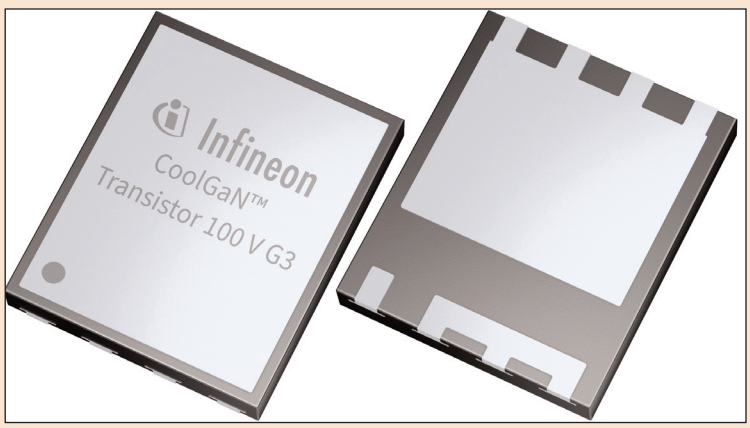
Infineon launches CoolGaN G3 Transistor in new silicon-footprint packages

Easy multi-sourcing strategies to drive industry-wide standardization

Since gallium nitride (GaN) suppliers have taken various approaches to package types and sizes, leading to fragmentation and a lack of multiple footprint-compatible sources for customers, Infineon has launched the high-performance CoolGaN G3 Transistor 100V in RQFN 5x6 package (IGD015S10S1) and 80V in RQFN 3.3x3.3 package (IGE033S08S1).

"The new devices are compatible with industry-standard silicon MOSFET packages, meeting customer demands for a standardized footprint, easier handling and faster time-to-market," says Dr Antoine Jalabert, product line head for mid-voltage GaN at Infineon.

The CoolGaN G3 100 V Transistor devices will be available in a 5x6 RQFN package with a typical on-resistance of 1.1mΩ. Additionally, the 80V transistor in a 3.3x3.3 RQFN package has a typical resistance of 2.3mΩ.



CoolGaN G3 Transistor in new silicon-footprint packages.

The transistors offer a footprint that, for the first time it is claimed, allows for easy multi-sourcing strategies and complementary layouts to silicon-based designs. In combination with GaN, the new packages offer a low-resistance connection and low parasitics, enabling high-performance transistor output in a familiar footprint.

Moreover, the chip and package combination allows a high level of robustness in terms of thermal cycling, in addition to improved thermal conductivity, since heat is better distributed and dissipated due to the larger exposed surface area and higher copper density.

Samples of the GaN transistors IGE033S08S1 and IGD015S10S1 in RQFN packages will be available in April.

www.infineon.com/gan

CGD raises $32m in Series C funding round

Cambridge University spin-out to expand operations in Cambridge, North America, Taiwan and Europe

Fabless firm Cambridge GaN Devices Ltd (CGD) — which was spun out of the University of Cambridge in 2016 to design, develop and commercialize power transistors and ICs that use GaN-on-silicon substrates — has closed a $32m Series C funding round led by a strategic investor with participation from British Patient Capital and supported by existing investors Parkwalk, BGF, Cambridge Innovation Capital (CIC), Foresight Group, and IQ Capital.

The funding will enable CGD to expand its operations in Cambridge, North America, Taiwan and Europe, and deliver the firm's value proposition to its growing customer base. The investment will fuel CGD's growth strategy, focusing on the continued delivery of highly efficient GaN products to high-power industrial, data-center and automotive markets.

Transforming power electronics with GaN

For power electronics, gallium nitride-based devices offer faster switching speeds, lower energy consumption, and more compact designs than traditional silicon-based solutions. CGD says that its proprietary monolithic ICeGaN technology, which simplifies the implementation of GaN into existing and progressive designs, delivers efficiency levels exceeding 99%, enabling energy savings of up to 50% in a wide range of high-power applications including electric vehicles and data-center power supplies. These innovations could save millions of tons of CO_2 emissions annually, accelerating the global transition to more sustainable energy systems due to the inherent ease-of-use that ICeGaN technology provides, the firm claims.

The funding round "validates our technology and vision to revolutionize the power electronics industry with our efficient GaN solutions and make sustainable power electronics possible," says CEO & founder Dr Giorgia Longobardi. "We're now poised to accelerate our growth and make a significant impact in reducing energy consumption across multiple sectors," she adds. "We look forward to collaborating with our strategic investor to penetrate the automotive market".

Market opportunity

The global GaN power device market is projected to grow at a compound annual growth rate (CAGR) of 41% to $2bn by 2029 (according to the report '2024 Power SiC and GaN Compound Semiconductor Market Monitor' by Yole Intelligence). CDG says that its ICeGaN technology is a viable alternative to existing solutions using silicon carbide (SiC), combining high energy-efficiency, miniaturization and monolithically integrated smart functionalities, enabling it to have access to a high-power market estimated to be in excess of $10bn by 2029. Having already secured customers in its pipeline, CGD reckons that it is well positioned to capitalize on this rapid market expansion.

"I'm thrilled to see this funding helping to deliver on customer deals we've already closed for CGD's latest-generation P2 products," says Henryk Dabrowski, senior VP of sales. "This investment will significantly boost our ability to meet the growing demand for our reliable and easy-to-use GaN solutions," he adds.

Global expansion and vision for the future

"CGD is at the forefront of technology that can reduce the energy demands of booming industries, like artificial intelligence and electric mobility," says John Pearson, chief investment officer at Parkwalk Advisors. "It has enormous global potential and widespread applications which will see CGD continue to innovate and grow," he adds.

"Following years of research, Cambridge GaN Devices have proven the impact of their semiconductor technology," notes George Mills, director – deeptech, direct & co-investments, British Patient Capital. "Their GaN devices consume less energy than their silicon-based counterparts, which both reduces costs and has a positive environmental impact. It's valuable technology that now needs long-term capital to scale."

www.camgandevices.com

CGD's senior VP of global sales to lead expansion into additional markets

Henryk Dabrowski to spearhead collaboration with top-tier accounts

Fabless firm Cambridge GaN Devices Ltd (CGD) — which was spun out of the University of Cambridge in 2016 to design, develop and commercialize power transistors and ICs that use GaN-on-silicon substrates — says that Henryk Dabrowski, appointed as senior VP of global sales last year, will lead its global sales strategy by expanding into additional markets exploiting the advantages offered by ICeGaN. As part of that expansion, CGD is growing its sales organization and will be hiring regional sales managers for both EMEA and North America who will report to Dabrowski.

"GaN is now generally acknowledged to be a disruptive power semiconductor technology with an established growth trajectory, enabling high efficiency, high power density and miniaturization," says Dabrowski. "It is a perfect opportunity for CGD, which has demonstrated the ruggedness, reliability and ease of use of its ICeGaN GaN IC technology. I am, therefore, delighted to be leading the sales focus as we scale up with major global customers in applications including servers, data centers, inverters, industrial power supplies and, in the near future, automotive EV applications," he adds.

Henryk Dabrowski.

Dabrowski's "extensive industry expertise, strategic vision and proven success will enable CGD's rapid expansion into new markets worldwide," reckons co-founder & CEO Dr Giorgia Longobardi. "As the demand for power significantly increases due to AI and the electrification of vehicles, I am confident that Henryk's expertise will be key to accelerating commercial adoption of CGD's effortless and energy-efficient ICeGaN GaN ICs."

Dabrowski has over 30 years' experience in technology design, commerce and sales leadership. Most recently, he built and led sales and applications teams for Vicor in EMEA. A Chartered Engineer (CEng) with the Institute of Engineering and Technology (IET), Dabrowski previously held commercial roles at Texas Instruments and Infineon, and also has experience within the distribution sales channel.

www.camgandevices.com

SounDigital uses Infineon's 100V normally-off E-mode CoolGaN transistors in new 1500W Class D amplifier

Energy efficiency boosted by 5% and energy loss cut by 60%

Manufacturers of audio equipment constantly seek to enhance sound quality while also meeting the growing demand for compact, lightweight, more integrated and energy-efficient designs. At the same time, they must ensure seamless connectivity, cost-effectiveness and user-friendly functionality, making audio product development more complex than ever. To overcome these challenges, SounDigital has integrated CoolGaN transistors from Infineon Technologies AG of Munich, Germany into its new 1500W Class D amplifier, which features an 800kHz switching frequency and five channels. Infineon says that its GaN technology has improved the amplifier's energy efficiency by 5% and reduced energy loss by 60%.

"GaN transistors significantly enhances our overall system performance with minimized system cost and increased ease of use," comments SounDigital's CEO Juliano Anflor.

"GaN technology is transforming the audio amplifier industry, providing unparalleled efficiency and performance," says Johannes Schoiswohl, head of Infineon's GaN business line. "Infineon's leading GaN solutions deliver superior sound quality, higher power density and reduced energy consumption, enabling SounDigital's audio systems to reach new levels of fidelity and performance."

For its 1500W Class D amplifier, SounDigital selected Infineon's 100V normally-off E-mode transistors: IGC033S101 in a PQFN-3x5 package and IGB110S101 in a PQFN-3x3 package. With their low on-resistance, the transistors are suitable for demanding high-current applications, enabling significant improvements in both sound quality and efficiency of SounDigital's amplifier. The GaN-based amplifier also delivers high performance while reducing power dissipation by 75W, allowing for a 50% smaller heat sink. Additionally, the overall system size has been reduced by 40% without compromising performance. The audio quality has been further improved by the CoolGaN transistors, with total harmonic distortion (THD) reduced by 70%, enabling more precise and detailed sound. At the same time, the idle current has been reduced by 40%, significantly improving energy efficiency.

www.infineon.com/gan

DARPA grants Penn State $3m to work with Northrop Grumman on heterogeneous integration

2D materials to be used as seed layers to grow gallium nitride on industry-compatible silicon (001)

Penn State University is to receive $3m from the US Defense Advanced Research Projects Agency (DARPA) as part of a larger grant awarded to defense, aerospace and technology firm Northrop Grumman targeting new materials and technologies to make faster, more efficient devices as silicon chips run into performance limits. The joint project will aim to develop a novel method for integrating gallium nitride (providing superior performance and faster switching speeds for power-intensive applications) with silicon substrates (for scalability and affordability). This hybrid approach can lead to more efficient power electronics with lower production costs, making them suitable for high-demand applications like electric vehicles, power electronics and data centers, where efficiency and durability are critical.

"Silicon is the common platform for microelectronics but it is challenging to combine new semiconductor materials with silicon," notes Joan Redwing, distinguished professor of materials science and engineering and director of the Penn State Materials Research Institute's (MRI) Two-Dimensional Crystal Consortium, a US National Science Foundation Materials Innovation Platform and national user facility. "To overcome this, we need new approaches to densely integrating advanced materials with silicon," he adds. "Our work with Northrop Grumman is designed to explore integrating gallium nitride directly onto silicon using two-dimensional materials as interlayers."

As a wide-bandgap semiconductor, GaN can withstand higher electric fields and sustain higher voltages and temperatures. Silicon is a lower-bandgap semiconductor, but it is cheaper and benefits from the well-established silicon manufacturing infrastructure. Combining GaN's ability to handle high voltages and high switching speeds with silicon's wide use in digital electronics can create chips that leverage the strengths of both materials.

"Data centers are expected to need 160% more power by 2030, largely because of the growing use of artificial intelligence," notes Joshua Robinson, professor of materials science & engineering and Penn State's principal investigator on the DARPA project. "Our work could help reduce that energy demand and contribute to a more sustainable future."

The team reckons that its work could also lead to smaller, faster and more efficient power electronics, i.e. mean reduced energy bills for consumers and devices that generate less heat.

A potential hurdle is that traditional methods of integrating gallium nitride with silicon can be complex and costly, often requiring interlayers that introduce thermal resistance and limit device performance. With the DARPA grant, Penn State researchers aim to develop a novel solution using 2D materials that are one to a few atoms thick, such as molybdenum disulfide and gallium selenide as seed layers to grow gallium nitride on industry-compatible silicon (001), which is the preferred crystal orientation used in existing semiconductor technology.

"The current approach to gallium nitride-on-silicon integration has too many drawbacks, from increased thermal resistance to device fabrication challenges on silicon (001)," says Robinson, who also is professor of chemistry and physics in the Eberly College of Science. "By using 2D materials as seed layers, we aim to eliminate these issues and develop a direct route to integrating gallium nitride-on-silicon with improved performance compared to current technologies. This could directly impact manufacturing costs and enable market entry into energy-efficient devices."

The current approach to gallium nitride-on-silicon integration has too many drawbacks

According to Robinson, Penn State's leadership in 2D materials and advanced manufacturing uniquely positions it to tackle this challenge and makes it a suitable partner for a major company like Northrop Grumman. The project will leverage the state-of-the-art infrastructure for growing and characterizing 2D materials and wide-bandgap semiconductors at Penn State.

"This program allows us to demonstrate that 2D materials could be key to enabling advances in 3D semiconductors," Robinson says. "We're combining our expertise in 2D research with the real-world need for improved semiconductor performance, setting the stage for years of innovation in heterogeneous integration."

The equipment and methodologies developed through the grant will be available to other researchers through MRI's user facilities, with the goal of fostering collaboration and innovation among partners.

Adri van Duin, distinguished professor of mechanical engineering, of chemical engineering, of engineering science and mechanics, of chemistry and of materials science and engineering, and Rongming Chu, professor of electrical engineering, are also participating in the DARPA project.

www.mri.psu.edu

MACOM European Semiconductor Center wins multi-year deal for France 2030-funded MAGENTA program

MESC to lead development and manufacturing of GaN-based Ka-band MMICs

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) says that its France-based European Semiconductor Center (MESC) has been awarded a multi-year contract from French Government agency Banque Publique d'Investissement (BPI) to lead the development and manufacturing of advanced semiconductor products, in collaboration with public and private sector partners.

The MAGENTA program is administered by BPI and financed by the French government within the framework of France 2030 (a €54bn investment plan launched in 2021 to decarbonize the French economy and promote environmentally friendly innovation while supporting future leaders of strategic sectors such as energy, digital technology, health and agriculture).

The MAGENTA program's goal is to develop next-generation Ka-band monolithic microwave integrated circuit (MMIC) front-end products, leveraging MESC's existing gallium nitride (GaN) technology. A key program focus will be the development of amplifiers with exceptional power-added efficiency that will push the boundaries of high-frequency communications system performance. The products and capabilities developed under the program are intended to support telecom systems in the 5G-FR2 bands and low Earth orbit (LEO) communication systems. Under the terms of the contract, MESC will lead manufacturing of the MMICs developed by MAGENTA partners.

"This noteworthy award will make MESC a stronger partner and supplier to the European Telecommunications and Space markets," says MACOM's president & CEO Stephen G. Daly. "The MAGENTA team will collaborate and explore new MMIC design and manufacturing techniques to improve performance of critical global communication systems," he adds. "We are pleased to have French government support as we build a stronger business in France to support the European market."

www.macom.com

Nimy collaborating with M2i to secure gallium supply for US government and defense industry

M2i to provide sustainable supply of gallium to defense industry

Mining firm Nimy Resources Ltd of Perth, Western Australia has executed a non-binding collaboration agreement with Nevada-based M2i Global Inc (Minerals Metals Initiatives) to assure a supply of gallium in support of the US Department of Defense (DOD).

M2i specializes in developing and executing a complete global value supply chain of critical minerals for the purposes of US national defense and economic growth and security, as well as that of US free-trade partners. Its subsidiaries US Minerals Inc and Metals Corp are engineering, research and services firms that bring together people, technology and solutions from across Government, business, not-for-profits and academia to provide access and availability to critical minerals and metals for the purpose of defense and economic security.

Through its Manufacturing Capability Expansion and Investment Prioritization Office, the US DOD is keen to secure a reliable, sustainable supply of gallium materials that can be used in support of the US Government including, but not limited to, the production of semiconductors, radar and aerospace technologies.

"Nimy's strategy of developing a diversified integrated gallium supply chain continues to gain momentum, and the agreement with M2i Global is a continuation of this progress," says Nimy chairperson Neil Warburton.

"Our core mission is fortifying our nation's critical material supply by providing secure and reliable access to key resources for the USA," notes M2i's executive chairperson Doug Cole. "We are excited to work closely with Nimy to advance their vision of setting the benchmark for the integrated supply of superior quality, natural gallium material to the growing technology industry."

"M2i will continue its efforts to meet the needs identified by the Manufacturing Capability Expansion and Investment Prioritization office, which works to assure a reliable, sustainable supply of gallium and other critical materials within the US to be used in the production of semiconductors in the advanced technology sector," says M2i's president & CEO Major General (Ret) Al Rosendo. "DOD wants to build a resilient industrial base to meet current and future national defense requirements."

www.m2i.global
www.nimy.com.au

Element Six unveils copper diamond composite

Cost-effective, high-performance thermal management solution for AI, high-performance computing and GaN RF devices

At Photonics West 2025 in Santa Clara, CA, USA (25–30 January), chemical vapor deposition (CVD)-based synthetic diamond materials firm Element Six of Oxford, UK (E6, part of the De Beers Group) launched a Cu-diamond product, a copper-plated diamond composite material that has high thermal and electrical conductivity. Designed to address the increasingly critical thermal management challenges in advanced semiconductor devices, the cost-effective solution is said to enable greater performance and reliability for applications such as AI, high-performance computing (HPC), and gallium arsenide (GaN) RF devices.

As semiconductor devices have grown larger and more powerful, managing heat dissipation has become a significant challenge for the industry, notes E6. More than 50% of all electronic device failures are heat-related, and data centers, which now consume 3.7% of total US power demand, are predicted to reach 10% by 2029. As a result, thermal management innovation is critical to enabling next-generation performance and energy efficiency.

"Thermal management for semiconductor devices remains a significant challenge as power levels increase and packaging continues to advance," notes chief technologist Daniel Twitchen. "Our copper diamond composite addresses these challenges by offering a scalable and affordable solution for next-generation AI and HPC devices," he adds. "This innovation empowers our customers to enhance performance and reliability, while reducing cooling costs."

E6's new copper diamond composite enables thermal conductivity in the 800W/mK range, optimized for high-demand applications. It provides high performance at a lower cost to facilitate widespread adoption and can be manufactured in complex shapes, allowing seamless integration into diverse 2.5/3D advanced packaging configurations, says E6.

"Through the unmatched thermal conductivity and durability of diamond-based composites, we are enabling a new era of high-performance devices, not only addressing today's challenges but also laying the groundwork for future advancements," says Twitchen.

During Photonics West, Element Six showcased the new copper diamond composite, offering live demonstrations and expert insights.

www.e6.com/en/products

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Fuji Electric Corp. of America **Distribution & Control Department**

For sales, product & distributor information, please visit americas.fujielectric.com/UL-Plug-In

or contact us: x-fea-fuji-dc@fujielectric.com

IQE raising £18m by issuing convertible loan notes

Issuance to preclude need to raise near-term capital

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that, further to its announcement of 18 November 2024, it has entered into subscription agreements with a consortium of existing investors and certain senior executives and directors, led by its largest shareholder Lombard Odier.

The noteholders have conditionally agreed to subscribe for, and IQE has conditionally agreed to issue, secured zero-coupon convertible loan notes with a conversion price of 15 pence per ordinary share pursuant to a convertible loan note instrument at 85% of the loan notes' face value to raise total subscription proceeds of £18m. The initial term of the loan notes is 12 months, with an option to extend them for a further six months.

The convertible loan notes will be secured against IQE's assets in the UK and subordinated to its existing financing facility with HSBC UK Bank plc, which will be amended and restated upon issuance of the loan notes. Following the completion of the proposed transaction, the directors do not expect to need to raise near-term capital.

No offer or invitation is being made to shareholders more generally to purchase, acquire or subscribe for any of the loan notes. No application will be made for the admission of the loan notes to trading on AIM or any recognised securities exchange.

General meeting

The issuance of the loan notes, and therefore the proposed transaction, is conditional, inter alia, on the passing of resolutions by shareholders at a general meeting of IQE on 10 March. IQE will soon send a circular and a notice convening the general meeting. The circular includes, inter alia, details of the convertible loan notes and the resolutions, which are being proposed (a) by way of ordinary resolution, to approve the directors' authority to allot ordinary shares with a total nominal value of up to £1,538,823.53, equal to 153,882,353 new ordinary shares, over which rights to subscribe are being granted by IQE pursuant to the issuance of the loan notes and, in the event that the conversion of the principal amount of the loan notes into new ordinary shares does not take place, warrants to subscribe for ordinary shares; and (b) by way of special resolution, to empower the directors to allot and issue equity securities for cash on a non-pre-emptive basis with an aggregate nominal value of up to £1,538,823.53, equal to 153,882,353 new ordinary shares, over which rights to subscribe are being granted by IQE pursuant to issuance of the loan notes and, in the event that conversion does not take place, the warrants.

As previously announced, IQE is undertaking a strategic review, which the directors believe will unlock significant unrealised value within the group. IQE says that the proposed transaction is integral to the strategic review and the firm's ability to demonstrate financial resilience to both its customers and potential parties to the strategic review.

IQE remarks that, if the resolutions are not approved at the general meeting, the proposed transaction cannot complete and it will not receive the net proceeds from the issuance of the loan notes. The directors of IQE believe that successful completion of the transaction is required to maintain sufficient short-term liquidity while the firm completes the ongoing strategic review.

Noteholders who are currently holders of (or who control the exercise of voting rights attaching to) IQE's ordinary shares have each undertaken to vote their existing holdings of ordinary shares in favour of the resolutions.

Use of proceeds

Following the ongoing strategic review and significant strategic progress, IQE is undertaking the proposed transaction to provide additional short-term liquidity whilst it completes its strategic review. The proceeds from the transaction will be applied towards the firm's short-term working capital requirements.

Lombard Odier nominee director

As previously announced on 17 May 2023 as part of a previous placing fundraising, Lombard Odier (as a substantial shareholder in IQE participating in such fundraising) was granted the right to nominate a non-executive director to IQE's board as a representative of funds or accounts managed on a discretionary basis by Lombard Odier, subject to Lombard Odier continuing to exercise or control, directly or indirectly, 12% or more of IQE's ordinary shares. In recognition of the significant additional investment by Lombard Odier pursuant to the proposed transaction, IQE has agreed to grant Lombard Odier the right to appoint an additional non-executive director for as long as funds or accounts managed by Lombard Odier continue to hold any loan notes.

"We are pleased a consortium led by our largest shareholder is providing this convertible loan note, which demonstrates continued support for IQE and belief in its long-term strategy and significant market opportunity," comments IQE's executive chair Mark Cubitt. "In parallel, IQE continues to make progress on its comprehensive strategic review of its asset base to ensure that it has a strong capital position to further invest in its core operations, with a particular focus on its Taiwan operations, for which all options are being assessed, including a full sale and IPO."

www.iqep.com

IQE raises 2024 revenue and adjusted EBITDA guidance

Cost control and improved operational performance boosts adjusted EBITDA

In a pre-close trading update for full-year 2024, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that it now expects revenue of £118m, exceeding 18 November's guidance of about £115m. This is up from 2023's £115.3m.

Combined with focused cost control and improved operational performance, adjusted EBITDA guidance has likewise been raised from at least £5m to at least £7.5m (up from 2023's £4.3m).

"Amid ongoing macro headwinds, Jutta and the leadership team have taken effective action to refocus the group on its core strengths and improve operational performance, resulting in an encouraging financial picture," comments executive chair Mark Cubitt.

Strategic review and proposed financing

As announced in November, IQE is undertaking a strategic review that the board believes will better unlock significant unrealised value within the group. At this stage, the strategic review is focused on its Taiwan operations, covering all strategic options including IPO or a full sale. While the review remains at an early stage, the board says that it is encouraged by the positive levels of interest from its partners and the broader recognition that the firm is a technical leader spanning strategically important vertical markets, with a well-invested asset base.

"I am really pleased by the reaction from our staff, customers and shareholders to the announcement of the strategic review, and the resulting positive engagement," comments Cubitt.

In addition, IQE is in the final stages of concluding its proposed convertible loan note and has received strong support from shareholders. This process is expected to conclude soon.

"The proposed financing will provide IQE with greater resilience as we continue to strengthen key customer relationships and expand further into emerging high-growth areas," concludes Cubitt.

www.iqep.com

Taiyo Nippon Sanso selling BRUTE Peroxide in Japan

Stainless canister with proprietary adsorbent technology enables supply hydrogen peroxide with low water concentration

After supplying Peroxidizer highly concentrated hydrogen peroxide gas delivery systems since 2013, industrial gas company Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan (part of Nippon Sanso Holdings Group) has added to the BRUTE suite of chemicals by beginning to sell BRUTE Peroxide in Japan.

In recent years, hydrogen peroxide (H_2O_2) has attracted wide interest as a promising new reactant because of its ability to deposit high-quality films at low temperatures, compared with conventional alternatives.

Peroxidizer has received a process-of-record from a major device manufacturer that can supply hydrogen peroxide at a high flow rate and concentration for mass-production processes. Moreover, TSNC has received requests from users to minimize the amount of water carried along with hydrogen peroxide.

California-based TNSC group company RASIRC Inc (which provides materials and vaporizers for semiconductor manufacturing processes using its membrane separation technology) has therefore developed and sold BRUTE Peroxide as a new hydrogen peroxide supply source in a stainless canister with proprietary adsorbent technology that enables safe handling and stable delivery of highly concentrated hydrogen peroxide vapor with lower water content for semiconductor fabrication processes, enabling a lower entry-point for the use of hydrogen peroxide.

The characteristics of the product are as follows:

- The conventional bubbling method of using a hydrogen peroxide solution can only supply up to a few hundred ppm of hydrogen peroxide, due to limitations posed by Raoult's Law. However, BRUTE Peroxide can supply hydrogen peroxide at more than 100 times higher concentration.
- The canister-type source offers users easy handling, a low initial cost, and the immediate use of hydrogen peroxide within customer tools, making it suitable for R&D as well as low-volume production processes.

Future plans

TSNC plans to expand the sale of BRUTE Peroxide to R&D applications as well as low-volume production process requirements, mainly targeting advanced semiconductor segments such as logic and memory. In addition, coupled with Peroxidizer, TSNC plans to expand the range of applications of hydrogen peroxide to optical devices and biomedical segments, where it has seen a significant increase in the number of inquiries.

www.tn-sanso.co.jp/en
www.MOCVD.jp

Forge Nano adds cleanroom, tripling ALD cluster tool production space to accommodate growing demand for commercial wafer coating equipment

2000ft² cleanroom dedicated to manufacturing commercial ALD equipment for 200mm semiconductor markets

Atomic layer deposition (ALD) equipment provider and materials science company Forge Nano Inc of Thornton, CO, USA has completed its new 2000ft^2 semiconductor cleanroom, which enables it to manufacture multiple commercial TEPHRA ALD cluster tools to accommodate growing demand from the semiconductor market.

Forge Nano announced the expansion of its semiconductor ALD business in 2024 with the launch of TEPHRA. The firm's ability to coat single wafers at 10x the throughput of traditional ALD systems has significantly grown customer demand, thus requiring the expansion of manufacturing capacity.

"The Forge Nano TEPHRA can enable conformal metal barrier seed layers for through-silicon and through-glass vias at aspect ratios greater than 25:1 at production speeds," says Matt Weimer, director of R&D. "With this new cleanroom, Forge Nano will be able to showcase the capabilities of our ALD atomic layer deposition processes to our customers and further our solutions for advanced packaging and 3D chip integration."

The new cleanroom provides a Class 10 (ISO 4) space for processing sensitive customer samples and includes a metrology lab for advanced thin-film measurement and particle inspection. The remainder of the cleanroom will house Forge Nano's own internal TEPHRA tool and provide space to build multiple customer tools, serving as a dual operating space for demonstrations and manufacturing. In addition to increased manufacturing space, this expansion is poised to accelerate Forge Nano's ability to provide proof-of-concept and commercial solution validation to manufacturers integrating new ALD processes.

Powered by Forge Nano's ALD technology, which offers ultrathin, uniform, pinhole-free films with 10x throughput for single-wafer processing, TEPHRA is dedicated to the manufacturing of specialty semiconductor applications on 200mm wafers and below. With 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 200mm applications in advanced packaging, power semiconductor, radio frequency devices (RFD), micro-LEDs, micro-electromechanical systems (MEMS), and more.

Forge Nano expects to deliver TEPHRA tools in early 2025. It is offering on-site TEPHRA demonstrations to new and existing customers starting in early 2025.

www.forgenano.com/semiconductors

Riber's full-year revenue grows 5% to €41.2m in 2024

For fourth-quarter 2024, molecular beam epitaxy (MBE) system maker Riber S.A. of Bezons, France has reported revenue of €22.7m, remaining strong as it was down just 2% on a high basis of comparison off €23.1m a year ago.

Full-year revenue has still grown, by 5% from 2023's €39.2m to €41.2m in 2024.

Revenues for Services & Accessories was steady, falling by just 1% from €10.3m to €10.2m.

MBE Systems revenues grew by 7% from €29m to €31m (despite delivering just 12 systems rather than the 13 in 2023).

Of total revenue, 57.3% came from Asia, 35.7% from Europe and 7.1% from North America.

Order book falls by 17%

Reflecting the sustained deliveries at the end of the year, the order book shrank by 17%, from €26.3m at the end of 2023 to €21.7m at the end of 2024.

Services & Accessories orders fell from €6.1m to €5m.

MBE Systems orders fell from €20.2m to €16.7m, comprising seven systems (including five production machines). This excludes two orders announced in January for a production system in Europe and a research system in the USA, both scheduled for delivery in 2025.

Full-year revenue growth expected in 2025

Given the solid revenue growth, Riber reaffirms its objective of achieving further earnings growth in 2024.

Riber says that, in an environment marked by accelerating technological innovation and growing demand for advanced semiconductor materials, it is pursuing an ambitious growth strategy based on enhancing its technological leadership and expanding its markets through the integration of the silicon photonics sector and the development of high-value-added solutions for quantum materials.

Given the composition of the order book at end-December 2024 as well as the outlook for orders to be delivered this year, Riber is forecasting further growth in revenue in 2025 compared with 2024.

www.riber.com

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AlixLabs collaborates with Linköping University

ALE Pitch Splitting to be extended from silicon to GaN and InN, while Linköping expands from deposition to etching

AlixLabs AB of Lund, Sweden — which was spun off from Lund University in 2019 and has developed the Atomic Layer Etching (ALE) Pitch Splitting technology (APS) — has entered into a research collaboration with Linköping University on gallium nitride (GaN) and indium nitride (InN) deposition and etch, strengthening not only their own respective expertise in RF and power electronics but also aligning with the Swedish semiconductor sector.

"Our goal is to widen our research portfolio beyond deposition to etching, which is AlixLabs' specialty," says Henrik Pedersen, professor in inorganic chemistry at Linköping University. "During our initial research phase, we found that we have the same plasma etch equipment in our university labs as AlixLabs has at its home base in Lund, meaning we can run research in parallel," he adds. "We look forward to exchanging information and know-how, especially in an all-Swedish collaboration."

The resulting research should help to strengthen AlixLabs' offering for RF and power semiconductors, which the European Union (EU) has labeled as critical for its climate goals. The firm is a participant in the GaN-centered, Infineon-led project All2GaN ('Affordable smart GaN IC solutions for greener applications'), which underpins the EU's ambitions to achieve climate neutrality by the year 2050.

"Our goal is to find ways to qualify our processes for use in materials beyond silicon, and we found significant synergies between our labs with regards to GaN and InN," says AlixLabs' CEO & co-founder Jonas Sundqvist.

Beyond leading-edge semiconductors, for which AlixLabs' flagship APS process caters, the power electronics market is expected to grow significantly until the end of the decade, with Yolé Developpement forecasting annual growth in revenue from power GaN devices of over 40% through 2029.

"Our etching processes have found a lot of interest among clients in the power electronics field," notes Sundqvist. "Ideally, our processes will have something to offer all players, no matter which semiconductor material they wish to process."

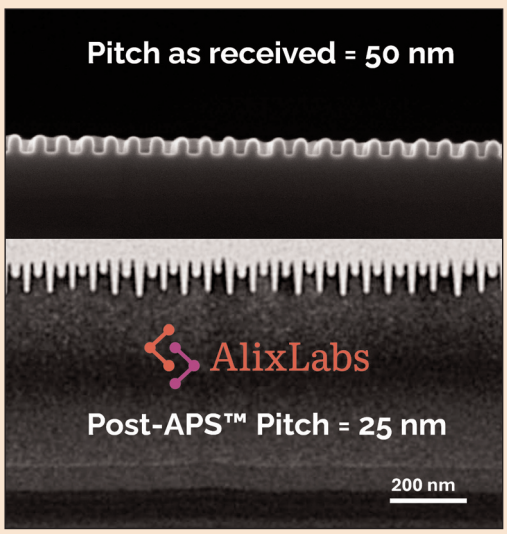
www.all2gan.eu
https://liu.se/en/employee/henpe50
www.alixlabs.com/2023/05/25/alixlabs-an-all2gan-eu-project-participant

AlixLabs showcases latest APS findings at SPIE Advanced Lithography + Patterning

3nm-class FinFET structures made with APS on Intel silicon

AlixLabs says that it has used its Atomic Layer Etching (ALE) Pitch Splitting technology (APS) technology to etch structures corresponding to commercial 3nm semiconductor processes on test silicon provided by Intel. The results were shared in full by chief technology officer & co-founder Dmitry Suyatin at the SPIE Advanced Lithography + Patterning trade show in San Jose, CA, USA (23–27 February).

"APS can help the industry lessen its reliance on multi-patterning solutions… while lowering costs and environmental impact," says Suyatin. "Our tech has been able to produce sub-10nm-class features on silicon, and with the help of Intel's Test Vehicle Program we have proven that sub-5nm-class features are possible on mass-production silicon by just etching."



AlixLabs' APS achieved a 25nm full metal pitch, comparable to 3nm-class technology from the leading foundries, on the Intel Low Global Warming Potential Etch Test Vehicle, representing a milestone on AlixLabs' road to commercialization, with further developments to follow later in 2025.

"APS proves that there's no need for complex multi-patterning like SADP and SAQP to produce 5nm chips and beyond," says Suyatin. "It extends the potential of immersion lithography for use with critical mask layers for even 3nm processes," says CEO & co-founder Jonas Sundqvist. "These results were produced with our alpha tool, with a beta tool to follow later in 2025," he adds. "We wish to thank Intel for providing leading-edge grade test silicon for this demonstration."

www.alixlabs.com

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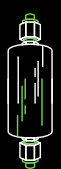
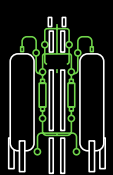
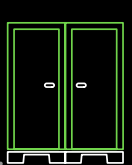


Point-of-Use Purifiers



Frame-Mounted Purifiers



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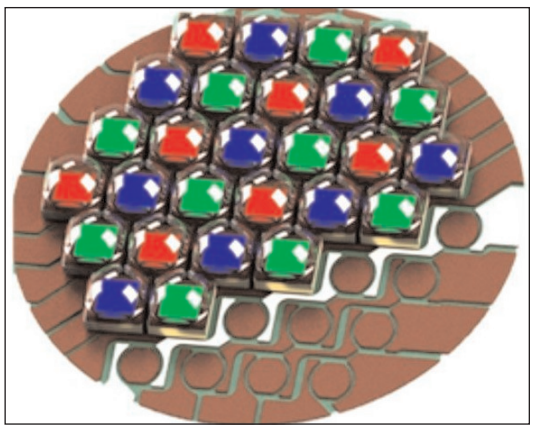
Lumileds' LUXEON C ES enables small, high-output, complex, multi-color arrays

2mm² chip, dome, and small ceramic package with 3-stripe pad enable denser array and better performance from single optic systems

Multi-color LED fixtures based on a large LED cluster under a single optical system are preferred in many situations for their ability to deliver highly accurate illumination with superior beam quality. Until now, however, LED design has not allowed engineers to address the conflicting needs and challenges inherent to close-packed, high-power LEDs. These challenges include maximizing light output, reducing array size, excellent color mixing, delivering efficiency, complex electrical routing, and thermal management. To properly address such issues, Lumileds LLC of San Jose, CA, USA determined that the best approach was to develop the new LUXEON C ES, available now through Lumileds' global distributor network.

"Through our discovery process we determined that the best results would come from a large die in a small package with a dome would yield the best, scalable result," says Benjamin Khoo, Lumiled' color LED product manager. "Key limiting factors to creating a scalable array solution included LED-to-LED spacing and package edge to die edge clearance. Lumileds engineers successfully addressed both with the new LUXEON C ES."



Multi-color arrays under a single lens.

A video review of Lumileds investigation and conclusions regarding large, complex color arrays has been published by the LED Professional Symposium.

As part of the design investigation, Lumileds engineers investigated optimal LED arrangement and electrical footprint. They determined that a 'random' arrangement of the LEDs provides optimal color mixing. Using multiple colors of course requires complex routing of electrical traces, which also needed to be managed, preferably, on a single layer of copper. The 3-stripe footprint proved to be an exceptional fit for this, especially given the very limited space between LEDs.

Extended analysis proved that high driver current and maximum thermal dissipation could be achieved through the design and the use of an isolated thermal pad with copper pedestal PCBs. In this scenario, LUXEON C ES can be driven at current of >2A for maximum output while achieving the necessary thermal management.

Optically, Lumileds' engineers determined that the use of a dome (rather than undomed) was optimal, and that light output could be increased by as much as 40% and flux per thermal Watt could increase by as much as 60%.

www.lumileds.com/products/color-leds/luxeon-ces-colors

Lumileds adds LUXEON HL2X-V LED

Lumen/$ ratios similar to mid-power LEDs reduces need to re-engineer

Lumileds LLC of San Jose, CA, USA says that its new LUXEON HL2X-V is the latest result of its commitment to addressing lighting manufacturing issues. Many manufacturers with high-power LED solutions are considering re-engineering their designs with mid-power LEDs to take advantage of their lumen/$ position. Now, with LUXEON HL2X-V, manufacturers can achieve lm/$ ratios similar to mid-power products without spending valuable resources on redesigning or re-engineering, says the firm.

"This is a double win for lighting manufacturers," says Keen Oun Yap, Lumileds' High Power product manager. "With the improved value position of LUXEON HL2X-V, the critical capital and resources required to re-work an existing and successful luminaire can be applied to creating new solutions and extending their reach in the market."

Because LUXEON HL2X-V is built on the industry-standard 3535 package with a 3-stripe footprint, it delivers improved value to designs regardless of which 3535 high-power LED is currently in the design.

The new parts are available in the full range of correlated color temperatures (CCTs), offer a typical output of 355lm at 700mA and a typical efficacy greater than 180lm/W at 4000K 70CRI (color rendering index).

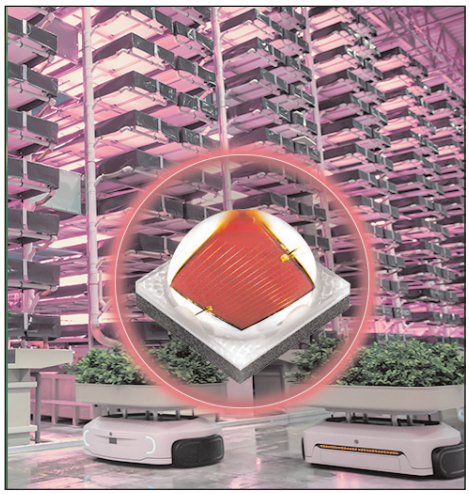
www.lumileds.com/products/high-power-leds/luxeon-hl2x

Cree LED launches XLamp XP-L Photo Red S Line LEDs

High efficiency and durability for horticulture lighting

Cree LED Inc of Durham, NC, USA (a Penguin Solutions brand) has launched XLamp XP-L Photo Red S Line LEDs for horticulture lighting. Designed for next-generation luminaires, the new LEDs deliver what is claimed to be outstanding efficiency and durability:

- **Efficiency** — With a typical wall-plug efficiency (WPE) of 83.5% at 700mA and 25°C, the XP-L Photo Red S Line LED offers a 6% efficiency boost over the XP-G3 Photo Red S Line LEDs. This extra performance can be used to lower Photo Red LED count in luminaires by 35% while still maintaining the same total system efficiency.
- **Durability** — Built with S Line technology, the LEDs feature what is claimed to be outstanding sulfur and corrosion resistance, making them suitable for harsh greenhouse environments.



- **Upgrade path** — Featuring the same 3.45mm x 3.45mm XP footprint as XP-G3 Photo Red S Line LEDs, XP-L Photo Red LEDs ensure an easy upgrade for existing systems.

Cree LED's S Line LEDs are designed for demanding horticulture applications, ensuring:

- system reliability through rigorous switching and dimming cycles;
- long-lasting performance derived from proven outdoor lighting technology;
- reduced maintenance costs and improved return-on-investment for greenhouse operators.

Cree LED notes that it continues to expand its portfolio of XLamp horticulture LEDs, delivering solutions for modern agriculture. From vertical farming to greenhouses, the S Line LEDs promise extended operational lifespans, heightened efficiency and optimized yields, helping growers in any environment, says Cree LED.

Samples of XLamp XP-L Photo Red LEDs are available now and production orders are shipping with standard lead times.

www.cree-led.com/products/leds/xlamp/xp-xt

VueReal raises US$40.5m in Series C funding round

Investment to scale production capabilities and expand ecosystem to support partners integrating micro-LEDs in commercial production

Micro-LED technology firm VueReal Inc of Waterloo, ON, Canada has secured access to US$40.5m in a Series C funding round was led by Export Development Canada (EDC) joined by existing VueReal investors including Cycle Capital, BDC Capital's Cleantech Practice, and TDK Ventures. The investment will enable VueReal to scale its production capabilities and enhance its ecosystem to support partners in achieving their goals of integrating micro-LEDs in commercial production.

VueReal says that the funding positions it to bring micro-LED and other micro semiconductor solutions to market at scale. With its MicroSolid Printing technology, the firm reckons that it has created a path for cost-effective, high-volume micro-LED production while addressing the critical transfer challenge and enabling unprecedented efficiency, scalability, performance and affordability for applications including consumer electronics, automotive and healthcare.

"VueReal has always been committed to delivering and scaling its breakthrough MicroSolid Printing platform to redefine the display and sensing landscape. This latest funding round is a testament to our partners' confidence in our technology and vision," says CEO Dr Reza Chaji. "This new capital infusion will enable us to scale the mass production of micro-LED lighting and displays while empowering our partners to enhance their production capabilities. By expanding the ecosystem, we aim to ensure the seamless integration of MicroSolid Printing technology into production lines worldwide," he adds.

"EDC recognizes VueReal as a pioneer shaping the future of the global micro-LED market," comments Lissa Bjerkelund, VP investments & mid-market lending at EDC. "VueReal's cutting-edge technology and commitment to establishing a world-class production platform are pivotal in unlocking the vast potential of micro-LED and other micro semiconductor innovations across industries," she adds.

"VueReal is transforming the lighting and display industry and creating a scalable, sustainable pathway for advanced manufacturing," comments Andrée-Lise Méthot, founder & managing partner of Cycle Capital. "We value VueReal's ability to drive innovation and commercialize the technology through innovative business plans."

The latest funding follows several recent developments for VueReal, including its partnership with micro-LED suppliers and foundries for cartridge scale-up production and significant patent portfolio growth.

www.vuereal.com

VueReal adds chief commercial officer

VueReal has appointed Robert Selley to the newly created role of chief commercial officer (CCO), overseeing all global sales and business development activities and helping to drive expansion across key industry sectors including lighting, consumer electronics, automotive, AR/VR, and health.

Selley has over 25 years of experience in the semiconductor industry, including driving commercial strategies and fostering innovation. He has held executive leadership positions at global semiconductor companies including Nova Semiconductor, FormFactor, Cascade Microtech, and MKS (Electro Scientific Industries). He has a track record of building high-performing teams, implementing effective processes, and nurturing key customer relationships, resulting in significant revenue and margin growth. VueReal says that Selley is known for his strategic vision and commitment to a customer-first approach, driving customer satisfaction and loyalty.

Selley will lead the sales, marketing and product teams, spearheading growth initiatives, strengthening customer engagement, and expanding market presence.

The appointment follows a series of strategic senior hires, including a VP of semiconductor engineering, a VP of engineering, and a VP of operations. The firm is positioning itself for accelerated growth in the micro-LED display and micro-semiconductor markets.

"His extensive experience and proven leadership in the semiconductor industry align perfectly with our mission to deliver cutting-edge solutions and exceptional service to our clients," comments CEO Reza Chaji.

"With a strong team, groundbreaking innovations, and a clear vision for the future, we have a tremendous opportunity to transform industries and deliver real value to our customers," believes Selley.

"Robert's deep expertise in the semiconductor industry and proven ability to drive commercial growth make him an invaluable addition to VueReal," comments chairman Tim Baxter, former president & CEO of Samsung Electronics NA. "As we scale our MicroSolid Printing platform and expand our global supply chain, his leadership will be instrumental in accelerating adoption and delivering transformative solutions to our customers."

www.vuereal.com

ProPhotonix launches 265nm UVC LED Area Light at Photonics West

Up to 35mW/cm² of uniform light targeted at machine vision, fluorescence detection and disinfection applications

Exaktera group firm ProPhotonix Ltd of Salem, NH, USA, a designer and manufacturer of LED lights and laser diode modules for OEMs and medical equipment companies (as well as a distributor of laser diodes for Ushio, Osram, QSI, Panasonic and Sony), has released its new UVC-Pro Area Light, which was displayedat Photonics West 2025 in San Francisco (25–30 January). Offering up to 35mW/cm^2 of uniform light at 265nm, the solution is suitable for machine vision, fluorescence detection, and disinfection.

The new ProPhotonix UVC-Pro Area Light combines the latest in UVC technology with a scalable form factor built for flexibility. Designed as a UVC LED solution for system designers, the compact yet powerful LED light delivers what is claimed to be exceptional performance in a streamlined form factor.

Operating at 265nm, the UVC-Pro Area Light offers optimized output for critical applications, ensuring high efficiency and consistent results. Its uniform light distribution enables even illumination across surfaces, which is critical for demanding applications.

The advances in UVC LED technology are enhancing existing applications and enabling new inspections. Pharmaceutical and chemical analysis, inspection including defect detection, verification of coatings, adhesives, and other fluorescent markers, quality control, sorting, and packaging verification can all benefit from the new UVC Area Light, says the firm.

By leveraging advanced LED technology, the UVC Area Light eliminates the need for traditional mercury lamps, providing a safer, more environmentally friendly and longer-lasting alternative. The compact design is said to facilitate easy integration into systems, making it a seamless upgrade.

www.spie.org/conferences-and-exhibitions/photonics-west
www.prophotonix.com/led-and-laser-products/led-products/led-area-lights/uvc-pro-area-light/

BluGlass showcases new product capability for quantum applications at Photonics West

Three US patents filed for high-power tunable GaN lasers for quantum, aerospace and biotech applications

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 filed three US patent applications (provisional patents) for next-generation high-power tunable GaN lasers, and published its results in a technical paper presented at SPIE Photonics West 2025 in San Francisco, CA, USA (28–30 January).

The firm says that it has demonstrated novel capabilities and device architectures designed to address key application challenges and enhance power and versatility of visible GaN lasers where power, precision and tunability are required.

It has filed three US provisional patents around its novel high-peak-power continuous wave tunable GaN lasers for use in three critical markets:

- aerospace, marine, and defence applications;
- quantum computing and quantum sensing applications;
- biomedical and biotech applications.

Senior product developer Dr Ryan Anderson is presenting a technical paper 'Advancements in GaN DFBs with embedded gratings and a path to higher power on BluGlass' advanced GaN DFB development and a path to high-power ultra-precision applications'. Ultra-precision, near-single-frequency DFB lasers offer benefits for emerging technologies, delivering precise and stable performance essential for applications such as quantum sensing, navigation, communication, and next-generation defence and aviation. BluGlass' GaN DFBs are being designed for wafer-scale fabrication to reduce downstream optical alignment costs, and address critical challenges in quantum technologies and computing while enabling greater production volume and smaller device sizes.

BluGlass' technical paper highlights the improved performance of its GaN DFB lasers, demonstrating near-single-frequency emission from violet to aquamarine, demonstrating side-mode-suppression ratios of greater than 40dB, and peak full-width-half-maximum linewidths of under 3pm.

The paper also showcases recent breakthrough results, demonstrating narrow-band high-power DFB sources, and initial results of semiconductor optical amplifier (SOA) gain chips. Additionally, it highlights that BluGlass has demonstrated an integrated GaN master oscillator power amplifier (MOPA), which achieved 750mW power in a single spatial mode. The integrated device replaces a single-mode laser with fast- and slow-axis lenses aligned to a semiconductor optical amplifier, increasing power while reducing size and complexity.

"Our leading advances in visible GaN lasers, single-mode, near-single-frequency, MOPA, and photonic integrated solutions are the key first steps in revolutionizing industries, including aerospace, defence, quantum computing, and biomedical applications," says CEO Jim Haden. "BluGlass is extending the bounds of visible laser capabilities, and the addition of DFB wavelengths from violet to aquamarine, world-class suppression of noise, and the integration of a single-mode laser with a power amplifier achieving 750mW of blue light in a single spatial mode are testaments to the incredible innovation pioneered by our world-leading team," he adds.

GaN DFB lasers have unrivalled advantages in cost and scale that will create new opportunities in quantum sensing and quantum computing

"Our growing strategic capability uniquely positions BluGlass to capitalize on the exciting growth markets of quantum sensing, communication, and computing. These advances will enable our customers to solve complex problems such as atmospheric LiDAR detection of clear air turbulence, underwater communications and LiDAR, and GPS spoofing and jamming by creating localized quantum solutions," Haden continues.

"GaN DFB lasers have unrivalled advantages in cost and scale that will create new opportunities in quantum sensing and quantum computing. These advantages, in turn, will enable innovation, enhance safety in commercial and defence aviation, expand biomedical and health technology, autonomous vehicles, drones, and advanced positioning systems."

At Photonics West, BluGlass showcased its DFB and MOPA designs, and improved performance of its Fabry–Perot lasers.

BluGlass' DFB development partner University of California, Santa Barbara (UCSB) is also presenting a paper on the joint GaN DFB laser development, showcasing what are claimed to be world-leading narrow linewidths and their potential applications. The research features joint BluGlass and UCSB performance data and was co-authored by BluGlass' senior laser scientist Ryan Anderson.

www.spie.org/conferences-and-exhibitions/photonics-west
www.bluglass.com.au

BluGlass receives AUS$120,000 order for specialized GaN laser bars

Repeat customer CREOL developing coherent beam combining array

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 received an AUS$120,000 order for semi-custom GaN laser diode bar products from a repeat customer, the College of Optics and Photonics (CREOL) at the University of Central Florida.

The order follows the university's demonstration of significant performance improvements using BluGlass' specialized GaN laser bars in a coherent beam combining (CBC) array. BluGlass says that its semi-custom designs have shown superior coherence and phase locking in high-power blue laser arrays, demonstrating improved performance and precision, compared with commercially available laser bars (ACS Publication, 'Coherence and Phase-Locking in High-power, Broad-Area, Highly Heterogeneous Blue Diode Arrays'). The CBC configuration merges light emitted from an array of broad-linewidth multi-mode lasers into a high-power single-mode, narrow-linewidth coherent beam.

BluGlass says that this coherent beam combining technique allows the customer to produce powerful, high-quality blue laser beams that maintain superior beam quality, phase stability and narrow linewidths — critical for next-generation technologies, including underwater and aviation LiDAR systems that map the seafloor or monitor clear-air turbulence, advanced space research and communications, and ultra-sensitive quantum sensors.

"This repeat order validates the exceptional performance of our custom GaN laser technology, demonstrating our ability to help customers solve critical challenges and pioneer next-generation visible laser applications," says CEO Jim Haden. "High-power coherent GaN lasers can transform defence and dual-use capabilities from secure underwater communications and imaging, and clear-air turbulence monitoring in atmospheric LiDAR, to counter-measures and jamming systems that disrupt enemy optics with high-intensity beams," he adds.

"These performance advantages help position the company for future growth and, building on this success, we will leverage our partnership with this leading university to pursue critical defence applications that require the superior coherence, stability and precision of BluGlass' GaN lasers."

https://pubs.acs.org/doi/10.1021/acsphotonics.4c01062
www.bluglass.com.au

Quantum Science expands into new facility

R&D, product development and now manufacturing centralized at Sci-Tech Daresbury

Quantum Science Ltd of Daresbury, Warrington, UK — which is developing and commercializing INFIQ infrared quantum dot (QD) nanomaterials and technologies for infrared imaging and sensing markets — is expanding into a new manufacturing facility as it prepares for upcoming growth in the short-wave infrared (SWIR) imaging and sensing markets.

The expansion will significantly enhance the firm's ability to meet growing demand from its international customer base, with the market for SWIR imaging and sensing forecast to hit $2.9bn by 2028. The company's INFIQ technology is said to facilitate high-performance SWIR capability at costs up to 1000 times lower than alternative technologies.

"Our expansion into the new manufacturing facility is a clear indication of our rapid growth and increasing market presence," says CEO & founder Dr Hao Pang. "As the demand for SWIR technology grows, we are seeing significant interest in our INFIQ QDs and QD inks – and the new facility will ensure that our supply of industry-leading QD technology keeps pace with our customers' requirements," he adds.

"This addition to our existing facility provides our team with a comprehensive hub for innovation and production, enhancing our production capacity and strengthening our position in the QD technology landscape. By centralizing our R&D, product development, and now advanced manufacturing capabilities at Sci-Tech Daresbury, Quantum Science is proving itself as the leading partner for the growing SWIR technology community."

Scale up and production processes will be moved to the new facility from January, enabling Quantum Science to bolster production of its INFIQ QDs and lead-free QD technology. The new lab is co-located with Quantum Science's existing R&D center and product development lab at Sci-Tech Daresbury and will feature increased storage capacity for consumables and inventory.

www.qscis.com
www.quantumscis.com

TRUMPF and iThera demo VCSEL-based subsystem for optoacoustic medical imaging and sensing

Power-efficient and compact system to replace existing photonic systems for routine clinical use

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for consumer electronics, datacom, industrial sensing and heating markets — and iThera Medical GmbH of Munich, Germany — a spin-off of the Helmholtz Center Munich that provides optoacoustic imaging (OAI) diagnostics for preclinical and clinical research — are introducing a solution for optoacoustic imaging for clinical applications. The VCSEL-based subsystem can replace existing photonic systems for routine clinical use, starting with soft-tissue perfusion and oxygenation measurements, applicable to a wide range of diseases.

"The power-efficient and compact photonic solution of TRUMPF and iThera is scalable and paves the way towards future patch and sensor optoacoustic applications. The VCSEL technology, with its benefits like precision, compact structure, energy efficiency and wide range of wavelengths, is perfect for this application," says Alexander Weigl, head of product management at TRUMPF Photonic Components. "We view the medical technology and life-sciences sector as a growth area for numerous VCSEL wavelengths and applications," he adds.

"Using VCSELs will allow us to cut light-source-related costs, volume and power consumption of our market-leading optoacoustic imaging devices by a factor of 100," says iThera Medical's chief technology officer Patrick Leisching. "Additionally, compared with the currently used tunable solid-state lasers, the VCSEL subsystem results in a downgrade of the laser safety classification from its current Class 4 to Class 1, eliminating the need for special safety measures, and it will provide a substantially improved operating stability," he adds. "These game-changing improvements will facilitate the translation of our technology from research into routine diagnostic use and also enable future sensing applications, making optoacoustic technology widely accessible across different care settings."

The photonic subsystem presented is based on a compact set-up of high-power VCSEL arrays and bare ToF CMOS driver chips. The heat dissipation can be buffered in a small copper block, so the subsystem can be directly mounted within a medical handheld device with no active cooling.

www.trumpf.com/s/VCSEL-solutions

Luminus adds red and blue multi-mode lasers

Portfolio expanded from initial 100mW-class single-mode green and blue lasers launched a year ago

Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — has expanded its laser portfolio with new multi-mode red and blue lasers for laser projection, lighting, illumination, biometric monitoring, and materials processing applications.

The red multi-mode laser achieves 1.2W continuous wave output at 640nm in a TO56 package. Luminus says that its advanced chip technology and electrically neutral case design enable superior thermal stability across diverse applications. The blue multi-mode laser delivers 2W minimum continuous wave output at 450nm, featuring an integrated Zener diode and TO56 package optimized for thermal conductivity and extended lifetime. Primary applications include stage lighting, illumination, and material processing applications like cutting and engraving.

"The launch of an expanded laser portfolio signifies our commitment to enhancing our product span in optoelectronic solutions that meet the evolving needs of our customers," says Chun-Jui Lee, laser business line director. "After introducing ~100mW-class single-mode green and blue lasers last year, Luminus is expanding their offering with high-output-power laser packages, demonstrating continued achievements in fields such as laser epitaxy, chip processing, and laser chip packaging."

Luminus says that the red laser introduction establishes it as one of the few manufacturers offering complete RGB laser light sources, essential for white light reproduction. The lasers are said to deliver excellent wall-plug efficiency, benefiting battery-powered systems while making laser light sources accessible across consumer, medical, life sciences, and industrial markets.

Luminus plans to expand its laser portfolio with additional wavelengths and advanced packaging solutions.

www.luminus.com

NUBURU agrees strategic transaction with private equity investment group

Acquisitions aim to expand defense business and enter security sector

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — has announced its entry into a commitment letter aimed at expanding its existing defense business and establishing a new presence in the security sector.

The strategic transaction with a private equity investment group signifies a transformation that is expected to include recapitalization, multiple acquisitions, licensing of advanced technologies, and the introduction of a management team with expertise relevant to these new ventures. The initiative will be led by executive chairman Alessandro Zamboni, who emphasizes a commitment to harnessing international investments to advance into both existing and emerging markets.

Through this first acquisition, NUBURU plans to develop a new hub focused on defense and security solutions and will embark on acquiring interests in additional technology companies that align with its strategic vision. This should enable NUBURU to expand its current expertise to generate potential synergies with the new ventures.

Pursuant to the terms of the commitment letter, NUBURU would acquire:

- a license of certain technology that would allow it to expand its existing business within the defense sector,
- a controlling ownership interest in a defense-tech company that specializes in the design, production and outfitting of a diverse range of vehicles, including industrial and military applications, as well as electronic devices for defense and security, advanced telecommunications, and tracking systems, and
- a controlling interest in a Software as Service (SaaS) startup focused on operational resilience (which includes business continuity, ICT risk management and cyber-security), offering significant potential synergies within the new hub.

The anticipated acquisitions will occur in two stages, with the first stage involving the acquisition of a license and purchase of a 20% ownership interest for an aggregate price of $1.5m in cash alongside $23.5m in five-year notes bearing a 10% interest rate. The second stage, requiring stockholder approval, involves the acquisition of additional ownership interests, resulting in NUBURU holding a controlling interest in the target entities, which would involve issuing more than 20% of the company's outstanding common stock as part of the purchase price.

The defense market is projected to expand at a compound annual growth rate (CAGR) of 7.3% from $491.06bn in 2024 to $527.06bn in 2025. Similarly, the cybersecurity market is set to grow at a CAGR of 10% from $243.15bn in 2024 to $267.51bn in 2025. According to The Business Research Company, these trends are driven by an increase in cyber threats, military modernization efforts, and growing demand for advanced military technologies.

"This transformative acquisition not only amplifies our technological capabilities but also positions NUBURU in the defense sector and the operational resilience emerging market needs," says Zamboni. "We are committed to leveraging our expertise and resources to drive innovation and provide cutting-edge solutions that meet the evolving needs of all the major critical industries."

www.nuburu.net

Celestial AI appoints Lip-Bu Tan to board

Entrepreneur and venture capitalist to help drive adoption of Photonic Fabric platform in next-gen data-center infrastructure

Celestial AI of Santa Clara, CA, USA, creator of the Photonic Fabric optical interconnect technology platform for AI computing systems, has appointed Lip-Bu Tan to its board of directors.

With more than 40 years of deep-tech expertise as well as extensive board experience, Lip-Bu Tan is an entrepreneur and venture capitalist with a track record of identifying and scaling transformative technologies. As the founder and chairman of global venture capital firm Walden International as well as a founding managing partner of Celesta Capital and Walden Catalyst Ventures, Tan has been helped to drive advances across semiconductor design, electronic design automation and AI-driven solutions.

Tan currently serves on the boards of leading companies including Schneider Electric SE and Credo Technology Group Holding Ltd. He also serves on the board of trustees and School of Engineering Dean's Council at Carnegie Mellon University and the School of Engineering Dean's Advisory Council at MIT, UC Berkeley School of Engineering and School of Computing, Data Science and Society Advisory Boards. Tan previously served as a director of Intel Corp, Softbank Group and Hewlett Packard Enterprises. He was also the former CEO and executive chairman of Cadence Design Systems from 2009 to 2023.

"With his exceptional track record in scaling technology companies and deep knowledge of the semiconductor and AI ecosystems, Lip-Bu's insights will be instrumental as we drive the growth of our Photonic Fabric platform and revolutionize next-generation data-center infrastructure for accelerated computing," believes Celestial AI's CEO Dave Lazovsky.

Tan's accolades for his contributions to technology and entrepreneurship include the Global Semiconductor Alliance's Dr Morris Chang Exemplary Leadership Award as well as the Semiconductor Industry Association's highest honor, the Robert N. Noyce Award. Celestial AI believes that Tan's insights and guidance as a director will be invaluable as it continues to accelerate innovation and deliver industry-first solutions.

"The transformative potential of Celestial AI's Photonic Fabric for AI computing, networking and memory solutions stands to be as significant as the impact OpenAI's GPT has had on AI models," reckons Lip-Bu Tan. "The Photonic Fabric technology platform introduces a revolutionary suite of architectural tools for optical interconnectivity that extend from AI accelerator and GPU packages to hyperscale AI clusters."

www.celestial.ai

OIF unites 35 members in interoperability demos at OFC

The Optical Internetworking Forum (OIF) says that, at the Optical Fiber Communication Conference & Exposition (OFC 2025) in San Francisco, CA, USA (30 March–3 April), 35 member companies are uniting to demonstrate advancements in interoperability tailored to addressing the growing demands of future-oriented data centers, AI/ML technologies and disaggregated systems.

Exhibiting in booth #5745, OIF's live interoperability showcase features key developments across technologies, including:

- 800ZR, 400ZR, OpenZR+ and Multi-Span Optics — Enhancing multi-vendor interoperability in high-capacity, long-distance optical networks.
- Energy Efficient Interfaces (EEI) and Co-Packaging — Driving sustainability and energy efficiency in data-center interconnects.
- Common Electrical I/O (CEI) CEI-448G, CEI-224G and CEI-112G — Advancing electrical interfaces for next-generation systems.
- Common Management Interface Specification (CMIS) — Standardizing management of optical and electrical devices to simplify scalability.

Interoperability in these technologies is shaping the next decade of network specifications and laying the foundation for hyperscalers to scale AI networks seamlessly across interconnected data centers, says OIF.

"OIF is focused on driving innovation and collaboration to meet the demands of hyperscalers and other stakeholders in the rapidly evolving data-center ecosystem," says Alphawave Semi's Mike Klempa, OIF board and Physical & Link Layer Interoperability Working Group chair. "Our members' commitment to advancing interoperability is paving the way for seamless scaling of AI networks and robust data-center interconnects."

OIF members participating in the OFC 2025 demo include Accelight Technologies Inc, Adtran, Alphawave Semi, Anritsu, AOI, Astera Labs, Cadence Design Systems Inc, CICT/Accelink, Ciena, Cisco, Coherent Corp, Eoptolink Technology, EXFO, HGGenuine, Hisense, Infinera, Juniper Networks, Keysight Technologies, Lessengers, MACOM Technology Solutions, Marvell Semiconductor Inc, Molex, MultiLane, Nubis Communications Inc, O-Net Technologies, Precision Optical Technologies Inc, Samtec, Semtech, Senko Advanced Components, Sumitomo Electric Industries, Synopsys Inc, TE Connectivity, Terahop US (PTE Ltd), US Conec and Wilder Technologies.

www.oiforum.com

Sivers signs MOU with optical infrastructure firm for high-volume production of laser arrays

$4.3m program to focus on production qualification, high-volume manufacturing readiness and pre-production units for system testing and field trials

Sivers Semiconductors AB of Kista, Sweden (which supplies RF beamformer ICs for SATCOMs and photonic lasers for AI data centers) has signed a strategic memorandum of understanding (MOU) with an optical infrastructure firm for large-scale AI workloads for the volume production of high-performance laser arrays.

The $4.3m program focuses on production qualification, high-volume manufacturing readiness and pre-production units for system testing and field trials.

With hyperscalers and next-generation data centers struggling with power constraints, bandwidth limitations and rising operational costs, the shift from copper to optical I/O interconnects has become critical, notes Sivers. Optical solutions offer the necessary bandwidth, efficiency and scalability to meet the growing demands of modern AI workloads and data-intensive applications, the firm adds.

This latest MOU represents a significant milestone for our company, and we are fully committed to ensuring the timely availability of our laser arrays for high-volume production deployments

"Our high-performance laser arrays are essential to accelerating the adoption of optical interconnects in AI data centers," says CEO Vickram Vathulya. "This latest MOU represents a significant milestone for our company, and we are fully committed to ensuring the timely availability of our laser arrays for high-volume production deployments."

www.sivers-semiconductors.com

Alexander McCann appointed as strategic senior advisor

Primary focus is to strengthen and scale photonics operations

Sivers Semiconductors AB of Kista, Sweden (which supplies RF beamformer ICs for SATCOMs and photonic lasers for AI data centers) has appointed Alexander McCann as a strategic senior advisor to the board and the CEO. His primary focus will be strengthening and scaling photonics operations.

McCann joins Sivers with more than 25 years of executive leadership experience in the semiconductor industry. He has played a key role in driving global operations and supply chain strategies for leading semiconductor companies including Linear Technology Corp, Analog Devices Inc and Dialog Semiconductor Ltd.

"His deep expertise in operations and supply chain management, along with his extensive industry network, are invaluable at this stage for our company," believes CEO Vickram Vathulya. "Alex has a proven track record of crafting and deploying operations strategies with successful outcomes, and we look forward to leverage his leadership towards our continued expansion and success in the photonics market."

Alexander McCann.

McCann was formerly the senior VP of global operations at Dialog Semiconductor, where he oversaw global operations and supply chain management. During his tenure, he was part of the executive team that executed Dialog's $6bn sale to Renesas Electronics in 2021.

Prior to joining Dialog, McCann served as VP of global operations at Analog Devices, where he led all operational functions including global multi-site manufacturing, engineering, facilities, customer service, supply chain functions and engineering support. Before joining Analog Devices, McCann also was chief operating officer at Linear Technology Corp for more than a decade, during which he helped to execute a $14bn sale to Analog Devices in 2017.

"Sivers has a very credible strategic plan and is at the forefront of innovation in photonics," comments McCann. "I look forward to working with Vickram and the team, applying my experience in operations and supply chain management to help scale the business and capitalize on the expanding market opportunities."

McCann holds a Master of Business Administration (with Distinction) from the University of Glasgow Business School. In addition to his new role with Sivers Semiconductors, he serves as president of Fortan Advisors and is a Semiconductor Partner at Alexa Capital. He also sits on the boards of LUMEOVA and Probe Test Solutions Ltd (PTSL).

ST launches SiPho and next-gen BiCMOS technologies for higher-performing cloud optical interconnect in data centers and AI clusters

Ramp up from second-half 2025 to address 800Gb/s and 1.6Tb/s optical modules

With the exponential growth of AI computing needs, challenges arise in performance and energy efficiency across computing, memory, power supply and interconnections linking them. STMicroelectronics of Geneva, Switzerland says that it is helping hyperscalers, and the leading optical module provider, to overcome these challenges by unveiling its next generation of proprietary technologies for higher-performing optical interconnect in data centers and AI clusters. Its new silicon photonics and next-gen BiCMOS technologies are scheduled to ramp up from second-half 2025 for 800Gb/s and 1.6Tb/s optical modules.

Inside a data center's transceivers, ST's new, proprietary silicon photonics (SiPho) technology will bring users the ability to integrate multiple complex components into one single chip, while ST's next-gen proprietary BiCMOS technology brings ultra high-speed and low-power optical connectivity, which are key to sustain the AI growth.

"AI demand is accelerating the adoption of high-speed communication technology within the data-center ecosystem. This is the right time for ST to introduce new power-efficient silicon photonics technology and complementing it with a new generation of BiCMOS for our customers to design the next wave of optical interconnect products, which will enable 800Gbps/1.6Tbps solutions for the hyperscalers," says Remi El-Ouazzane, president of ST's Microcontrollers, Digital ICs and RF products Group. "Both technologies will be manufactured on 300mm processes in Europe, bringing customers an independent high-volume supply for two key components of their optical module development strategy. Today's announcement represents the first step for our PIC [photonic integrated circuit] product-family and, thanks to close collaboration with key partners across the entire value chain, our ambition is to become a key supplier of silicon photonics and BiCMOS wafers for the data-center and AI cluster market, be it pluggable optics today or optical I/O tomorrow," he adds.

STMicroelectronics' fab in Crolles, France.

"AWS is pleased to collaborate with STMicroelectronics to develop a new silicon photonics technology, PIC100, that will enable interconnection between any workload including artificial intelligence," says Nafea Bshara, VP & distinguished engineer at Amazon Web Services. "AWS is working with STMicroelectronics based on their demonstrated capability to make PIC100 a leading SiPho technology for the optical and AI market. We are enthusiastic about the potential innovations this will unlock for SiPho," he adds.

Both technologies will be manufactured on 300mm processes in Europe, bringing customers an independent high-volume supply for two key components of their optical module development strategy.

"The pluggable optics for data center market is experiencing significant growth, valued at $7bn in 2024," notes Dr Vladimir Kozlov, CEO & chief analyst at LightCounting. "This market is expected to grow at a compound annual growth rate (CAGR) of 23% during 2025–2030 to exceed $24bn at the end of this period," he adds. "Market share of transceivers based on silicon photonics modulators will increase from 30% in 2024 to 60% by 2030."

ST's SiPho technology combined with the ST BiCMOS technology comprise a unique 300mm silicon platform to serve the optical market. Both technologies are being industrialized and will be manufactured in ST's Crolles (France/Europe) 300mm fab.

www.st.com/content/st_com/en/about/innovation---technology/silicon-photonics.html

Infinera's acquisition by Nokia expected to complete on or about 28 February

Infinera Corp of San Jose, CA, USA — a vertically integrated manufacturer of open optical networking systems and optical semiconductors — says that its pending acquisition by Nokia Corp should be completed on or about 28 February, subject to receipt of remaining outstanding regulatory approvals and the satisfaction of other remaining customary closing conditions.

Infinera hence also says that the deadline to revoke a previously made election with respect to the form of merger consideration to be received in the transaction is 5pm New York City time, on 21 February. In the event that the anticipated completion date is delayed, Infinera will communicate an updated election revocation deadline.

Holders of shares of Infinera's common stock who have made a valid election with respect to the form of merger consideration to be received in the transaction and who wish to sell or otherwise transfer such shares may revoke their election prior to and in connection with selling or transferring such shares. No revocations will be accepted or effected after the election revocation deadline.

A holder of shares of Infinera's common stock that are the subject of an election that has not been properly and timely revoked will no longer be able to sell or transfer such shares following the election revocation deadline, and the holder will be entitled to receive the applicable merger consideration with respect to such shares upon completion of the transaction.

Infinera stockholders of record may, at any time prior to the election revocation deadline, revoke a previously made election prior to and in connection with selling or transferring their shares by delivery of a notice of withdrawal to the exchange agent Computershare Trust Company N.A. at the applicable address.

A revocation will be valid only if a properly completed and signed Notice of Withdrawal is received by the exchange agent by the election revocation deadline.

Infinera stockholders who hold shares through a bank, broker or other nominee may be subject to an earlier deadline for revoking elections, and should contact their bank, broker or other nominee for assistance revoking an election in connection with selling or transferring such shares.

If an Infinera stockholder validly revokes a previously made election prior to the election revocation deadline (or any earlier deadline applicable to the stockholder), that stockholder will be deemed to have elected to have those shares converted into the right to receive $6.65 per share in cash, without interest.

The aggregate merger consideration payable by Nokia is subject to proration as described in the proxy statement/prospectus filed with the US Securities and Exchange Commission by Infinera and Nokia in connection with the transaction. Infinera and Nokia intend only to announce the results of stockholder elections and required proration, if any, in connection with the closing of the transaction.

Infinera stockholders of record who wish to request election revocation materials, including a Notice of Withdrawal, should contact Sodali & Co at (800) 662-5200 (for registered holders of Infinera common stock) or (203) 658-9400 (for banks and brokers), or by email at INFN@investor.sodali.com. Infinera stockholders who hold shares through a bank, broker or other nominee should contact their bank, broker or other nominee for assistance revoking an election.

www.infinera.com

POET engaged by global financial services firm to develop custom optical engine

POET Technologies Inc of Toronto, Ontario, Canada — designer and developer of the POET Optical Interposer, photonic integrated circuits (PICs) and light sources for the data-center, telecom and artificial intelligence (AI) markets — has signed an agreement to develop a novel optical engine for use in a high-frequency securities trading operation for a global capital markets firm. High-frequency trading (HFT) is a type of automated trading that uses powerful computers to execute a large number of trades in fractions of a second.

The multi-phase project is said to be a pioneering effort to increase the speed and decrease the latency inherent in existing transceiver solutions utilized by securities trading operations. The first phase begins immediately, with POET designing prototypes of Optical Interposer-based transceiver engines built to meet the customer's specification. Subsequent phases include building additional prototypes and, if successful, production optical engines customized for this application.

"This project generates revenue for POET this year and demonstrates the versatility of the POET Optical Interposer and the entry into a new, related market space by the company," notes POET's chief revenue officer Raju Kankipati.

www.poet-technologies.com

Lumentum appoints Michael Hurlston as president & CEO as Alan Lowe retires

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for cloud/AI, networking and industrial and consumer laser applications) has appointed Michael Hurlston as president & CEO and director, effective 7 February. He succeeds Alan Lowe, who has served as president & CEO since 2015 and will continue to serve on the board of directors and as an advisor.

Hurlston has over 30 years of senior leadership experience within the industry. He joins Lumentum from Synaptics Inc, a pioneer of human interface hardware and software, where he was president & CEO and a member of its board of directors since joining the company in August 2019. From January 2018 to August 2019, he was CEO and a member of the board of optical communications firm Finisar Corp, where he oversaw its acquisition by II-VI Inc. He also served as executive VP, worldwide sales and in a variety of management roles at Broadcom Ltd during his 17 years with the firm and its predecessor corporation (from November 2001 through October 2017) across sales, marketing and general management functions, including serving as senior VP & general manager of the Mobile Connectivity Products/ Wireless Communications and Connectivity Division. Previously, Hurlston held senior marketing and engineering positions at Oren Semiconductor Inc, Avasem, Integrated Circuit Systems, Micro Power Systems, Exar and IC Works from 1991 to 2001.

Hurlston has served as a member of the board of directors and the Audit Committee of Flextronics International Ltd. since September 2020. From August 2016 to August 2021, he was a member of the board of directors and the Compensation, Audit and Nominating and Governance Committees of Ubiquiti Networks Inc. He sits on the board of executive trustees of the UC Davis Foundation, the Dean's Executive Committee for the College of Engineering and the Dean's Advisory Counsel for the Graduate School of Management at the University of California, Davis. Hurlston holds Bachelor of Science and Master of Science degrees in Electrical Engineering and a Master of Business Administration from the University of California, Davis.

"He will help us continue and grow our current strong momentum in our cloud/AI data-center strategy and build upon our success in the networking and industrial markets – contributing to an accelerated multi-year growth trajectory," believes Penny Herscher, chair of Lumentum's board of directors. "Michael's global experience, with his combined background in semiconductors and the optical communications industry, and his proven ability to lead through sustained periods of profitable growth, makes him uniquely qualified to lead our company in this specialized segment of the industry, and will enable Lumentum to capitalize on the rapidly evolving global photonics opportunity," she adds.

Lowe has "driven strong execution against our long-term growth strategy and positioned us well within the cloud and AI photonics market," Herscher continues. "He will continue to serve Lumentum as a director to effect a smooth transition, and look forward to continuing to benefit from his expertise and insights."

"Leading the talented Lumentum team for the past 18 years — first at our predecessor company and then over the last decade as a standalone public company — has been both a privilege and a joy," comments Lowe. "In that time, our business has undergone tremendous transformation and growth in both existing and new markets. We have intensely focused on serving our customers, invested in market-leading innovation, and entered new markets, and are now on a clear growth trajectory," he adds.

"The company's highly differentiated portfolio of foundational photonic technologies and strategically located manufacturing capabilities coupled with positive demand trends point to the significant opportunities ahead," says Hurlston.

www.lumentum.com

First Solar declares final sale amount of 2024 Section 45X Advanced Manufacturing Production tax credits

Firm to receive gross cash proceeds of about $819m

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has announced the final amount for the sale (announced on 11 December) of Section 45X Advanced Manufacturing Production tax credits generated by the production and sale of solar modules in the USA in 2024 by its operational manufacturing footprint in the USA, including three factories in Ohio and a new Alabama facility.

The transaction for the sale of $857m of tax credits was the result of two separate tax credit transfer agreements announced in December, under which a third party agreed to pay First Solar $0.955 per $1.00 of tax credits. The agreements covered a fixed transaction of $645m of tax credits, paid for in two parts on 6 December and 30 December, and a variable transaction of $212m in additional tax credits, the sale of which is expected to be completed by 28 February. Upon completion of the transaction, First Solar expects to receive gross cash proceeds of about $819m.

"This is a case of the Section 45X tax credits working exactly as they were intended, creating and retaining billions in economic value in our country and supporting tens of thousands of American jobs," says CEO Mark Widmar. "The value of the tax credits is directly tied to the volume of solar panels produced at our facilities in Ohio and Alabama for deployment in power generation projects across America, the highest volume we've produced in the US since we began manufacturing in 2002," he adds.

"This transaction strengthens our balance sheet even as we continue to invest in our US manufacturing capacity and research and development infrastructure, which are crucial to our growth," notes chief financial officer Alex Bradley. "As it relates to the 2024 financial year, we expect a pre-tax impact to earnings of approximately $39m and a post-tax impact to earnings of approximately $45m. This is expected to reduce our diluted earnings by approximately $0.42 per share for the year."

Having manufactured in the USA since 2002, First Solar is the country's leading PV solar technology and manufacturing company and the only one of the world's largest solar manufacturers headquartered in the USA. Already the largest solar manufacturer in the Western Hemisphere, the firm is on track to achieve 14GW of annual domestic energy technology manufacturing capacity in 2026, by which time it is expected to support over 30,000 direct, indirect, and induced jobs across the country, representing almost $2.8bn in labor income, according to a study commissioned by First Solar and conducted by the University of Louisiana at Lafayette. Each of its factories has over 800 staff, with an average manufacturing salary of $80,000 annually.

www.firstsolar.com

Near-room temperature 8µm interband cascade lasers

Researchers believe that room temperature operation is within reach.

Researchers based in China and the USA have reported the highest operation temperatures so far for interband cascade lasers (ICLs) emitting at wavelengths around 8µm [Yuzhe Lin et al, Optics Express, v32, p46439, 2024].

The team, from the Institute of Semiconductors and Nanjing University in China and University of Oklahoma in the USA, sees advantages of ICLs over quantum cascade lasers (QCLs) for many applications.

"The output powers of ICLs are lower with smaller currents and reduced voltages than what can be achieved in QCLs. However, several milliwatts of output power are sufficient for many sensing applications and lower power consumption is a more important figure of merit. Hence, in such scenarios, ICLs with a low threshold current and reduced voltage would be more desirable."

The reported devices continued operating in pulse mode up to around 280K, around 20 degrees short of typical room temperatures of around 300K (27°C), and more than 50K higher than previous reports.

The researchers comment: "Considering that the attained operating temperature is already close to RT, with additional effort in optimizing design parameters, RT operation of ICLs should be achievable in the wavelength region near 8µm."

The ICL structures were grown by molecular beam epitaxy on n-type indium arsenide (InAs) wafers with 18 gain stages (Figure 1). Two wafers were prepared, F and G, with slightly different layer thicknesses. Wafer F had layers with aluminium antimonide (AlSb)/InAs/gallium indium antimonide ($Ga_{0.65}In_{0.35}Sb$)/InAs/AlSb in a thickness sequence 23/31.5/28/28.5/12Å. In wafer G the InAs/GaInSb/InAs section was changed in thickness to 32.5/26/29.5Å, aiming at a longer emission wavelength.

The gain stages were placed within a waveguide structure consisting on each side of inner 0.73µm InAs separated-confinement layers (SCLs), intermediate 1.5µm InAs/AlSb superlattices (Sls), and n+-InAs outer cladding. The SL cladding was also doped at two levels with a view to reducing losses associated with free-carrier absorption (FCA). Such a hybrid cladding waveguide structure has been widely used to enhanced the performance of ICLs over a range of wavelengths.

The materials were fabricated into 2mm-long broad-area lasers of 100µm and 150µm widths, using wet etching. The devices were mounted on copper heatsinks epi-side up, fastened with indium solder.

One 100µmx2mm device from wafer F continued lasing up to 280.4K with a 7.7µm emission wavelength

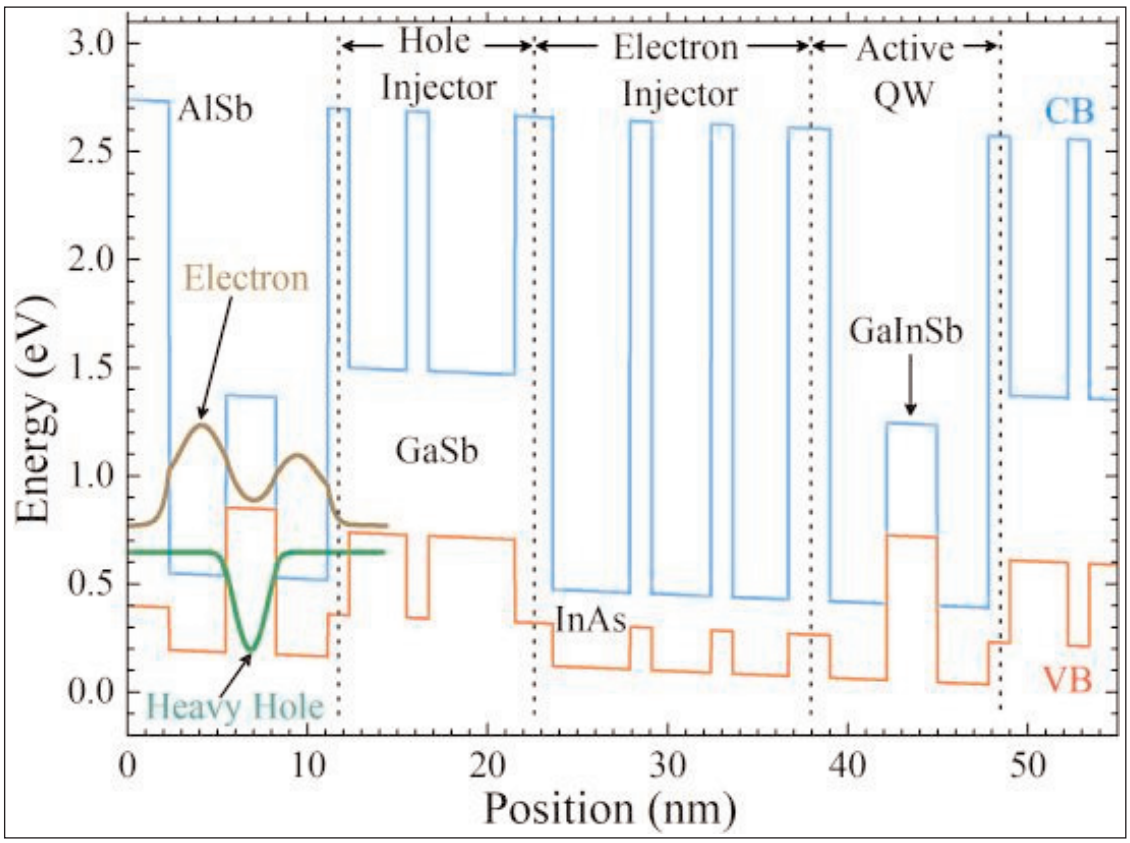


Figure 1. Schematic band diagram of one cascade stage and layer sequence under an applied electric field of 70kV/cm.

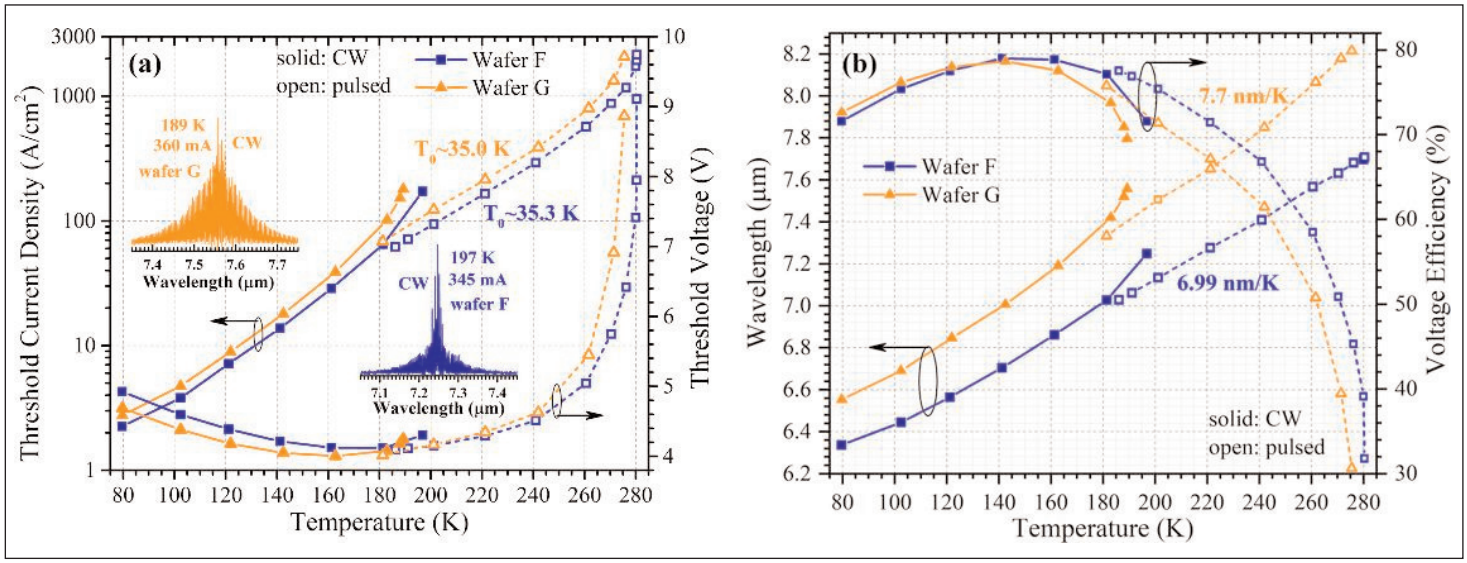


Figure 2. (a) Threshold current density and threshold voltage versus temperature, and insets continuous wave (CW) emission spectra; and (b) lasing wavelength and voltage efficiency versus temperature for 100μm-wide F/G devices.

(Figure 2). The lasing threshold current density was 2150A/cm2. The current was pulsed at 5kHz with 500ns duration (the pulse width was increased to 1μs for temperatures below 270K). A similar device from wafer G lased up to 275.5K with 2070A/cm^2 threshold. The wavelength was 8.22μm.

At 80K, the wafer F device achieved a 2.25A/cm^2 threshold, and the wavelength was 6.34μm. The G device threshold was 2.75A/cm^2 with 6.55μm emission wavelength.

The researchers comment: "Such low threshold current densities at 80K imply very high quality of the grown materials with notable low Shockley–Read–Hall recombination." The maximum voltage efficiency reached 79% at 140K (CW) in both devices, "the highest among semiconductor lasers at these long wavelengths," the team adds.

The slope efficiency at 78K was 500mW/A/facet (Figure 3), which gives an external quantum efficiency (EQE) of more than 500%. In ICLs, each electron flowing through the device can emit multiple photons, allowing EQEs above 100%.

The researchers also used simulations as a guide towards potential enhancements in future work. A particular concern was FCA and plasmonic effects. The FCA loss could be reduced with lower doping levels.

The team is also concerned that there could be "substantial absorption loss due to intervalence-subband-transitions". Researchers based in Austria and Germany have shown that this effect can be ameliorated with valence-band engineering, which the team also plans to explore. ■

https://doi.org/10.1364/OE.546307

Author: Mike Cooke

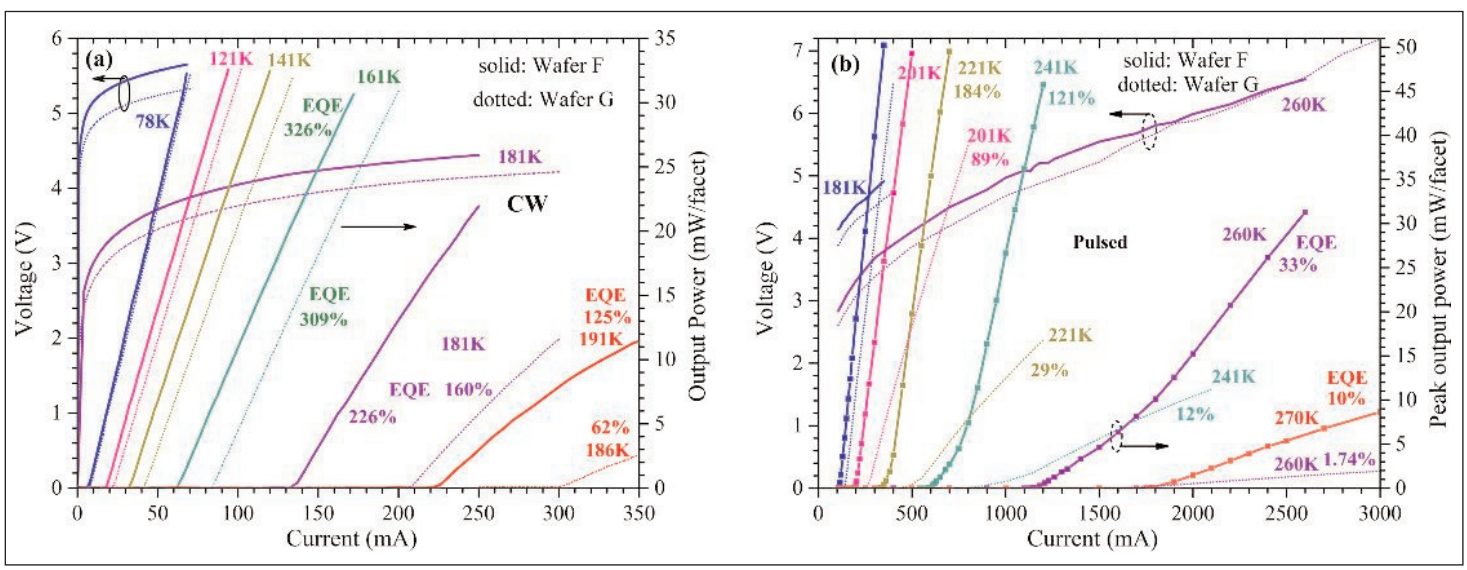


Figure 3. (a) CW and (b) pulsed current–voltage–light output power characteristics of 100μm-wide devices from wafers F and G at various temperatures.

Red InGaN LEDs on scandium aluminium magnesium

An alternative substrate could enable future development of full-color displays.

Researchers at Saudi Arabia's King Abdullah University of Science and Technology (KAUST) and Japan's Aichi Institute of Technology claim the first demonstration of fully indium gallium nitride (InGaN) red light-emitting diodes (LEDs) on a scandium aluminium magnesium, $ScAlMgO_4$ (SAM), substrate [Mohammed A. Najmi et al Appl. Phys. Express, v17, p111001, 2024].

The researchers comment: "The material quality is currently far from that of state-of-the-art red LEDs grown on GaN/sapphire and GaN/Si, and therefore the device performance shows a significant disparity. However, the InGaN/SAM configuration has the potential to improve the material quality due to the lattice matching. Improvement of the material quality, and the interface between the InGaN and SAM substrates, could significantly enhance the efficiency of the red LEDs."

The lattice-matched composition to SAM is $In_{0.17}Ga_{0.83}N$. Red InGaN LEDs are being developed in particular for combination with green and blue InGaN devices in full-color display deployments. The advantage would be simpler processing compared with mixing devices from other III–V compound semiconductor families, such as indium gallium arsenide phosphide (InGaAsP).

The team explains: "The requirements of display systems necessitate integrating these three primary colors of light emitters into one pixel. RGB emitters can all be realized through alloying III–nitrides (GaN, InN) due to their bandgap versatility. This advantageous characteristic makes III–nitrides particularly suitable for display applications. Despite the theoretical possibility of color tunability, achieving efficient InGaN-based longer-wavelength LEDs/LDs remains an unresolved research problem within the III–nitrides community."

The LED's epitaxial structure was grown by metal-organic vapor phase epitaxy (MOVPE) on c-plane SAM substrate (Figure 1). The buffer layer, designed to give a Ga-polar structure, was grown at low temperature (LT). The team reports that a Ga-polar structure reduces residual electron concentrations, "and enables us to realize an effective p-type InGaN layer."

Hall measurements on the sample gave a p-type conductivity with an effective $8x10^{17}/cm^3$ hole concentration and $0.7cm^2/V\text{-}s$ mobility. The resistivity was 11Ω-cm.

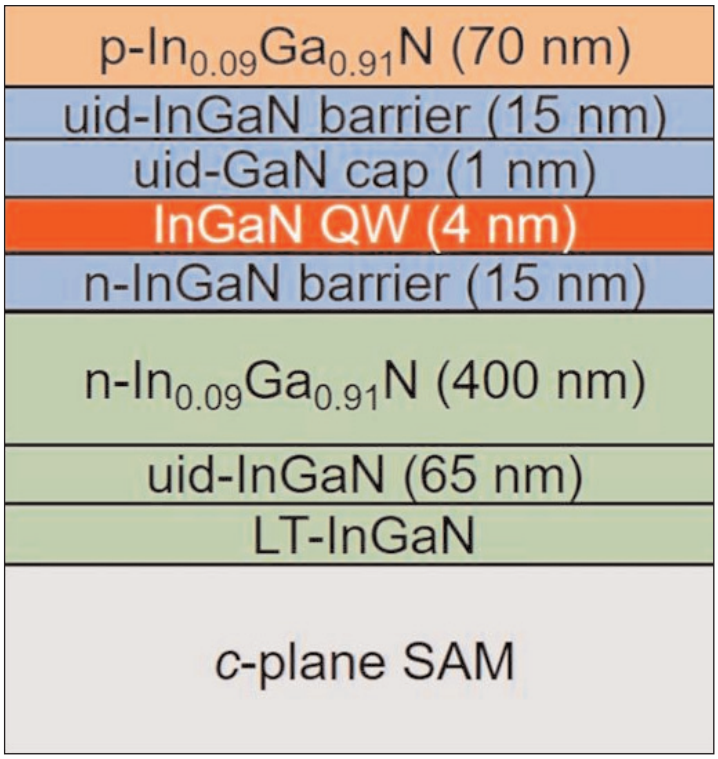


Figure 1. Schematic view of LED structure.

The researchers comment: "The (0002) and (10$\bar{1}$2) x-ray rocking curve values of the Si-doped $In_{0.09}Ga_{0.91}N$ layer were 1354arcsec and 2452arcsec, respectively." Although molecular beam epitaxy can achieve narrower x-ray peaks for InGaN/SAM, MOVPE typically renders material with 2500–3000arcsec full-widths at half maximum (FWHMs) for the (0002) peak. The team has previously achieved N-polar InGaN/SAM material with 940arcsec and 1960arcsec FWHMs, respectively, for the (0002) and (10$\bar{1}$2) peaks. Unfortunately, this material had a high ~10^{19} electron concentration and a rough surface.

The researchers found a high V-pit density, suggesting a high threading dislocation density. The team comments: "The high density of dislocations can be attributed to the presence of the LT-buffer layers. The underlying layers consist of a Si-doped n-InGaN layer with an LT-buffer InGaN. The material quality of the LT-buffer layers is expected to be inferior to the directly grown InGaN on SAM due to the amorphous phase resulting from LT growth."

Also, the researchers suggest that the relatively low growth temperature of the device layers (825°C) was not sufficient to recrystallize the material grown on top

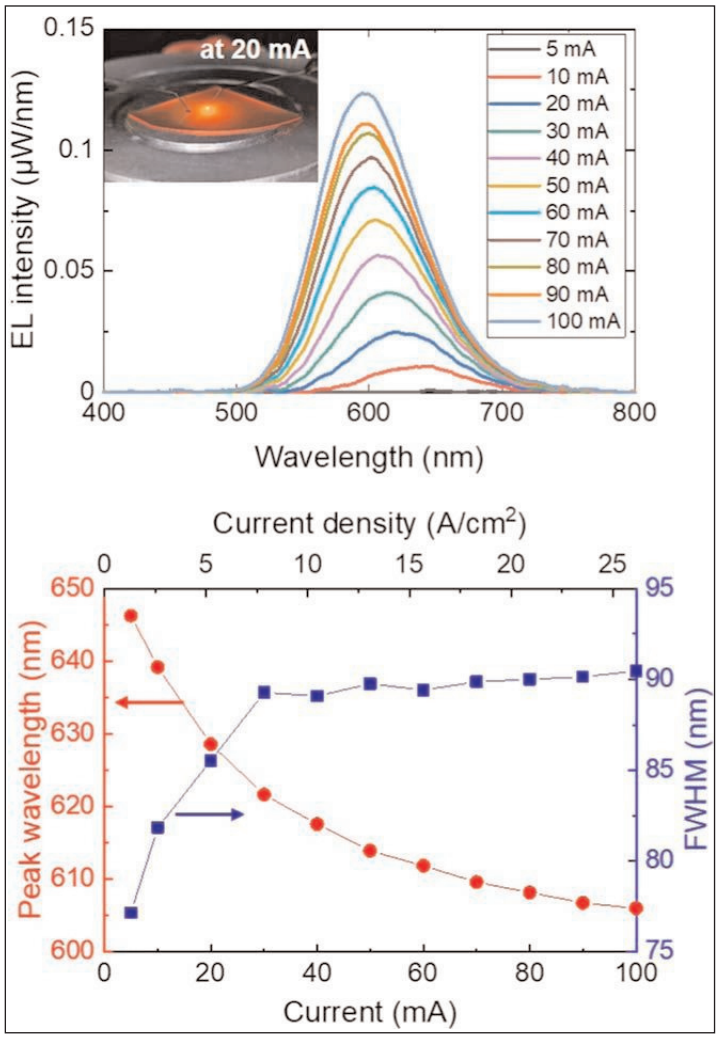


Figure 2. (a) Red LED electroluminescence (EL) spectra with different current injections at room temperature. Inset: photograph of EL at 20mA. (b) Peak wavelengths and FWHMs versus current injections.

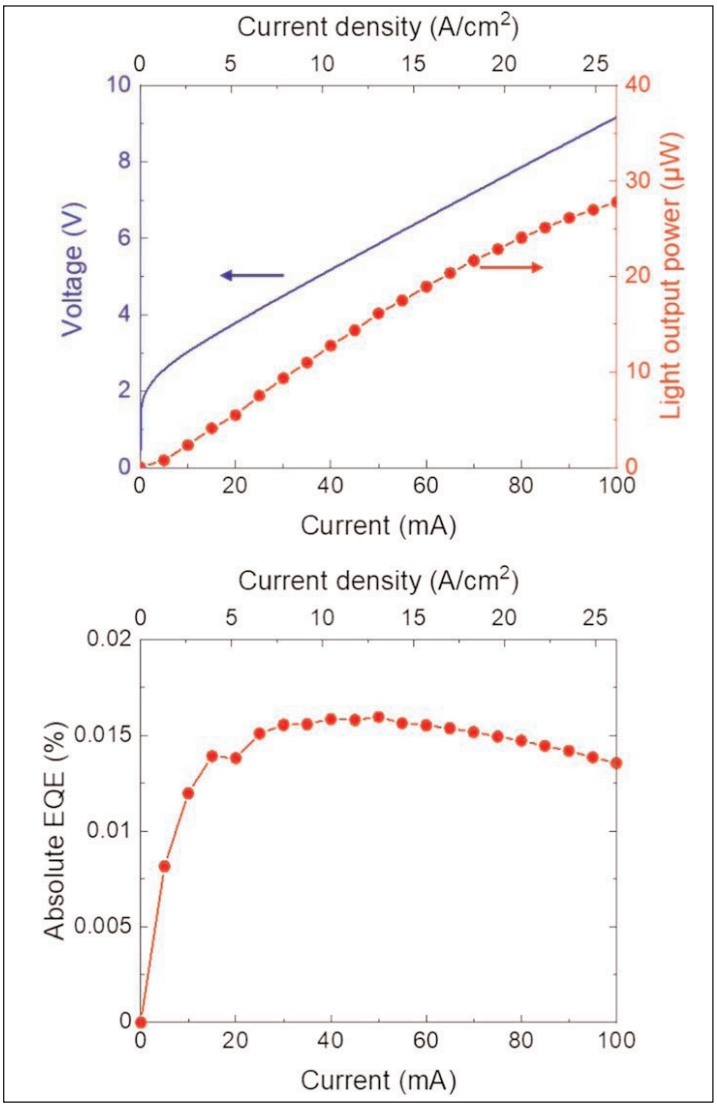


Figure 3. (a) Forward voltage and light output power (b) absolute EQE values at different injection currents.

of the LT buffer layer. High-quality GaN is generally grown at temperatures around 1000°C.

Electroluminescence (EL) spectra showed wide single peaks (Figure 2). At 20mA the peak position was at 629nm, just in the red range of the visible spectrum (625–750nm). At the lower 5mA injection, the peak was more established in the red range at 647nm, but at higher currents the peak shifted out of the red region (617nm at 40mA) into to shorter orange wavelengths (590–625nm), towards the blue end of the visible spectrum.

"This blue-shift behavior is a typical phenomenon of c-plane InGaN-based LEDs caused by the quantum-confined Stark effect (QCSE)," the team explains. The QCSE arises from the strain-generated electric fields in the epitaxial structure and the different charge polarization behaviors of the partial ionic III–N chemical bonds.

The team also suggests that the compositional fluctuations of InGaN in the quantum well structure could lead to shorter-wavelength regions being more active as the current injection increases, and the higher turn-on voltage bias is reached, adding to the blue-shift effect. The fluctuations also contribute to widening the peak at higher injection.

The researchers also blame the SAM substrate quality for the non-ideal EL emission behavior. In particular, the substrates have step/terrace structures, affecting the subsequent epitaxial growth quality.

The researchers comment: "The prospect of LEDs with narrow FWHMs and small blue-shifts can potentially be achieved using a cleaved substrate, which allows for the fabrication of a completely step-free surface. Alternatively, we suggest that a large misoriented substrate with a highly dense step and terrace structure may also be acceptable for achieving uniform InGaN layer growth."

The external quantum efficiency (EQE) reached 0.016% at 40mA injection and 12.6μW light output power (Figure 3). At 20mA the light output and EQE were 5.5μW and 0.014%, respectively. ■

https://doi.org/10.35848/1882-0786/ad8f0e

Improving hole injection in deep UV LEDs

Researchers report 20% enhanced light output power and 6% voltage reduction at 40mA.

Researchers based in Wuhan, China, report improved light output power (LOP) and operating voltages for deep ultraviolet (DUV) light-emitting diodes (LEDs) from reducing carbon (C) impurities in the p-type layers [Ziqi Zhang et al, Appl. Phys. Lett., v125, p241109, 2024]. The carbon impurity comes from the metal-organic (MO) precursors used in the chemical vapor deposition (CVD) aluminium gallium nitride (AlGaN) growth process used to create DUV LED material.

The team from Wuhan University, Wuhan JingWei Technology Co Ltd and Ningbo ANN Semiconductor Co Ltd comments: "This C impurity acting as a shallow donor may reduce hole concentrations due to the compensation effect."

The reduced C content was effected by slowing the growth rate of the AlGaN. In particular, the C content was reduced in the electron-blocking layers (EBLs) and graded p-AlGaN layers, allowing higher Al content. EBLs are critical for reducing electrons from penetrating into the p-type layers.

The researchers comment: "Carbon is one of the most common impurities in III–nitride semiconductors, and the AlGaN layer grown by MOCVD usually contains a higher carbon impurity than GaN due to the chemical activity of Al, which further limits the electrical properties of the high-Al-content p-EBL."

The reduced C incorporation is thought to have enabled a higher hole concentration, increasing hole injection into the active region for recombination with electrons, despite the higher potential barrier presented by higher-Al-content AlGaN.

DUV LEDs are increasingly being deployed for material processing, large-area and high-speed sterilization, and bio/chemical sensing applications. Increased efficiency is a key factor for mass commercialization.

The DUV LEDs (Figure 1) were grown using nitrogen-rich MOCVD on c-plane (0001) flat sapphire substrate (FSS). The precursors were trimethyl-Ga/Al (TM-Ga/Al) and ammonia (NH_3). The n- and p-type dopants were silane (SiH_4) and bis-cyclopentadienyl magnesium.

The LED structure included 3μm AlN template, 120nm $Al_{0.7}Ga_{0.3}N$ transition, 70nm AlN/AlGaN superlattice (SL), 1μm n-AlGaN, multiple quantum well (MQW), 40nm EBL, 30nm graded p-AlGaN, and

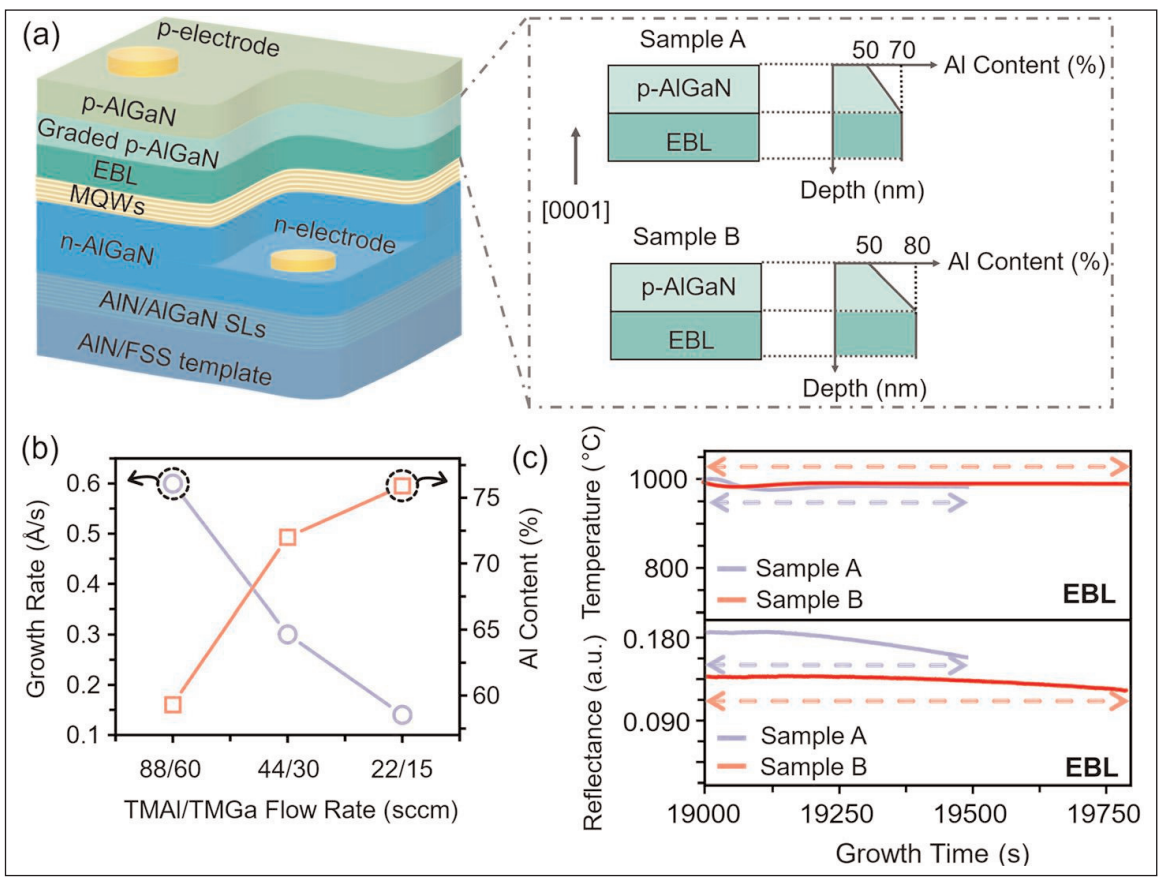


Figure 1. (a) DUV LED schematic structures with inset samples A and B variations. (b) Growth rate and Al content in AlGaN versus TMAl/TMGa flow rate. (c) In-situ temperature and reflectance transients during epitaxial growth of EBL and graded p-AlGaN.

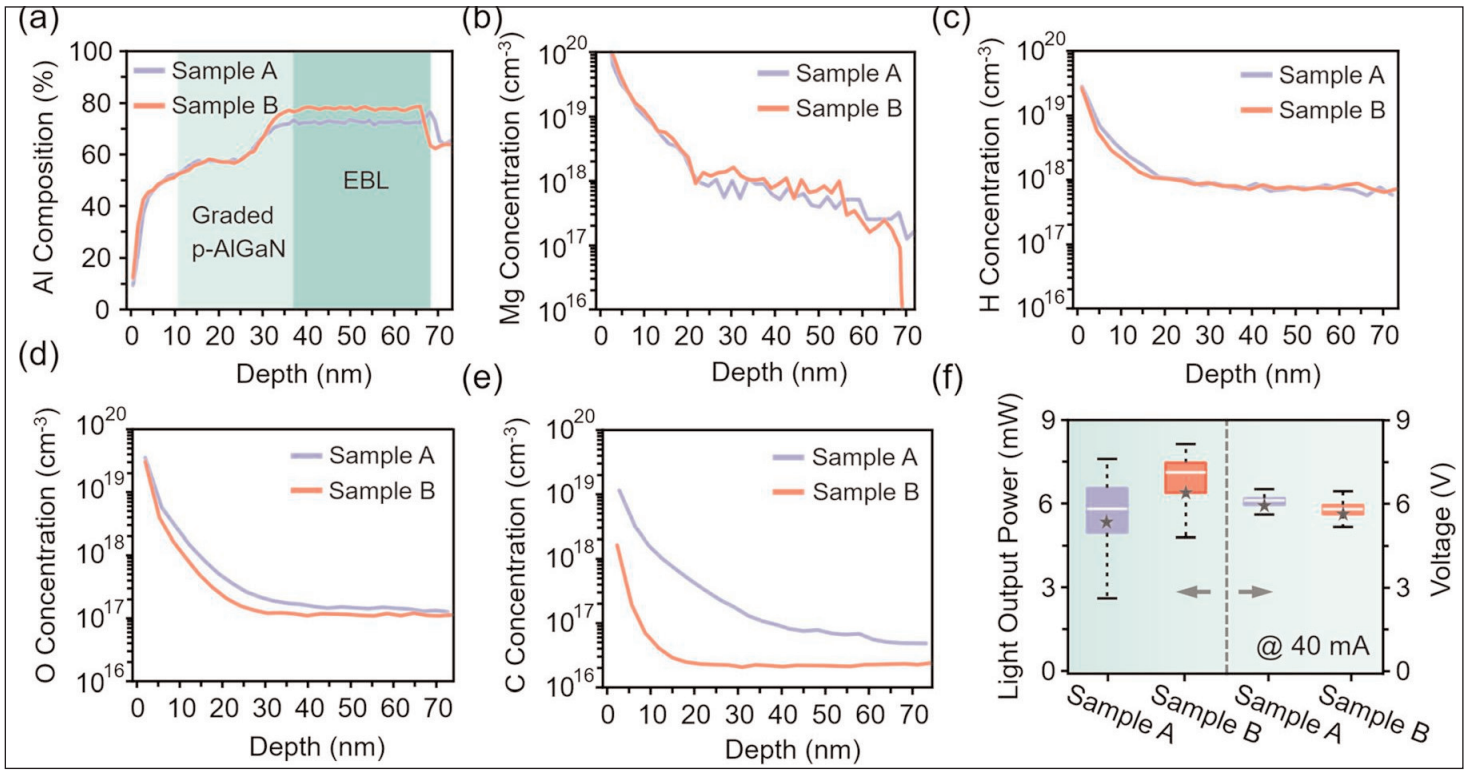


Figure 2. Secondary-ion-mass spectroscopy (SIMS) results of (a) aluminium, (b) magnesium, (c) hydrogen, (d) oxygen, and (e) carbon. (f) Statistics for optoelectronic performance of DUV LED chips for each sample across 2-inch wafer. Black star, white horizontal line, and black vertical dotted line represent mean, median and 1.5x interquartile range of data, respectively.

20nm p-AlGaN layers. The five-period MQW consisted of 2nm $Al_{0.4}Ga_{0.6}N$ wells separated by 10nm $Al_{0.6}Ga_{0.4}N$ barriers.

The difference between the reference sample A and optimized sample B came in the EBL and graded p-AlGaN regions. The EBL differed in Al content: the 70% Al content of sample A was increased to 80%, and the gradings were changed respectively from 70–50% to 80–50%. In both cases, the 10nm p-contact layer had 40% Al. The EBL growth temperature was 1050°C. After the MOCVD growth, both samples were annealed at 750°C in nitrogen to activate the p-type doping.

The researchers carefully studied the effects of varying the precursor flow rates to optimize Al incorporation in the high content layers. Naturally, the slower flow rates needed for higher Al content required longer processing times to achieve the same layer thickness. In particular, the slower growth of sample B enabled reduction in the C content to the order of $10^{16}/cm^3$, almost an order of magnitude lower than for A.

The team suggests that the lower TMGa/Al flow rates enabled more of the carbon to be converted to methane (CH_4), rather than incorporated into the AlGaN material, through reactions like:

$$N{-}H + Ga{-}CH_3 \longrightarrow GaN + CH_4$$

The researchers comment: "This reaction is facilitated by a higher partial pressure of NH_3, which reduces carbon incorporation into the AlGaN layer. A reduced metal-organic precursor flow corresponds to a higher V/III ratio, which may explain the reduced carbon incorporation in the EBL of sample B."

The researchers used the samples to fabricate 254μm x 508μm DUV LEDs with 450nm deep mesas produced using inductively coupled plasma (ICP) etch. The surfaces were passivated with plasma-enhanced CVD silicon dioxide.

One enhancement of using the optimized sample B was reduced contact resistance between the p-AlGaN and nickel/gold p-electrode: 2.8Ω-cm^2, compared with 3.3Ω-cm^2 for sample A. "This can be attributed to the increased hole concentration in p-regions, including the EBL and graded p-AlGaN layer," the team explains.

The researchers speculate that the higher Al contents of sample B increases the C impurity ionization energy, while lower impurity concentrations also reduce point defect density, enhancing carrier transport. The hole concentration should also be increased by a higher induced polarization charge from the steeper grading in sample B.

The optimized sample B achieved higher average light output power and lower operating voltage 40mA injection, both of which factors contribute to higher efficiency (Figure 2). The averages were made over 10,000 chips from each sample material. The mean LOPs were 5.3mW and 6.4mW for A and B, respectively. The corresponding forward voltages were 5.9V and 5.6V. ■

https://doi.org/10.1063/5.0247937

Author: Mike Cooke

Fully vertical GaN p-i-n diodes on silicon

Soft breakdown reaches 1200V with 0.48mΩ-cm^2 on-resistance.

Researchers from France's Institute of Electronics, Microelectronics and Nanotechnology (IEMN) and Siltronic AG in Germany claim the first demonstration of high-current operation (above 10A) for vertical gallium nitride (GaN)-based devices on silicon substrates [Youssef Hamdaoui et al, IEEE Transactions on Electron Devices, vol. 72 (2025), no. 1 (January), p338].

The team comments: "The diodes deliver an unprecedented high ON-state current with more than 11.5A for a 1mm anode diameter. This is ascribed to both the optimization of backside N-face ohmic contacts and the implementation of thick copper electroplating replacing the silicon substrate as a heat sink."

The devices used a fully vertical, rather than pseudo-vertical, structure. 'Pseudo-vertical' refers to a device where all the contacts are made on the front-side of the chip or wafer. While the current flow in the main body of the device is approximately vertical in such arrangements, the current flows laterally in the n-contact layer. The result is that current-crowding effects tend to reduce the power-handling capability of pseudo-vertical devices.

The fully vertical structure promises higher breakdown voltages, along with reduced on-resistance delivering higher currents. Production on silicon substrate, rather than silicon carbide or bulk/freestanding GaN, should also make GaN devices more competitive for low-cost applications.

Two six-inch GaN/Si wafers were prepared (Figure 1) by metal-organic chemical vapor deposition (MOCVD). One wafer had a 4.5µm lightly n-doped (n^-) drift layer. The other wafer had instead a 7.4µ drift region. The silicon doping concentration in the drift layers was $3x10^{16}/cm^3$ with $9x10^{15}/cm^3$ net ionized electron density, according to electrochemical capacitance–voltage (ECV) measurements. The thicker drift layer should withstand higher voltages, but at the cost of higher on-resistance.

Inspection with a transmission electron microscope (TEM) in weak beam darkfield mode determined a threading dislocation density of ~$5x10^8/cm^2$. Hall-effect measurements gave a drift layer mobility of $756cm^2/V\text{-}s$.

The p-i-n diodes were fabricated, beginning with the deep beveled mesa used as edge termination. The deep etching was carried out by plasma reactive ion etch (RIE), and the bevel by inductively coupled plasma (ICP) etch. The purpose of the edge termination was to spread the electric field at the junction periphery, and to reduce leakage.

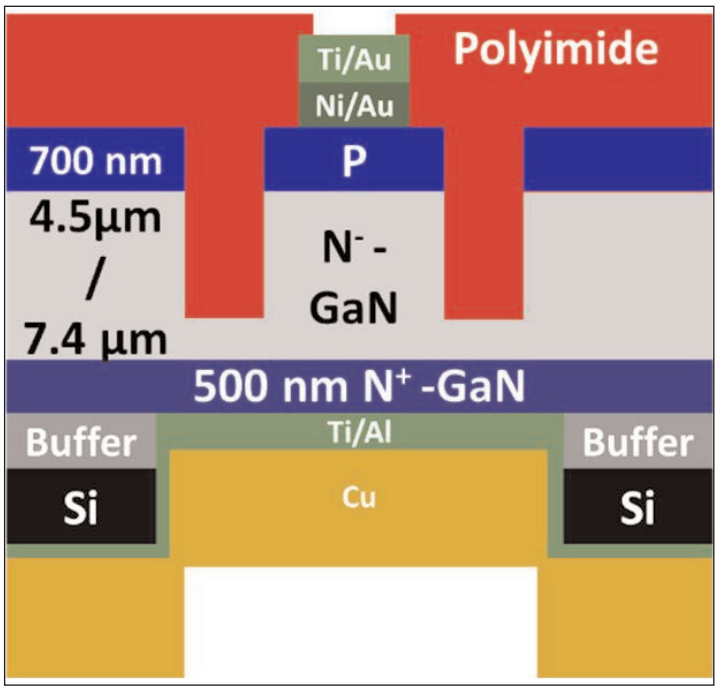


Figure 1. (a) Schematic cross section of fully vertical p-i-n diode. (b) Focused ion beam cross-section image. (c) Optical image of wafer backside after silicon and buffer removal where the front-side circular diodes appear by transparency.

The anode contact to the p-GaN layer was through an annealed nickel/gold (Ni/Au) ohmic electrode, followed by a titanium/gold (Ti/Au) contact pad.

The front-side of the device was passivated with polyimide, which also filled the deep mesa trenches to provide enhanced mechanical strength to the membrane structures of the final devices. The polyimide was applied in a three-stage spin-coat process. The initial spin speed was slow to ensure filling of the trenches, particularly in the corners. The spin-speed was increased to improve coating uniformity, and then further increased to increase the coat thickness.

The front-side was completed with a silicon dioxide (SiO_2) protection layer.

The silicon substrate was thinned from 1mm to 300µm by back-side thinning. Local etching under the p-i-n diodes was achieved by deep RIE to remove the intervening silicon, followed by ICP etch of the GaN buffer layer to access the n-GaN contact layer. The circular membrane regions were 3mm diameter. The etched membrane surface was treated with hydrochloric (HCl) acid to

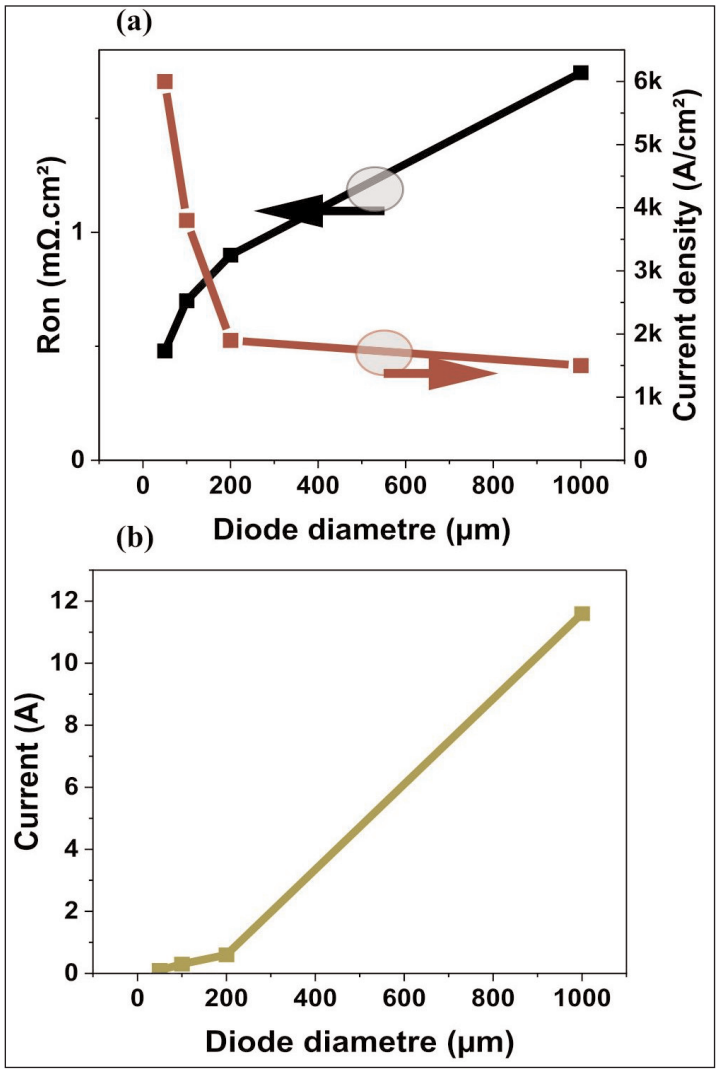


Figure 2. (a) Extracted $R_{on,sp}$ & on-state current density. (b) Forward current vs diode anode diameter at 8.5V.

reduce the n-contact resistance from over $10^{-4}\Omega$-cm^2 without treatment to $9x10^{-6}\Omega$-cm^2 after treatment.

The backside was completed with deposition of the titanium/aluminium (Ti/Al) cathode ohmic contact, and electroplating of 300μm copper (Cu) as a heat-sink.

The team comments: "It is important to note that the highly strained thick Cu deposition is enabled by the polyimide protection on the front-side that strengthens the mechanical robustness of the membranes, otherwise resulting in cracked and damaged devices."

The reverse-bias breakdown voltage of diodes with 7.4μm drift layer reached 1230V. The team estimates a critical electrical field at the junction of over 2.2MV/cm, and 1.66MV/cm average across the drift layer.

The breakdown was soft/recoverable. The researchers see this as hinting at an avalanche mechanism, which is "an essential feature for the industrialization of these new types of devices".

The team comments: "Avalanche breakdown provides a safe leakage current path that protects the devices from irreversible damage. In this case, the leakage current is induced by the impact ionization of the accumulated carriers when exceeding a specific energy. Increasing the temperature causes a delay in the onset of impact ionization due to phonon scattering."

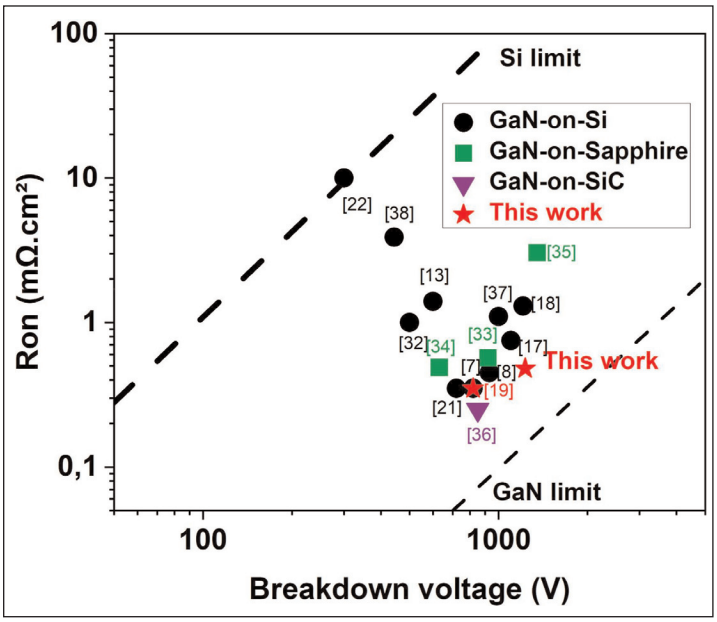


Figure 3. Benchmark of fully and pseudo-vertical small GaN-on-foreign substrate diodes.

The breakdown voltage (BV) on small diodes, less than 100μm diameter, increased slightly with temperature, presumably due to the increased number of phonons delaying impact ionization. For larger devices, soft breakdown was observed, and the voltage did not increase with temperature, leading to hard breakdown effects.

The researchers explain: "The absence of soft breakdown for large diodes is attributed to the larger amount of defects that may contribute to increase the leakage current, especially at high temperature preventing the avalanche phenomenon. This suggests that defect-assisted tunneling or trap-assisted recombination may dominate the leakage current in these devices."

The turn-on voltage of the small and large devices was around +5V. The current at 8.5V roughly scaled with device size from 100mA to 11.6A (Figure 2). The larger diodes, more than 200μm diameter, were operated in pulse mode to avoid self-heating effects. The smaller devices were tested in continuous wave (CW) mode. The specific on-resistance ($R_{on,sp}$) of small diodes with 50μm-diameter anode was 0.48mΩ-cm^2. For 1mm diameter, $R_{on,sp}$ was 1.7mΩ-cm^2.

The optimization of the copper heat-sink layer and packaging could further improve the thermal management over pulse operation, reducing Ron,sp in the larger diodes, the team believes.

The small diodes achieved Baliga figures of merit (BFOMs) up to 3.17GW/cm^2 ($BV^2/R_{on,sp}$), representing the balance between BV and $R_{on,sp}$ (Figure 3).■

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Author: Mike Cooke

Record-performance N-polar GaN Schottky barrier gate HEMTs on low-cost sapphire

University of California, Santa Barbara reports record large-signal gain and record power-added efficiency at W-band frequencies.

N-polar gallium nitride (GaN) deep-recess high-electron-mobility transistors (HEMTs) have demonstrated excellent power density and efficiency at W-band frequencies. The utilization of a GaN cap on the GaN channel layer in N-polar orientation enables high-power-density operation with excellent DC-to-RF dispersion control and high access region conductivity. In addition, unlike Ga-polar GaN devices, the wider-bandgap barrier layer is under the channel, which enables the independent tuning of the channel charge density and gate aspect ratio, thereby enabling high gain and power simultaneously. Traditionally, deep-recess N-polar GaN HEMTs have employed SiN gate dielectric layer to suppress the gate leakage current. Although this effectively minimizes the gate leakage current, it comes with the cost of reduced gate aspect ratio, which prevents exploiting the advantages of the N-polar GaN technology to its fullest extent.

To tackle the reduced gate aspect ratio with the inclusion of a gate dielectric, Dr Emre Akso and Dr Henry Collins, the main contributors in the project, studied the formation of Schottky barrier junctions on the AlGaN cap, which is situated right above the GaN channel. Choosing the correct gate material was the key, as it had to not

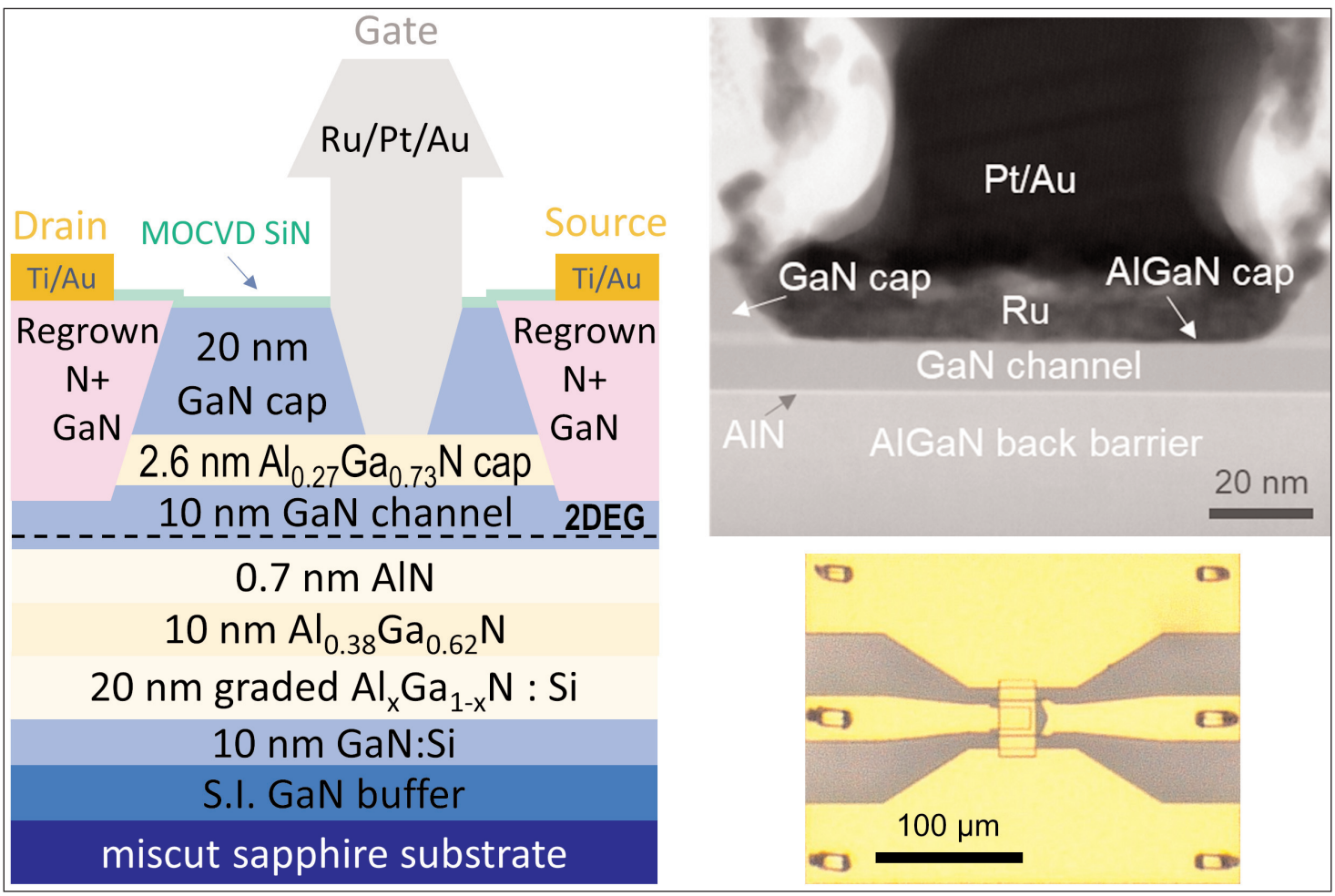

Figure 1. (a) Device structure and epitaxial layers (b) TEM image of a recessed Schottky barrier gate structure with 90nm L_G. (c) Fabricated devices with CPW pads (W_G:2x25µm). Figure © [2024] IEEE [1].

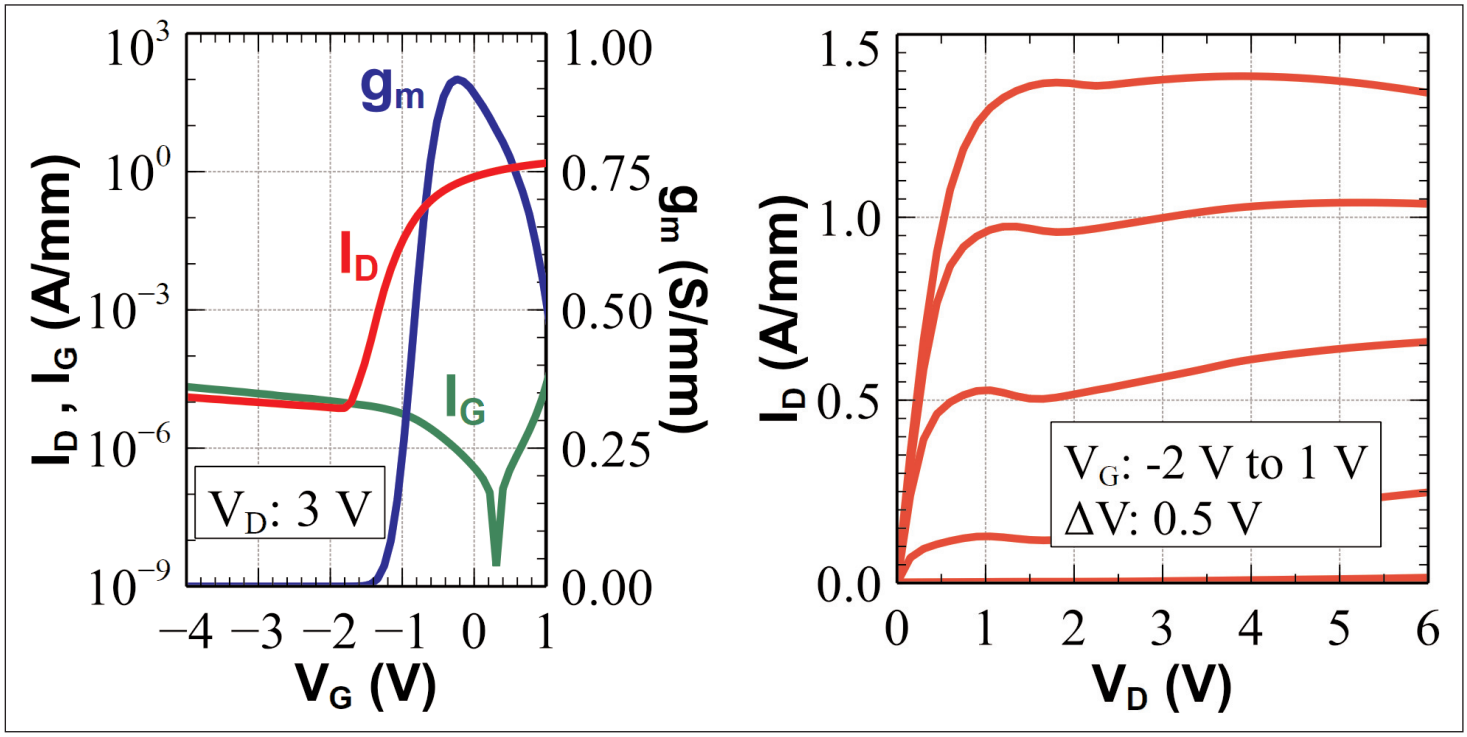

Figure 2. (a) DC characteristics at 3V V_D. (b) DC output characteristics for V_G of −2V to +1V with 0.5V step. Figure © [2024] IEEE [1].

only form a low-leakage Schottky barrier junction with no Fermi-level pinning, which can impede the channel charge modulation, but also should be deposited with a technique compatible with filling narrow gate trenches. That's why our focus was on the materials available in the UCSB atomic layer deposition (ALD) system.

Dr Akso and Dr Collins first studied Schottky barrier gate HEMTs with ALD ruthenium (Ru) gates. The HEMTs were built on N-polar GaN-on-sapphire epitaxy with a scaled channel thickness of 10nm and GaN cap thickness of 20nm, as shown in Figure 1.

Along with transistors, the team fabricated diodes on the recessed HEMT structure to evaluate the reverse leakage current against the previous diode studies with ALD Ru fabricated on 600nm-thick n-GaN with no 2DEG (two-dimensional electron gas). The reverse leakage current from the diode on a recessed HEMT structure was 43A/cm^2, as opposed to the 2μA/cm^2 from a traditional Schottky barrier diode on thick n-GaN. The increased leakage for the diode on the recessed HEMT structure could be attributed mainly to the increased tunneling current with a metal-to-2DEG spacing of only 13nm. Despite this, for a scaled transistor with a gate length of 100nm, this per-area leakage would correspond to 43μA/mm reverse current, which is excellent to ensure a current modulation of more than four decades for an on-current greater than 1A/mm.

As a result of improved gate aspect ratio and low expected reverse leakage current from the diodes, the transistors demonstrated remarkable DC, RF and large-signal performance. The particular transistor reported in the paper had a source–drain spacing (L_{SD}) of 540nm, gate length (L_G) of 77nm, gate–source spacing (L_{GS}) of 100nm, and 2x25μm gate periphery. DC characterization showed that the transistor has a peak transconductance (g_m) of 917mS/mm, which is the highest reported g_m from N-polar GaN/AlGaN devices to date. The extraordinary improvement in the g_m corresponds to almost twice as much as the g_m of previously reported deep-recess HEMTs with gate dielectrics. Additionally, as expected from the diode characterization, the reverse gate leakage for the transistor remained below 40μA/mm, which ensured more than five decades of on-to-off ratio, as shown in Figure 2.

As expected from the improved aspect ratio, despite the increased fringe capacitance through the sidewalls of the recess with Schottky contact, the transistor showed a significant RF performance improvement over MISHEMTs with gate dielectric, as illustrated in Figure 3.

The key to high power-added efficiency (PAE) is to make a transistor that has high gain at low current density. The ALD Ru-gated Schottky barrier HEMTs demonstrated larger than 1S/mm RF g_m at a current density of as low as 0.3A/mm. Additionally, the increased aspect ratio improved the output resistance (r_{DS}), which culminated in an intrinsic gain (g_m*r_{DS}) of 50.6. This is one of the highest reported intrinsic gains reported from scaled GaN HEMTs.

The large-signal characterization was done with a W-band active load-pull system operating at 94GHz. Biased at $V_{DS,Q}$ of 10V and $I_{DS,Q}$ of 0.25A/mm, the transistor demonstrated record transistor-level gain of 10.5dB and record combined PAE and power of 50.2% with 2.8W/mm, as shown in Figures 4.

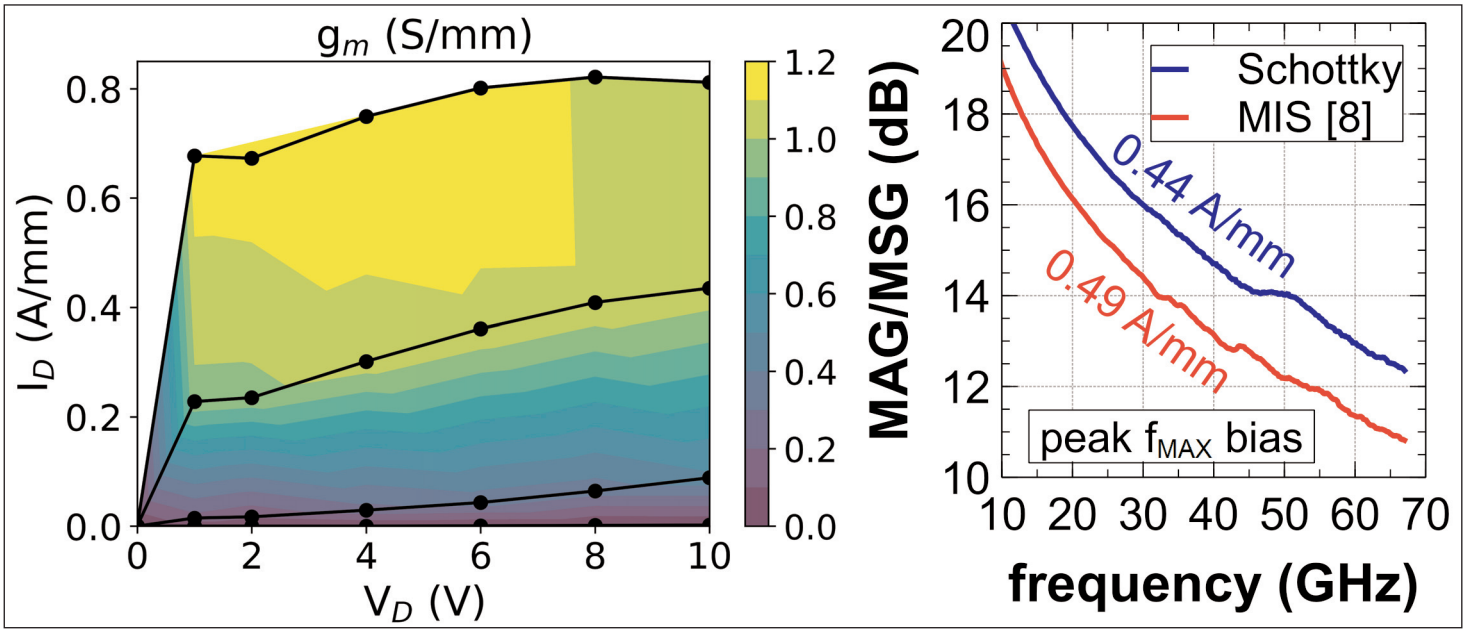

Figure 3 . (a) Bias-dependent RF g_m extracted at V_G of −2V to 0V with a 0.5V step. (b) Comparison of MAG/MSG of Schottky barrier gate versus MISHEMT at peak f_{MAX} bias. Figure © [2024] IEEE [1].

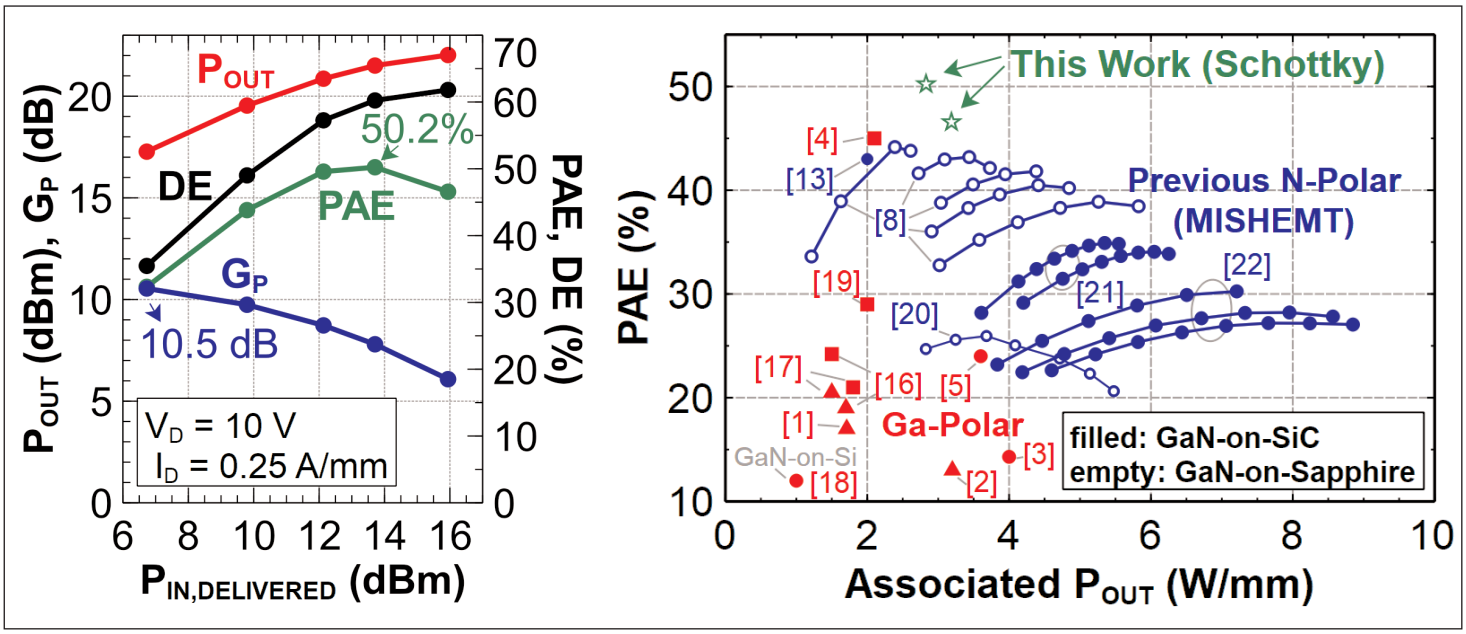

Figure 4. Power sweep at V_D = 10V and I_D = 0.25A/mm at 94GHz (b) PAE versus associated P_{OUT} at W-band (83–95GHz) for GaN, circle: load pull, square: pre-matched device, triangle: MMIC Figure © [2024] IEEE [1].

Furthermore, the team explored another ALD material as a Schottky barrier contact material: titanium nitride (TiN). TiN was used to establish the contact with the AlGaN surface, so the thickness was kept at 2nm because of the limited conductivity of the TiN. On top of TiN, an ALD Ru layer was deposited to fill the narrow gate trenches further with a more conductive material.

The team fabricated diodes and transistors as in the case of the samples with ALD Ru only. The diodes alone showed an improvement in the reverse leakage current compared with ALD Ru only. Furthermore, the breakdown voltage measured by the drain current injection (DCI) method showed a significant improvement with the inclusion of TiN.

The transistors with TiN gates showed a comparable DC performance to that of those with Ru gates. However, the TiN contact improved the RF performance of the transistors, as shown in Table 1. This improvement in f_{max} and f_T can be attributed to the lower gate resistance (R_G) with better filling of the trench associated with TiN, and reduction in the fringing capacitance, respectively.

The peak f_{max} of 362GHz and peak f_T of 193GHz are again record numbers for the deep-recess N-polar GaN HEMTs. With the increased breakdown voltage, the team was able to bias the transistor at a higher quiescent voltage of 12V for large-signal characterization. The TiN-gated transistor, biased at 0.25A/mm quiescent current density, showed another record large-signal performance with

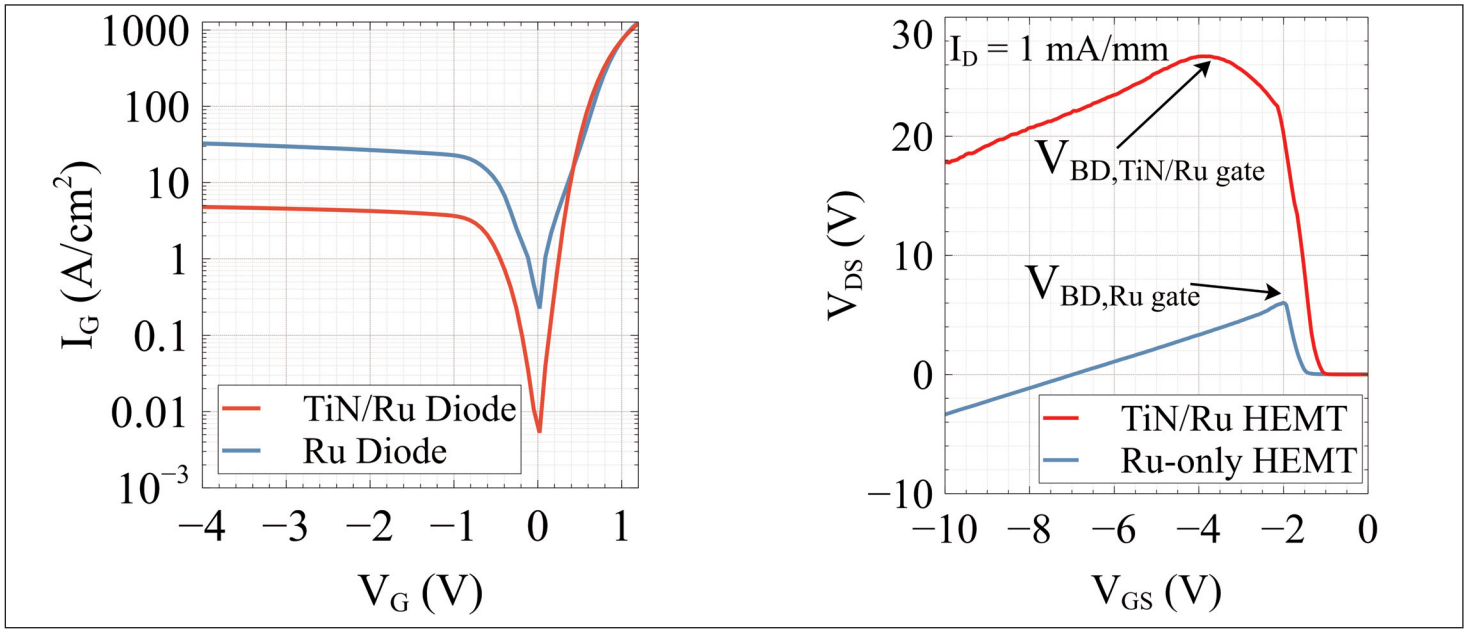

Figure 5. (a) I–V sweep comparing TiN and Ru-only Schottky diodes on N-polar deep-recess GaN epitaxy. (b) Breakdown measurement via DCI. Figure © [2024] IEEE [2].

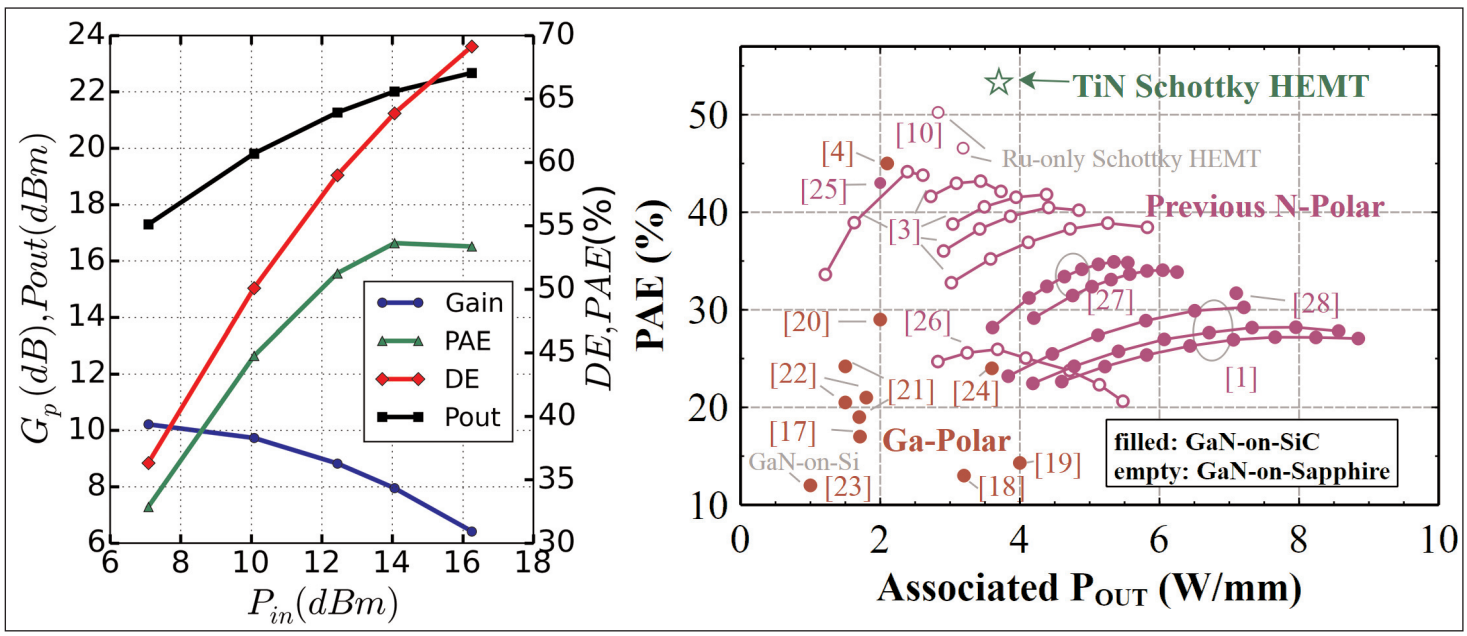

Figure 6. (a) 94GHz load-pull power sweep of the TiN Schottky gate HEMT. (b) Benchmark comparison of W-band load-pull performance showing the excellent combination of PAE and P_{out} attained by the TiN Schottky HEMT (this work). Figure © [2024] IEEE [2].

	L_g (nm)	Peak f_t (GHz)	Peak f_{max} (GHz)	$g_{m,RF}$ (S/mm)	$c_{g,fringe}$ (pF/mm)	R_G (Ω)
Ru-gated MIS	57	132	306	N/A	N/A	N/A
Ru-only Schottky	50	176	307	1.13	0.42	3.4
TiN Schottky	50	193	362	1.03	0.21	1.8
	60	169	339	1.07	0.21	1.6

Table 1. Peak f_T and f_{max} for MIS and Schottky HEMTS and small-signal parameter extraction at peak f_T bias. Table © [2024] IEEE [2].

3.7W/mm associated with 53.4% PAE, as illustrated in Figure 6.

This work presented the first successful demonstration of Schottky barrier gate N-polar GaN deep-recess HEMTs in the literature with record large-signal performance at W-band frequencies. These devices with extraordinary performance were demonstrated on low-cost sapphire substrate, unlike the state-of-the-art Ga-polar GaN devices on costly silicon carbide (SiC). This record performance on a low-cost substrate platform will pave the way for low-cost yet high-performance wireless communication and radar systems.■

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[1] Akso et al, IEEE Microwave and Wireless Technology Letters, vol.34, no.2 (February 2024), p183–186
[2] Collins et al, IEEE Microwave and Wireless Technology Letters, vol.34, no.7 (July 2024), p907–910

Fast gallium oxide MOCVD growth

Researchers achieve high mobility comparable to material grown at slower rates.

Ohio State University (OSU) in the USA reports on increasing the growth rate for gallium oxide (β-Ga_2O_3) epitaxy using metal-organic chemical vapor deposition (MOCVD) [Dong Su Yu et al, Appl. Phys. Lett., v125, p242106 2024]. In particular, the team studied the effect of modifying the oxygen precursor and using off-axis substrates.

The researchers comment: "Results from this work provide guidance on MOCVD development of high-crystalline-quality β-Ga_2O_3 films for vertical power electronics."

The resulting films, grown at 4.5µm/h, showed electron mobilities up to 190cm^2/V-s at low 7x10^{15}/cm^3 carrier concentration, as needed in drift layers in high-power/high-voltage vertical devices, such as transistors and Schottky barrier diodes. The ultrawide bandgap (UWBG) of β-Ga_2O_3 also makes it attractive for ultra-violet (UV) solar-blind photodetectors.

The team reports: "Among several UWBG semiconductor candidates, such as aluminium nitride (AlN), diamond, and boron nitride (BN), β-Ga_2O_3 has a unique advantage of the availability of high-quality bulk Ga_2O_3 synthesized with low density of defects from melt growth techniques."

MOCVD is attractive for β-Ga_2O_3 over faster halide vapor phase epitaxy (HVPE) in terms of resulting in smoother surface with fewer defects. HVPE films thus require further process steps such as chemical mechanical planarization (CMP). HVPE growth rates typically exceed 5µm. The OSU work has demonstrated good performance from MOCVD growth rates of 4.5µm/h, approaching the results of 3µm/h MOCVD.

The epitaxial β-Ga_2O_3 was grown on commercial semi-insulating (010) iron-doped β-Ga_2O_3 substrates. The substrates, with and without a 2° off-cut angle, were supplied by Novel Crystal Technology Inc. The Ga precursor was trimethyl-gallium (TMGa). For the oxygen component, the researchers compared the use of high-purity (>99.9999%) oxygen (O_2), and the use of oxygen with 10 parts per million water mol-

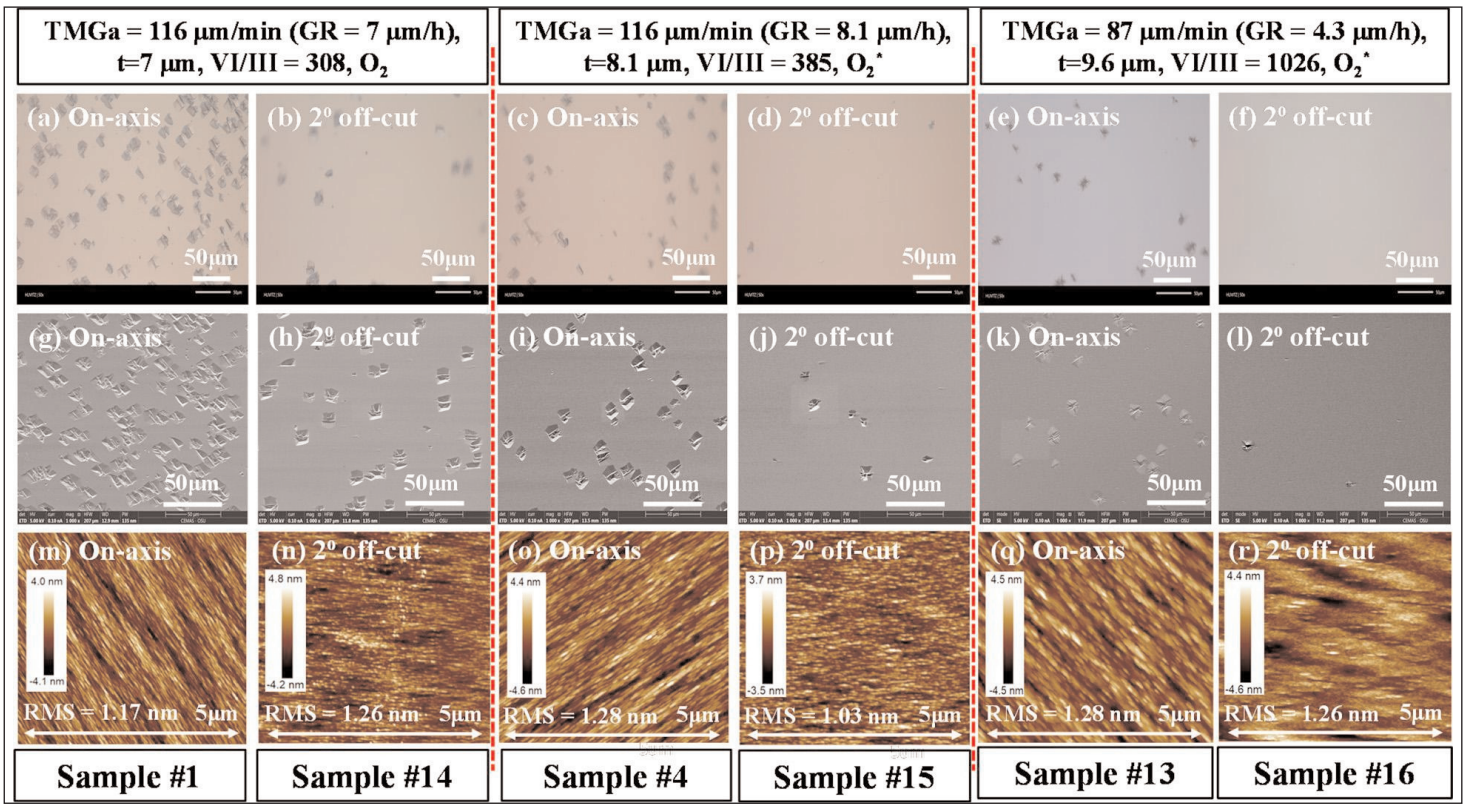

Figure 1. Surface views in optical, field emission scanning electron microscope (FESEM), and atomic force microscope (AFM) images of β-Ga_2O_3 epi-films grown on 2° off-cut and on-axis (010) semi-insulating β-Ga_2O_3 substrates under varied growth conditions (µm/min=µmol/min).

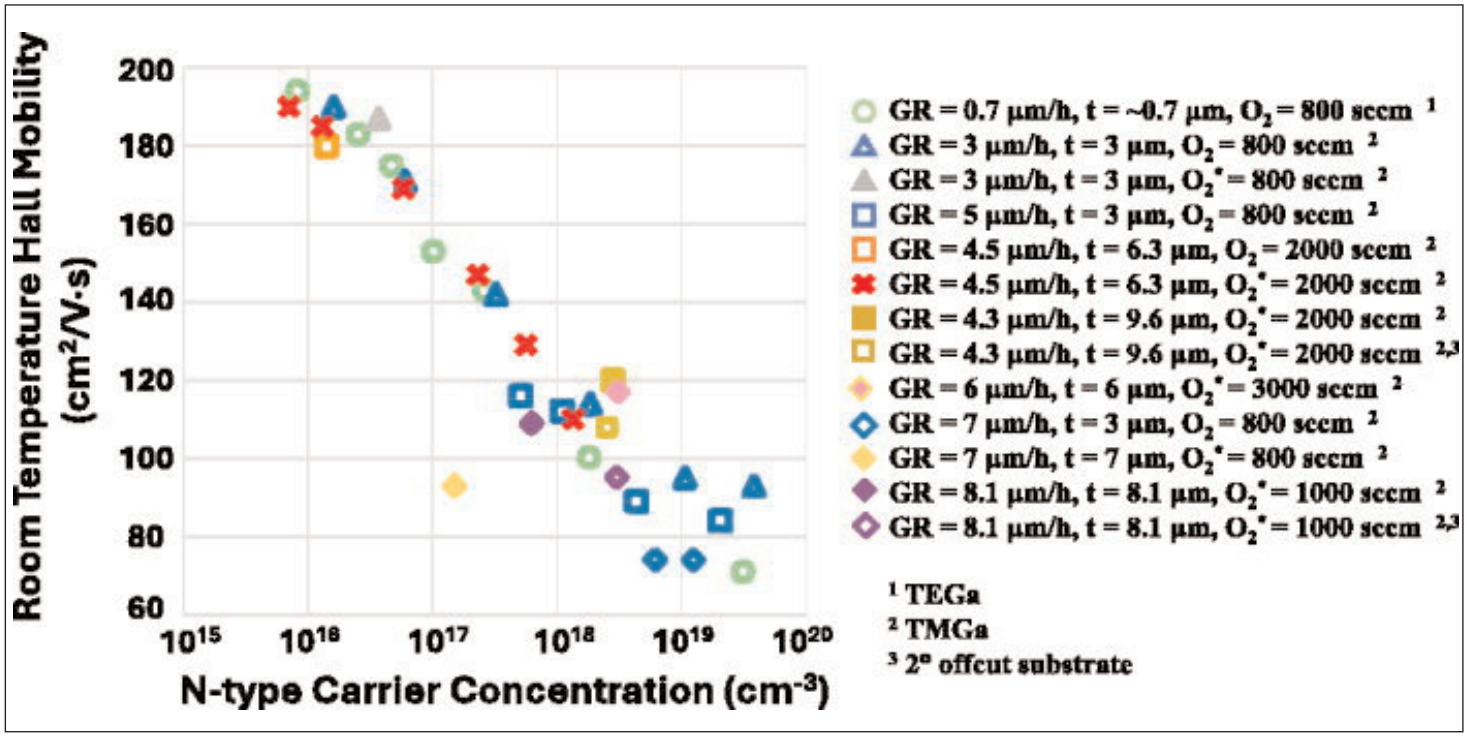

Figure 2. Comparison of room-temperature Hall mobility data for (010) β-Ga_2O_3 epi-films grown using TMGa with fast growth rates (4.3–8.1μm/h) versus electron concentration from OSU's latest and previously reported data from MOCVD with TMGa and triethyl-Ga (TEGa) precursors.

ecules (O_2*). The carrier gas was argon. The growth temperature and pressure were 950°C and 60Torr, respectively.

The growth rates ranged from 4.3μm/h to 8.1μm/h, depending on the precursor flow rates. Silane (SiH_4) was used for n-type doping with silicon.

The introduction of an off-cut angle on β-Ga_2O_3 substrates provides preferred nucleation sites for incoming Ga adatoms along the steps/edges, which suppresses the random nucleation sites and the formation of 3D defects

One effect of using O_2* was to reduce the size and density of 3D pyramid-shaped surface defects, compared with high-purity O_2. However, the O_2* samples did have "a relatively high density of surface structures with much smaller feature sizes".

Based on previous work, the researchers suggest that the presence of H in O_2* MOCVD reaction increases the mobility of the adatoms on the substrate surface, increasing diffusion length, "leading to smoother and more uniform film surfaces". The surface roughness with O_2* was 1.48nm, compared with 2.59nm for a sample grown using high-purity O_2.

Two on-axis samples with 6.3μm films (4.5μm/h growth) showed similar electron transport characteristics: $1.3x10^{16}/cm^3$ and $1.4x10^{16}/cm^3$ electron carrier concentration, and $185cm^2/V$-s and $180cm^2/V$-s mobility, for O_2* and O_2, respectively.

The researchers comment: "As the film thickness reduces, one should expect a more prominent influence of the surface or interface roughness on the transport properties. Future investigation is still required to understand the impact of the surface morphology on device performance. In particular, for devices with thick epitaxial layers, additional optimization of surface morphology may still be necessary."

The use of 2° off-cut substrates further improved the surface morphology (Figure 1). The researchers comment: "The introduction of an off-cut angle on β-Ga_2O_3 substrates provides preferred nucleation sites for incoming Ga adatoms along the steps/edges, which suppresses the random nucleation sites and the formation of 3D defects. Furthermore, the use of O_2* and relatively high V/III ratio result in optimal surface smoothness."

High oxygen flow rates were also found to suppress carbon incorporation, according to secondary-ion mass spectroscopic analysis. Carbon tends to reduce the effectiveness and accuracy of silicon n-type doping due to severe charge compensation effects.

The researchers achieved low controllable n-type doping with $7x10^{15}/cm^3$ carrier concentration and $190cm^2/V$-s mobility (Figure 2). The growth rate was 4.5μm/h, and the performance was close to the ~$200cm^2/V$-s record achieved with a slower growth of 3μm/h. These values are also close to the theoretical limit. The highest electron carrier concentration achieved was $3.6x^{18}/cm^3$. ■

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Author: Mike Cooke

suppliers' directory

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(Vital Materials subsidiary)
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Tel: +49 35205 520-0
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www.lpe-epi.com

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Austria
Tel: +43 5672 600 2422
info@plansee.com
www.plansee.com

Plasma-Therm LLC
10050 16th Street North,
St. Petersburg, FL 33716,
USA
Tel: +1 727 577 4999
Fax: +1 727 577 7035
www.plasmatherm.com

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Tel: +1 952 934 2100
Fax: +1 952 934 2737
www.svta.com

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
Livermore, CA 94551,
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Tel: +1 925 245 5817
Fax: +1 925 449-4096
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Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797,
USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

Kayaku Advanced Materials Inc
200 Flanders Road,
Westborough, MA 01581,
USA
Tel: +1 617 965 5511
www.kayakuam.com

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

Evatec AG
Hauptstrasse 1a,
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Fax: +44 (0) 1389 879 042
www.logitech.uk.com

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

SAMCO International Inc
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Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

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

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

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Switzerland
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Fax +41 21 694 35 01
www.synova.ch

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054 ,
USA
Tel: +1-408-748-0100
Fax: +1-408-748-0111
Contact Person: Cathy W. Hung
Email: sales@tecdia.com
www.tecdia.com

Veeco Instruments Inc
(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd
Ermine Business Park, Huntingdon,
Cambridgeshire PE29 6WR, UK
Tel: +44 (0) 1480 424800
Fax: +44 (0) 1480 424900
www.goodfellow.com

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Austria
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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,
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Tel: +44 (0)1954 786800
Fax: +44 (0)1954 786818
www.cambridge-fluid.com

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www.csclean.com

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www.iemtec.com

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Tempe, AZ 85284, USA
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www.versummaterials.com

11 Process monitoring and control

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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
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USA
Tel: +1 734 426 7977
Fax: +1 734 426 7955
www.k-space.com

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CA 95035, USA
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Fax: +1 408 875 4144
www.kla-tencor.com

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www.vacuumbarrier.com

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Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald,
Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

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

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

13 Characterization equipment

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)

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2978 Main Street,
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Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

16 Assembly/packaging equipment

CST Global Ltd
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Tel: +44 (0) 1698 722072
www.cstglobal.uk

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

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www.PalomarTechnologies.com

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Fax: +1 508-832-0506
www.pi.ws
www.pi-usa.us

TECDIA Inc
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Santa Clara, CA 95054,
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Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

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San Diego, CA 92127, USA
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Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

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

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

19 Facility equipment

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

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USA
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www.vacuumbarrier.com

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20 Facility consumables

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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

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Contact Person: Cathy W. Hung
www.tecdia.com

24 Resources

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7140 San Jose, CA 95126, USA
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www.alshuktz.com

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USA
Tel: +1 408 943 6900
www.semi.org

Yole Développement
69006 Lyon,
France
Tel: +33 472 83 01 86
www.yole.fr

event calendar

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

2–6 March 2025
11th International Workshop on Semiconducting Oxides (IWSC-2025)
Arizona State University, Tempe, Arizona, USA
E-mail: Farida.Selim@asu.edu
https://semte.engineering,asu.edu/semiconductor-workshop

16–20 March 2025
IEEE Applied Power Electronics Conference (APEC 2025)
Atlanta, GA, USA
E-mail: apec@apec-conf.org
www.apec-conf.org

26–28 March 2025
SEMICON China 2025
Shanghai New International Expo Centre (SNIEC), Shanghai, China
E-mail: semichina@semi.org
www.semiconchina.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

1 April 2025
ITF Photonics USA 2025 - Shedding light on advances in integrated photonics
W Hotel, San Francisco, CA, USA
www.imecitf.com/photonics

29 April – 1 May 2025
28th Annual Components for Military & Space Electronics Conference & Exhibition (CSME 2025)
Four Points by Sheraton (LAX), Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

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

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8–12 June 2025
2025 Symposium on VLSI Technology & Circuits – 'Cultivating the VLSI Garden: From Seeds of Innovation to Thriving Growth'
Rihga Royal Hotel, Kyoto, Japan
www.vlsisymposium.org

22–25 June 2025
83rd annual Device Research Conference (DRC)
Duke University, Durham, NC, USA
E-mail: sud70@psu.edu
https://2025.deviceresearchconference.org

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: support@mtt.org
www.ims-ieee.org

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

23–25 June 2025
Strategic Materials Conference (SMC 2025)
Hayes Mansion in San Jose, CA, USA
E-mail: spoblete@semi.org
www.semi.org/en/connect/events/strategic-materials-conference-smc

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

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

29–31 July 2025
7th International Congress on Advanced Materials Sciences and Engineering 2025 (AMSE-2025) — "Transforming Technologies for a Sustainable Future"
Krakow, Poland
E-mail: eve@istci.org
https://istci.org/amse2025/Register.asp

10–12 September 2025
China International Optoelectronic Exposition (CIOE 2025)
Shenzhen World Exhibition and Convention Center, Shenzhen, Guangdong, China
E-mail: cioe@cioe.cn
www.cioe.cn/en

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

24–26 September 2025
PCIM Asia – International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management (PCIM Asia Shanghai 2025)
Shanghai New International Expo Centre, China
E-mail:pcimasia@china.messefrankfurt.com
www.pcimasia-expo.com

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

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

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

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