

semiconductor **TODAY**

C O M P O U N D S & A D V A N C E D S I L I C O N

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News from APEC and OFC 2023



Infineon acquiring GaN Systems • Mitsubishi building 8" SiC fab
NI buys SET • Porotech opens new UK and Taiwan facilities



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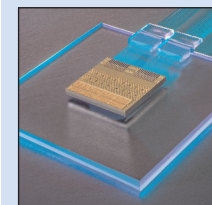
p12 Mitsubishi Electric is building a new 8-inch silicon carbide wafer fab for power semiconductor production.



p24 SweGaN's new headquarters and production facility in Linköping, Sweden, to be completed by the end of second-quarter 2023.



p39 Porotech has celebrated the opening of new facilities at its base in Cambridge, UK as well as in Hsinchu, Taiwan (pictured above).



Cover image: At OFC 2023, Ayar Labs gave a public demonstration of the first 4Tbps bidirectional WDM optical solution, moving data from one TeraPHY optical I/O chiplet to another at 2.048Tbps in each direction, powered by its SuperNova light source.
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Broadening applications aid stability

As usual, March has seen the occurrence of two major annual industry events — the Optical Fiber Communication conference (OFC) in San Diego and the Applied Power Electronics Conference (APEC) in Orlando — news from which is reported on pages 45–59 and 15–19, respectively.

OFC saw the usual focus on higher-speed optical components, in this case up to 1.6Tb/s, for which the QSFP-DD multi-source agreement is being extended to a new specification. In addition, Ayar Labs demonstrated the first 4Tb/s bidirectional WDM optical solution.

With much development based on silicon photonics, the scaling of optical interconnects down to the chip-to-chip level is broadening the applications of optical communications beyond traditional telecoms & datacoms to other applications, e.g. high-performance computing, machine learning/artificial intelligence (ML/AI), industrial, and automotive. For example, Avicena has used its gallium nitride (GaN) micro-LED array-based LightBundle communication architecture and technology to demonstrate the “highest-temperature” optical link, operating at up to 235°C. This is enabled by the suitability of wide-bandgap materials such as GaN to operate well in harsh environments such as automotive applications.

For similar reasons, APEC featured many developments in the application of gallium nitride and silicon carbide to electric vehicles (EVs). Last month, we reported how silicon chip makers such as Arizona-based Microchip are expanding their SiC production capacity further, while SiC-focused company Wolfspeed announced plans to build a second 200mm-wafer device fab, this time in Germany (surpassing the size of its 200mm Mohawk Valley device fab in Marcy, NY, opened in April 2022). Now, after completing this issue’s news pages, we hear of US President Joe Biden’s first stop of his ‘Invest in America’ tour taking place at Wolfspeed’s HQ in Durham, NC. There, the firm announced that, together with North Carolina Agricultural and Technical State University, it is applying for CHIPS and Science Act funding to build a new SiC R&D facility. This will complement The John Palmour Manufacturing Center for Silicon Carbide, currently being constructed in Siler City, NC to expand SiC materials production capacity by more than 10x.

A potential spoiler came on 1 March when, at its 2023 Investor Day, EV maker Tesla (which pioneered the use of SiC MOSFETs in EV DC-to-AC power inverters, despite the greater cost than silicon equivalents) said that the greater efficiency of its next-generation, lower-power drive-train in its lower-cost ‘Model 2’ EVs would use 75% fewer of the costly SiC devices (12 devices providing 200 Amps, rather than 48 devices providing 400 Amps, still operating at 400V). This led to a predictable sudden (albeit temporary) dip in the share prices of SiC-related companies back up the supply chain.

However, Aehr (which makes systems for testing SiC devices) believes that this will not necessarily reduce the SiC market by 75%. First, Tesla’s higher-performance models will retain the existing inverter. Second, the SiC chips used in the new-generation, lower-performance power-train will be about 50% larger in SiC surface area than in Tesla’s existing power-trains.

Also, EVs are proliferating further, beyond Tesla, at other car makers, which are introducing 800V EVs (requiring SiC for the higher power) in 2023–2024 (see page 8). So, whereas Tesla has previously had a dominant influence on the SiC supply chain, it has now been overtaken in global EV market share by China’s BYD, suggesting that a more diversified EV market could lead to greater stability in the SiC supply chain.

Mark Telford, Editor

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Semiconductor Today covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices

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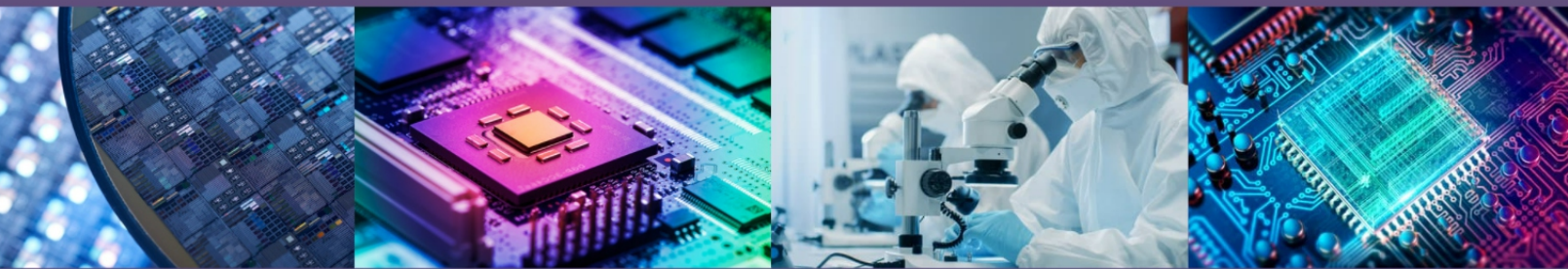
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Smartphone shipments to fall 1.1% in 2023, rather than prior forecast of 2.8% growth

Recovery pushed into 2024 amidst weak demand and macroeconomic challenges

Due to a slower recovery than previously expected as the market continues to suffer from weak demand and ongoing macroeconomic challenges, International Data Corporation (IDC) has revised its forecast for worldwide smartphone shipments in 2023 from the 2.8% growth in the prior forecast to a decline of 1.1% to 1.19 billion units, according to the firm's latest Worldwide Quarterly Mobile Phone Tracker forecast.

Real market recovery is not expected to occur until 2024, when IDC expects 5.9% year-on-year growth followed by low single-digit growth leading to a five-year compound annual growth rate (CAGR) of 2.6%.

"With increasing costs and ongoing challenges in consumer demand, OEMs are quite cautious about 2023. While there is finally some good news coming out of China with the recent reopening, there is still a lot of uncertainty and lack of trust, which results in a cautious outlook," says Nabila Popal research director with IDC's Mobility and Consumer Device Trackers. "However, we remain convinced the global market will return to growth in 2024 once we are past these short-term challenges as there is a significant pent

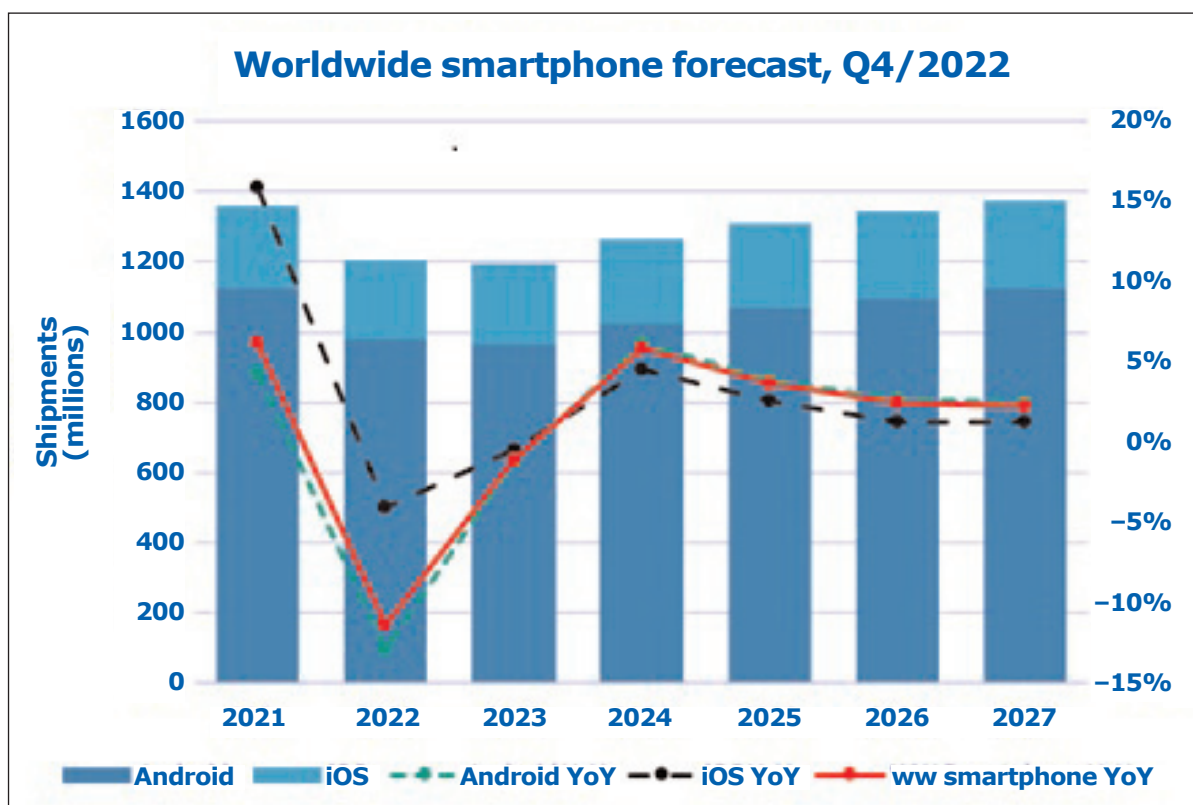
up refresh cycle in developed markets as well as room for smartphone penetration in emerging markets to fuel stable long-term growth."

5G continues to grow and will account for 62% of smartphones shipped worldwide in 2023, rising to 83% by 2027. Market momentum also continues to build around foldable phones as the segment is expected to grow to nearly 22 million units this year — a 50% increase while the overall market contracts. This segment will continue to grow as costs decrease and more OEMs launch this form factor, as we have seen this week with multiple Android foldable launches at Mobile World Congress. Finally, a smartphone average selling price (ASP) that saw rapid growth over the last few years (from \$334 in

2019 to \$415 in 2022) will begin to decline, starting in 2023, and is expected to reach \$376 by end of the forecast period.

"2023 is set to be a year of two halves, with the first half piggybacking off the downhill slide from the fourth quarter of 2022," says Anthony Scarsella, research director with IDC's Mobility and Consumer Device Trackers. "Most regions will face double-digit declines in the first half of the year, make a turn into positive territory in the third quarter, and then boost into double-digit growth in the last quarter of the year," he adds. "We expect the influx of premium flagships that typically launch in the third and fourth quarters will keep the full-year decline from being worse."

www.idc.com/

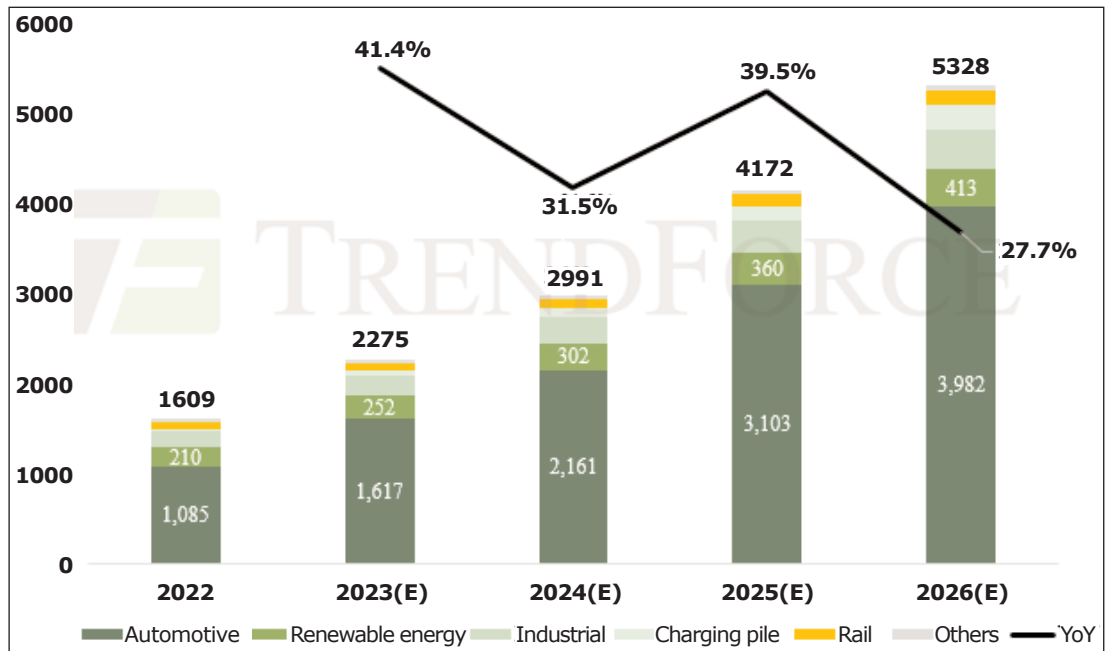


SiC power device market rising 41.4% to \$2.28bn in 2023 CAGRs of 38% for EVs and 19% for renewable energy segments to drive growth to \$5.33bn in 2026

According to its latest survey of the market for compound semiconductors, market research firm TrendForce projects that the global market for silicon carbide (SiC) power devices will grow by 41.4% year-on-year to \$2.28bn in 2023, highlighted by chip-makers onsemi and Infineon respectively forming collaborative relationships with both carmakers and developers of energy solutions, for the two largest application segments: electric vehicles (\$1.09bn in 2022, comprising 67.4% of the market) and renewable energy (\$210m in 2022, or 13.1% of the market).

US-based onsemi has entered into a strategic agreement to provide its EliteSiC 1200V power modules to Volkswagen for main traction inverters. Kia has also adopted the EliteSiC series for its latest electric compact crossover SUV, EV6 GT. Also, US-based Wolfspeed has strengthened its partnership with major carmaker Mercedes-Benz, signing an agreement to supply its SiC power devices for use in electric vehicles.

In renewable energy, onsemi has begun collaborating with Ampt to provide power semiconductor devices for solar photovoltaic and energy storage systems. Specifically, Ampt will adopt onsemi's SiC MOSFET for its DC string optimizers. Likewise, Infineon's CoolSiC devices have been adopted by Taiwan-based Delta Electronics for its bi-directional inverters, which can serve as a hybrid three-in-one system for the integration of solar photovoltaics, energy storage, and charging of electric vehicles. Cool-SiC devices have also been selected by US-based hydrogen platform developer Bloom Energy to further



improve the efficiency of its fuel cell system and electrolyzer.

SiC substrates not only account for up to 49% of the cost of a SiC power device but also determine the product's quality. Currently, Wolfspeed has more than 60% of the market for SiC substrates. Recently, Japan's Resonac (formerly Showa Denko) secured a long-term agreement with Infineon to first supply mostly 6-inch SiC materials, and then to support Infineon's transition to 8-inch SiC. Also, France-based Soitec has expanded its collaboration with STMicroelectronics (ST), in which ST will use Soitec's SmartSiC technology to manufacture 8-inch SiC substrates.

Regarding the growth in SiC substrate production capacity, Wolfspeed currently has a plant for producing 8-inch SiC substrates, and plans to build a second fab for SiC power devices on 8-inch substrates, this time sited in Germany (in which automotive electronics component maker ZF Group is a joint investor, committing hundreds of millions of dollars).

Currently, semiconductor companies worldwide are highly attentive

to the transition in SiC substrate diameter. With Wolfspeed being the first to activate production capacity for 8-inch SiC substrates, other suppliers will follow suit and pursue collaborations with player both upstream and downstream in the supply chain, expects TrendForce. The market research firm hence forecasts that the global SiC power device market will climb to about \$5.33bn in 2026. The two largest application segments will remain electric vehicles (rising at a CAGR of about 38% from 2023 to \$3.98bn in 2026) and renewable energy systems (rising at a CAGR of about 19% from 2023 to \$410m in 2026), concludes TrendForce.

The market for third-generation (compound) semiconductors encompasses products based on silicon carbide (SiC) and gallium nitride (GaN). In particular, SiC products account for about 80% of the total market value. SiC is suitable for applications that require high voltages and high current levels. The adoption of SiC power devices will hence further improve the efficiency of electric vehicles and renewable energy systems.

www.trendforce.com

Adoption of 800V in mass-market EVs to boost transition of power electronics to SiC

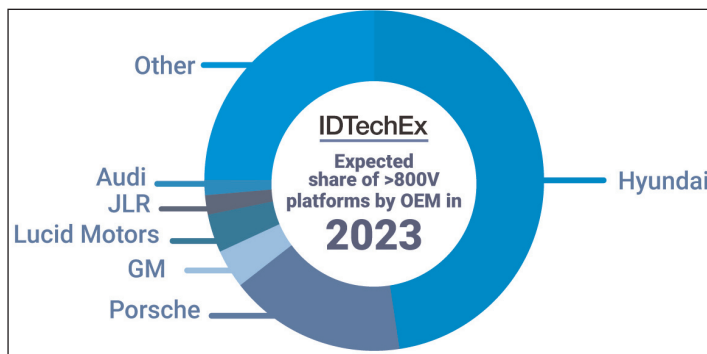
Hyundai's 800V E-GMP-based model sales more than double in Korea

The demand for electric vehicle (EV) power electronics will increase dramatically in the next ten years, primarily driven by rapid growth in the battery electric vehicle (BEV) car market, where market analyst firm IDTechEx predicts a compound annual growth rate (CAGR) of 15% globally over the next decade. Currently, the weighted-average battery capacity of BEV cars is increasing in all regions, piling pressure on battery supply chains, and creating uncertainty. The result is that drive cycle efficiency must come to the forefront of powertrain design, meaning the time has come for high-voltage wide-bandgap (WBG) power electronics.

The new IDTechEx report 'Power Electronics for Electric Vehicles 2023–2033' provides insight into the evolving semiconductor and package materials, including silicon, silicon carbide (SiC) and gallium nitride (GaN) semiconductors, die-attach materials, wire bonding and thermal management, as well as forecasts detailing unit sales, GW and US\$ demand for inverters, onboard chargers (OBC) and DC-DC converters segmented by voltage (600V, 1200V) and semiconductor type (Si, SiC, GaN).

While silicon insulated-gate bipolar transistors (IGBTs) have dominated the medium-to-high power device range for 20 years, including in EV power electronics, they are giving way to a new generation of WBG materials: SiC and GaN. This will fundamentally impact the design of new power devices, including the package materials, as high-voltage and high-power-density modules operating at higher temperatures becomes the trend.

The two drivers often cited to move from 350–400V to 800V and beyond are higher power levels of DC fast charging (DCFC), for example 350kW, and drive cycle efficiency gains. DCFC compatibility



Expected share of 800V platforms by OEM in 2023.

today is a relatively weak driver due to low availability versus AC chargers and the high costs associated with 800V infrastructure. Indeed, IDTechEx's report 'Charging Infrastructure for Electric Vehicles and Fleets 2022–2032' estimates that about 3 million AC charging installations took place in 2022, compared with ~50,000 DCFCs over 100kW. In addition, higher levels of DCFC do not necessarily drive a transition to 800V, although it is more optimal. Tesla is a good example, having deployed 250kW superchargers without moving beyond its 350V platform.

The efficiency argument for 800V is the stronger one. This allows joule losses to be reduced and high-voltage cabling to be downsized. Combined with SiC MOSFETs, it typically leads to 5–10% efficiency gains, which can potentially downsize the expensive battery, save costs, or improve the vehicle's range, creating a competitive advantage.

Yet, it is a challenging time for the automotive industry and 800V adoption experienced some pitfalls in 2022. The Lucid Air, the first 900V production car, sold about 7000 units in 2022 after an initial goal of 20,000. Porsche's Taycan was also one of the OEM's best-selling models in Europe in 2020–2021, but sales declined in 2022. Both are the results of continued parts shortages and supply chain challenges,

for example wire harness shortages due to the Russia-Ukraine war.

On the other hand, Hyundai is demonstrating the success of 800V platforms. Sales of its models using the 800V E-GMP (Electric – Global Module Platform)

more than doubled in South Korea to about 70,000 units/year, driven by the popularity of the IONIQ 5 and Kia EV6 models. This takes the 800V car market out of the luxury segment and predominantly into mainstream car segments for the first time. To support the rapid growth, Hyundai is diversifying its SiC supply partnerships, signing new deals with Onsemi and STMicroelectronics in 2022 to add to existing relationships with Infineon and Vitesco.

China is also signaling a transition to 800V vehicles, with development plans from major OEMs in 2022, including BYD, XPeng, Great Wall Motors, GAC, and others. These vehicles will most likely use SiC MOSFETs, allowing the SiC industry to tap into the world's largest EV market, as China sold over 6.5 million EVs in 2022.

While 1200V SiC MOSFETs (adopted in 800V vehicle platforms) will play a key role in optimizing drive cycle efficiency, it is still only one piece of the puzzle. Drive cycle efficiency can be improved in many areas, from improved battery chemistry to solar bodywork, high-voltage cable reduction per vehicle, 600V SiC, improved motor design, and so on. The task for automakers is to work towards constantly improving the overall drive cycle efficiency to ensure that battery supply does not go wanting.

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PRFI moves to larger lab and office premises

Doubling of cleanroom space allows expansion of business

PRFI Ltd of Cambridge, UK (which designs and develops RFICs, MMICs and microwave/millimeter-wave modules) has moved to new premises at Abbey Barns in Ickleton, near Cambridge.

Housed in a converted and restored agricultural building that originally dates from the 15th century, the new PRFI facility has a larger cleanroom and more office space to allow for expansion of the business.

Specifically, the ground floor provides open-plan office space, along with a cleanroom that is double the size of the company's previous clean area. There is also additional laboratory space outside the cleanroom, as well as a meeting room and kitchen facilities. A mezzanine floor above provides a second, larger, meeting room and a staff relaxation area.



"Moving to these new premises is a significant step forward for the company, giving us a self-contained building with enough space to expand as the business grows," says CEO Liam Devlin. "The offices are also conveniently located, close to good travel links by rail as well as the M11 motorway, and with Stansted Airport only 20 miles away."

PRFI has a list of clients for its microwave and mmWave design services that includes Samsung, Sony, Analog Devices, BAE Systems and Qorvo. So far, the firm has designed over 100 custom ICs at frequencies ranging from baseband to 100GHz. In-house test facilities span both bare die (RFOV) and SMT packaged components. Designs are used in applications from test instrumentation to infrastructure equipment and very high-volume consumer wireless devices. Microwave and mmWave module development activity encompasses technologies including conventional SMT on laminate substrates, high-density interconnect (HDI), chip and wire, thin film, thick film and LTCC.

www.prfi.com

Guerrilla RF completes final closing of \$9.2m private placement equity financing

Gross proceeds of \$9.2m including \$5m from initial closing in January

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — a provider of radio frequency (RF) and microwave communication solutions for wireless OEMs — has completed its private placement equity financing, selling about 7.1 million units to accredited investors (each unit comprising one share of the firm's common stock and one warrant to purchase one half of a share of common stock) for \$1.30 per unit. The warrants have an exercise price

of \$2 per share and a term of five years. The private placement has resulted in aggregate gross proceeds of about \$9.2m (including \$5m from the initial closing in early January).

"The funds will provide the resources needed to support our working capital, expand our R&D initiatives and accelerate our growth through new market penetration, expand our product offerings, and capitalize on our

strong competitive position," says founder & CEO Ryan Pratt.

"These investments in our expanded design center, lab space and R&D initiatives are expected to translate into future revenue," he adds. "The strong investor demand is a positive indicator of confidence in our team's ability to expand into different markets spanning automotive to SATCOM, GPS and infrastructure-related projects."

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Mitsubishi Electric to build new 8-inch SiC fab to boost power semiconductor production

Five-year investment plan doubled to ¥260bn through March 2026

Tokyo-based Mitsubishi Electric Corp is to double the investment plan (that it announced in 2021) from ¥130bn to about ¥260bn in the five-year period to March 2026, mainly for constructing a new wafer plant to increase production of silicon carbide power semiconductors.

Under the plan, Mitsubishi Electric expects to respond to the rapidly increasing demand for SiC power semiconductors for electric vehicles (EVs) as well as expanding markets for new applications that require, for example, low energy loss, high-temperature operation or high-speed switching.

About 100bn yen of the 130bn yen increased investment will be used to construct a new 8-inch SiC wafer plant and to enhance related production facilities. The new factory, which will incorporate an owned facility in the Shisui area of Kumamoto Prefecture, will produce large-diameter 8-inch SiC wafers. The firm will also enhance its production facilities for 6-inch SiC wafers to meet the growing demand in this sector.

In addition, Mitsubishi Electric will newly invest about 10bn yen in a new factory that will consolidate existing operations (currently

dispersed throughout the Fukuoka area) for the assembly and inspection of power semiconductors. The integration of design, development and production technology verification is expected to greatly enhance the company's development capabilities and facilitate timely mass production in response to market demand.

The remaining 20bn yen of the new investment will be targeted at equipment enhancements, environmental arrangements and related operations.

www.mitsubishielectric.com/semiconductors/products/powermod

ROHM's silicon carbide devices chosen by Apex for new power module family

1200V S4101 SiC MOSFETs & 650V S6203 SiC SBD supplied as bare die

Japan's ROHM says its silicon carbide MOSFETs and Schottky barrier diode (SBD) are being adopted by precision power analog company Apex Microtechnology of Tucson, AZ, USA (a part of HEICO Corp's Electronics Technologies Group) for a new line of power modules. The product family currently includes the three-phase SA310 module, suitable for driving high-voltage BLDC motors, as well as two half-bridge devices SA110 and SA111, which suit a wide range of high-voltage applications.

ROHM's 1200V S4101 SiC MOSFETs and 650V S6203 SiC SBD are supplied in bare die form, enabling Apex to save space and increase the performance and reliability of its modules. In addition to the SiC devices, Apex's new line of power modules use ROHM's tightly matched BM60212FV-C gate drivers in bare die format, contributing to high-efficiency operation of high-voltage motors and power supplies.

By using these parts in bare die form, Apex has been able to increase the levels of integration

offered by these power modules. According to a study commissioned by the company, such modules are usually 67% smaller than discrete solutions developed by customers. Apex is often able to include not only MOSFETs, gate drivers and SBDs but also bootstrap supply and bypass capacitors with compact surface-mount form factors.

"Apex Microtechnology's portfolio of high-power, high-precision analog and mixed-signal solutions are used in some of the world's most demanding applications," says the firm's president Greg Brennan. "Our devices power systems ranging from medical equipment in a surgical suite, to flight instrumentation, to satellites in orbit. This in mind, Apex designs its products to meet or exceed the most stringent standards throughout the industry, and as such we seek to partner with suppliers sharing our high standards of quality and care," he adds. "Not only has the service and support we have received from ROHM been excellent, but they have been able to stably

supply us throughout the semiconductor shortages, allowing us to continue production and on-time deliveries to our customers. As Apex continues to develop innovative analog and mixed-signal solutions in order to solve the industry's complex challenges, we look forward to additional collaboration with ROHM."

Apex designs and manufactures precision power analog monolithic, hybrid and open frame components for a wide range of industrial, test & measurement, medical, aerospace and military applications. ROHM provides SiC power semiconductors along with power solutions combined with gate driver ICs.

"Together with Apex Microtechnology, we want to further improve the efficiency of high-power applications by fully exploiting the potential of ROHM's strengths in power and analog technologies," says Jay Barrus, president of ROHM Semiconductor USA LLC.

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

Lawrence Livermore chooses SemiQ's silicon carbide diodes for particle accelerator project

Top-side solderable 1200V 10A SiC diode in SMC package to withstand continuous high-current-pulse operation at 15 times rated current

SemiQ Inc of Lake Forest, CA, USA — which designs, develops and manufactures silicon carbide (SiC) power semiconductors and 150mm SiC epitaxial wafers for high-frequency, high-temperature and high-efficiency power semiconductor devices — says that Lawrence Livermore National Laboratory (LLNL) has chosen it to supply

silicon carbide diodes for an ongoing particle accelerator project.

SemiQ developed its top-side solderable 1200V 10A silicon carbide diode in a SMC (surface-mount component) package to withstand continuous high-current-pulse operation at 15 times rated current. The diodes are used as a snubber

circuit and energy discharge circuit; with 60 devices in parallel on a single pulser board with high packing density.

The accelerator will enable x-ray images that can be used to certify the safety, security and effectiveness of modernized nuclear warheads without nuclear testing.

www.SemiQ.com

ROHM's SiC SBDs chosen by Murata for data-center power supply units

Murata using ROHM's SiC MOSFETs in 3-phase inverter development

Japan's ROHM says that its high-performance silicon carbide (SiC) Schottky barrier diodes (SBD) are being used by Murata Manufacturing Group company Murata Power Solutions to increase performance and reduce the size of power supply units (PSUs) for data-center applications. ROHM says that its SCS308AH SiC SBDs feature high surge resistance and short recovery time, enabling high-speed switching.

Murata's D1U front-end AC-DC power supply series includes many active units such as the D1U54P-W-2000-12-HB3C and D1U54P-W-1200-12-HC4PC, highly efficient power-factor-corrected front-end power supplies that provide 12V main and 12V/3.3V standby output. Multiple units can share current and operate in parallel.

The power supplies support hot-plugging and are protected from fault conditions such as over-temperature, over-current and over-voltage. Also, the low-profile 1U package makes them suitable for delivering reliable, efficient power to servers, workstations, storage systems and other 12V distributed power systems

while minimizing the number of required power modules.

"By moving to SiC devices, we are able to develop power supplies with higher efficiency and higher power density. We can push the switching frequency of SiC devices higher to reduce the volume of passive components and heatsinks," remarks Dr Longcheng Tan, senior electrical engineer and project leader, Murata Power Solutions. "Murata Group has a special procurement department for evaluating different SiC device vendors and their products. ROHM was chosen, mainly because their products are reliable. Samples were also available for prototyping, and ROHM provides prompt support. Their performance of the SBDs is excellent, and we are now in mass production with the D1U power supplies. Murata is also using ROHM's SiC MOSFETs in 3-phase inverter development projects, and the performance of those SiC MOSFETs is satisfying," he adds.

"We are the leading company in SiC power semiconductors and have achieved a significant technological lead in this field along with the provision of power solutions combined with gate driver ICs,"

claims Jay Barrus, president, ROHM Semiconductor USA LLC.

"Together with Murata Power Solutions, we want to further improve the energy efficiency of power supply systems by using the full potential of SiC technology for industrial and data infrastructure."

ROHM's latest third generation of SiC SBDs, which have been adopted by Murata Power Solutions, offer greater surge current capability while further reducing what is claimed to be the industry's smallest forward voltage of its second-generation SBDs. The total capacitive charge (Q_c) of ROHM's SiC SBDs is small, reducing switching loss while enabling high-speed switching operation. In addition, unlike silicon-based fast-recovery diodes where the t_{rr} (reverse recovery time) increases along with temperature, ROHM's SiC devices maintain constant characteristics. Also, the firm says that its SiC SBDs allow manufacturers to reduce the size of industrial equipment and consumer electronics, making them suitable for use in power-factor correction (PFC) circuits and inverters.

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

onsemi's EliteSiC technology to be used in BMW's electric vehicle drivetrains

Long-term supply agreement to equip BMW's EVs with onsemi EliteSiC die

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA has announced a long-term supply agreement (LTSA) for its EliteSiC technology to be used by German premium car manufacturer BMW AG in its electric drivetrains for 400V DC bus. onsemi's latest EliteSiC 750V M3 die is used in a full-bridge power module delivering several hundred kW of power.

onsemi says that the companies' strategic collaboration during the development and integration of the electric drivetrain enabled it to provide differentiated and application-specific die solutions, including optimized size and layout as well as high performance and reliability. Enhanced electrical and



mechanical characteristics produce high efficiency and lower overall losses while delivering the highest system-level performance, the firm adds.

"With maximum range being a primary consideration for purchasing an EV, onsemi's system approach

for optimized performance across all of BMW's electric vehicles provides a key competitive advantage," says Asif Jakwani, senior VP & general manager, Advanced Power Division, Power Solutions

Group, onsemi. "In addition, we are able to support the rapidly increasing demand for BMW's premium electric vehicles by continuously ramping all production steps of our robust, vertically integrated SiC supply chain."

www.onsemi.com

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onsemi launches simulation tools to bring complex power electronics applications to market faster

PLECS models and system-level simulation valid for hard- and soft-switching applications, corner modeling and custom parasitic environment, enabling virtual prototyping

For its EliteSiC silicon carbide (SiC) product family and its applications, power semiconductor IC supplier onsemi of Phoenix, AZ, USA has launched the online Elite Power Simulator and Self-Service PLECS Model Generator, which provide insights for complex power electronic applications through system-level simulations at an early stage of the development cycle. The tools are said to save power electronic engineers time by providing accurate simulation data, enabling EliteSiC product selection tailored to customer applications, instead of costly and time-consuming hardware fabrication and testing.

Users have the power and flexibility to create high-fidelity system-level PLECS models when the Elite Power Simulator is deployed in conjunction with the Self-Service PLECS Model Generator. Whether uploaded to onsemi's Elite Power Simulator or downloaded for direct

use, the self-service PLECS models deliver the optimization and accuracy required for demanding power electronic simulations. The models are generated based on typical or worst-case conditions to let the customer design within the technology boundaries. The capability to define application-specific parasitics ensures that the generated PLECS models provide highly accurate results for the customer's system-level simulations.

"Our PLECS simulator has proven very popular with power designers due to speed and ease of use," comments Jost Allmelling, managing director & co-founder, Plexim. "It is particularly exciting to see the truly novel aspects here, including the ability to simulate soft switching accurately, the customized models via the onsemi Self-Service PLECS Model Generator and the ready-made models for corner cases."

To date, system-level simulators and their associated PLECS models have only been valid for hard-switching topologies, with simulation results for soft-switching applications such as inductor-inductor-capacitor (LLC) or capacitor-inductor-inductor-capacitor (CLLC) being highly inaccurate. onsemi claims that its industry-first PLECS models break this trend and solve this problem.

"This is a significant step for the industry, increasing its ability to get both hard- and soft-switching designs to market quickly," says Asif Jakwani, senior VP & general manager of the Advanced Power Division (part of onsemi's Power Solutions Group). "Our tools enable our customers to understand how our devices perform in their application environment and fully optimize the performance within the boundaries of the technology."

www.onsemi.com/design/tools-software/elite-power-simulator

onsemi showcases intelligent power technologies at APEC

New online power simulator tool for EliteSiC family demonstrated

At the Applied Power Electronics Conference (APEC 2023) in Orlando, Florida (19–23 March), power semiconductor IC supplier onsemi of Phoenix, AZ, USA featured a diverse range of demonstrations for the industrial and automotive markets, including an area dedicated to the EliteSiC silicon carbide family, complete with an electric vehicle (EV) charging station. Another showcase demonstrates the latest industrial power supply and charging solutions: a 6.6/11kW power factor correction (PFC) inverter, an ultra-high-density 240W USB PD 3.1 solution and a 600W battery charger.

At APEC, onsemi introduced and demonstrating a new simulator for the EliteSiC family. The online tool allows engineers to virtually test and validate EliteSiC products through an expansive library of customizable circuit technologies. When the simulator is used with advanced PLECS models, engineers can gather insights into the application at a very early stage of the design cycle without relying on hardware fabrication and testing. At APEC, onsemi gave two presentations:

- 'Online SiC System Level Simulator Driven by Advanced PLECS Models' by Didier Balocco

- 'A Virtual Prototyping System for Silicon Carbide Power Modules' by James Victory.

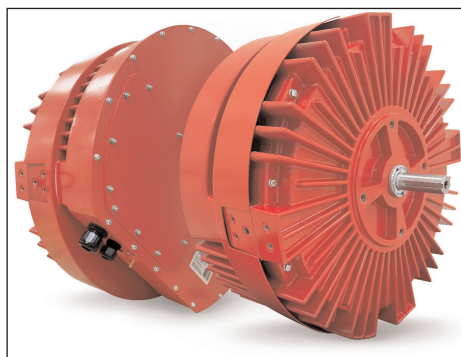
Alongside the simulator, onsemi announced a new series of 1200V Trench Field Stop VII (FS7) insulated-gate bipolar transistors (IGBTs). The devices provide low switching loss and optimized switching to provide high-efficiency operation in various industrial applications including motor control, uninterruptable power supply (UPS) and solar applications.

www.apec-conf.org
www.onsemi.com/products/discrete-power-modules/silicon-carbide-sic

Infineon providing CoolSiC MOSFETs for Infinitum's air-core motor drive

Infineon Technologies AG of Munich, Germany is joining forces with Infinitum of Round Rock, TX, USA, creator of the sustainable air-core motor. Infineon will provide silicon carbide CoolSiC MOSFETs and other key semiconductor components that contribute to the Infinitum motor system's precise motor control, optimal power and energy savings.

The Infinitum Aircore EC motor for commercial and industrial applications was showcased at Infineon's booth at Applied Power Electronics Conference (APEC 2023) in Orlando, FL, USA (19–23 March). The motor uses Infinitum's patented air-core motor design, which replaces the heavy iron used in traditional motors with a light-weight printed circuit board (PCB). The firm's motors are reckoned to be 50% smaller and lighter, 10% more



The Infinitum Aircore EC motor.

efficient and use 66% less copper than traditional motors.

"Infineon is a leading provider of silicon carbide chips and embedded technologies that can greatly contribute to Infinitum motor system's value-added features from an energy, carbon footprint and performance standpoint," comments Infinitum's president Rick Tewell. "We are

excited to team with Infineon on our continued collaboration. The company helps us bring innovative new breakthroughs to our customers in the industrial sector," he adds.

"Infineon and Infinitum are two companies with the same mission to drive decarbonization, with greater efficiency in motor control and less waste in hardware for industrial applications," says Michael Williams, director of product marketing for Infineon's Industrial Power Control Division. "With our proven SiC and semiconductor technologies, we are helping Infinitum deliver more precise motor control for better power and energy savings."

www.apec-conf.org

www.goinfinitum.com

www.infineon.com/apec

GaN Systems unveils 11kW/800V on-board charger reference design

GaN-based OBC delivers 36% higher power density and 15% lower BOM cost versus SiC transistors

At the Applied Power Electronics Conference (APEC 2023) in Orlando, FL, USA (19–23 March), GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) unveiled a new GaN-based 11kW/800V on-board charger (OBC) reference design that is claimed to deliver 36% higher power density and up to 15% lower bill of materials (BOM) cost compared with silicon carbide (SiC) transistors.

The OBC combines a three-level flying capacitor topology for a bridgeless totem-pole power factor correction (PFC) structure and dual active bridge in AC/DC and DC/DC, respectively. The GaN transistors, in the three-level topology with

superior switching performance, reduce the transistor voltage stress to half and allow the economical 650V GaN to be used in this and many other 800V applications.

Key features of the OBC design are:

- AC/DC stage peak efficiency >99%, DC/DC stage peak efficiency >98.5%;
- smaller total semiconductor power loss;
- minimized gate ringing, lower noise and ringing during switching transitions;
- improved thermal performance by employing an IMS interface.

GaN power semiconductors increase the efficiency of the OBC by reducing switching losses and power dissipation during operation. This improved efficiency reduces power losses during electric vehicle (EV) charging, making the OBC sig-

nificantly more energy efficient and cost effective, says the firm. For example, the solution's higher efficiency reduces the complexity and cost of the cooling system design. The compact and highly efficient design helps to reduce overall size and weight of the OBC, freeing up space and weight that can be allocated to other areas of the EV design.

"The GaN-powered 800V on-board charger reference design is a major advance that will accelerate GaN adoption in the automotive sector," says CEO Jim Witham. "Our new cutting-edge design delivers extraordinary gains in efficiency, power density, cost, thermals and CO₂ footprint reduction to deliver a game-changing solution for our automotive customers."

www.gansystems.com

Infineon to acquire GaN Systems for US\$830m

GaN Systems' R&D resources, application understanding and customer project pipeline to accelerate GaN roadmap for power systems

Infineon Technologies AG of Munich, Germany has signed a definitive agreement to acquire GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) for US\$830m. Employing more than 200 staff, GaN Systems has a broad portfolio of transistors that address applications including consumer electronics, data-center servers and power supplies, renewable energy systems, industrial motors, and automotive electronics.

"GaN technology is paving the way for more energy-efficient and CO2-saving solutions that support decarbonization. Adoption in applications like mobile charging, data-center power supplies, residential solar inverters, and onboard chargers for electric vehicles is at the tipping point, leading to a dynamic market growth," says Infineon's CEO Jochen Hanebeck. "The planned acquisition of GaN Systems will significantly accelerate our GaN roadmap, based on unmatched R&D resources, application understanding and customer project pipeline. Following our strategy, the combination will further

strengthen Infineon's leadership in power systems through mastery of all relevant power technologies, be it on silicon, silicon carbide or gallium nitride," he adds.

"The GaN Systems team is excited about teaming up with Infineon to create highly differentiating customer offerings, based on bringing together complementary strengths. With our joint expertise in providing superior solutions, we will optimally leverage the potential of GaN," says GaN Systems' CEO Jim Witham.

"Combining GaN Systems' foundry corridors with Infineon's in-house manufacturing capacity enables maximum growth capability to serve the accelerating adoption of GaN in a wide range of our target markets," he adds. **GaN Systems' foundry corridors with Infineon's in-house manufacturing capacity enables maximum growth capability**

"As an integrated device manufacturer with a broad technology capability, Infineon enables us to unleash our full potential."

As a wide-bandgap material, GaN offers value through higher power density, higher efficiency

and size reductions, especially at higher switching frequencies. These properties enable energy savings and smaller form factors, making GaN suited to a wide range of applications. GaN revenue for power applications will rise at a compound annual growth rate (CAGR) of 56% to about US\$2bn by 2027, according to 'Compound Semiconductor Market Monitor-Module I Q4 2022' from market analyst firm Yole.

As such, GaN is becoming a key material for power semiconductors, alongside silicon and silicon carbide, and coupled with new topologies such as hybrid flyback and multi-level implementations. In February 2022, Infineon said that it was investing more than €2bn in a new front-end fab in Kulim, Malaysia, to strengthen its market position in wide-bandgap semiconductors. The first wafers will leave the fab in second-half 2024, adding to Infineon's existing wide-bandgap manufacturing capacities in Villach, Austria.

The acquisition of GaN Systems in an all-cash transaction will be funded from existing liquidity. The transaction is subject to customary closing conditions, including regulatory approvals.

www.gansystems.com
www.infineon.com

Infineon highlights silicon and wide-bandgap power electronic devices at APEC

At the Applied Power Electronics Conference (APEC 2023) in Orlando, FL, USA (19-23 March), Infineon Technologies AG of Munich, Germany showcased its range of high-performance and energy-efficient power electronic devices.

Infineon featured five technology zones highlighting its sustainable solutions — including data-center power management, efficient

energy storage systems, comprehensive charging options, fast EV charging, and energy-efficient motor control solutions — demonstrating how the company balances efficiency and performance to meet specific application requirements.

Infineon says that the demonstrations showcased its power solutions' green potential and higher performance with fewer

energy losses, enabling up to 10.5% energy savings per year for consumers.

Infineon also participated in over 20 industry and technical sessions, including nine chaired tracks and three exhibitor sessions. Also, its booth featured product-to-system models in power management, demonstrating how its solutions can enable a sustainable future.

www.apec-conf.org

Transphorm and Weltrend partner to release integrated GaN system-in-package

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — and fabless firm Weltrend Semiconductor Inc of Hsinchu Science Park, Taiwan, which specializes in the design, testing, application development and distribution of mixed-signal/digital ICs in power supplies, motor controls and image processing, have released their first GaN system-in-package (SiP).

The WT7162RHUG24A SiP integrates Weltrend's WT7162RHSG08 multi-mode flyback PWM controller with Transphorm's 240mΩ, 650V SuperGaN FET.

Despite adding the PWM chip, the surface-mount device is available in a 24-pin 8x8 QFN package, allowing a low profile/small system footprint and reducing PCB size. With peak power efficiency of more than 93%, power density is 26W/in³.

As well as the targeted topology (flyback with QR mode/valley-switching multi-mode operation),

other key specifications include: wide output voltage operation (USB-C PD 3.0 and PPS 3.3~21V); and maximum frequency of 180kHz.

The WT7162RHUG24A SiP is optimized for use in high-performance, low-profile 45–100W USB-C PD power adapters for charging mobile/IoT devices such as smartphones, tablets, laptops, headphones, drones, speakers and cameras.

Transphorm showcased the Weltrend SiP for the first time at the 2023 Applied Power Electronics Conference (APEC), where the firms are also releasing details of the related WTDB_008 65W USB PD Power Adapter Evaluation Board.

"The WT7162RHUG24A is the industry's first publicly announced SiP using Transphorm GaN. It enables manufacturers to develop a less expensive system solution given fewer components are required and a smaller PCB can be used among other advantages. It also reduces system development time. Effectively, we're removing design barriers for adapter manufacturers," says Weltrend's presi-

dent Tony Lin. "Notably, this product also allows Weltrend to move into a new market. It is the first-ever SiP for our PWM controllers, validating our commitment to supporting high-volume growth sectors. And, with the integration of the GaN FET, we've raised the level of performance output," he adds.

"The adapter fast charger market is a fast-growing segment for GaN adoption today," notes Transphorm's president & chief operating officer Primit Parikh. "We are gaining market share and continue to innovate, most recently with this GaN SiP, which allows for even easier use of our GaN devices," he adds. "Weltrend has delivered a leading power conversion platform which creates a simple-to-use solution for adapter/fast-charger customers that both companies can use to accelerate wins in this market."

Device samples of the new WT7162RHUG24A will be available in second-quarter 2023.

www.apec-conf.org
www.transphormusa.com
www.weltrend.com

Transphorm presents at APEC 2023

Transphorm highlighted its broad spectrum (low- to high-power) GaN power conversion solutions at the Applied Power Electronics Conference (APEC 2023) in Orlando (19–23 March).

Specifically, the firm showcased the new WT7162RHUG24A device, the SuperGaN system-in-package (SiP) developed with Weltrend Semiconductor Inc of Hsinchu Science Park, Taiwan designed to round out its FET portfolio.

Transphorm says that this device will provide another opportunity to easily and quickly design in its high-performance GaN platform while reducing bill-of-materials (BOM) component count and overall system cost.

Transphorm is also showcasing new in-production products from top-tier global brand customers representing various markets. APEC attendees will also learn about drop-in and replacement solutions for existing GaN power applications.

One core platform, spanning the power spectrum

Transphorm claims to support the largest range of power conversion requirements (45W to 10+kW) across the widest range of power applications. Its FET portfolio includes 650V and 900V devices, with 1200V devices in development. Since they are JEDEC and AEC-Q101 qualified, they are optimal solutions for power adapters and

computer power supply units (PSUs) through to broad industrial uninterruptible power supplies (UPS) and electric vehicle (EV) mobility systems. The mix of customer products displayed at APEC underscores the broad usability of the SuperGaN platform, says the firm. Speaking engagements

At APEC, Transphorm gave the following presentations:

- 'High-Power 650 V and 1200 V GaN Devices for EV Applications' by Davide Bisi, member of technical staff, Office of the CTO — Industry Session (IS03);
- '900V GaN – Designing for Reliability' by VP of engineering Dr Likun Shen — Industry Session (IS12).

Transphorm releases 3kW inverter board with Microchip's digital signal controller

Evaluation board with SuperGaN FET and dsPIC DSC simplifies and quickens development of high-voltage power systems

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has announced availability of its third high-power GaN design tool using a digital signal controller from Microchip Technology Inc of Chandler, AZ, USA. The TDINV3000W050B-KIT is a 3.0kW DC-to-AC non-isolated full-bridge inverter evaluation board. It pairs Transphorm's TP65H050G4WS 650V, 50m_ SuperGaN FET (in a TO-247 package) with Microchip's dsPIC33CK digital signal controller (DSC) plug-in module (PIM), which includes pre-programmed firmware that can be easily customized per end-application requirements. Transphorm says that use of the new board highlights GaN's superior performance and enables an understanding of how GaN can be used for broad industrial and renewables power systems.

As with the previous two SuperGaN/Microchip DSC evaluation boards (the 4kW TDTP4000W066C-KIT) and the 2.5kW TDTP2500B066B-KIT), the single-phase 3.0kW inverter board

is backed by access to Microchip's worldwide technical support team for firmware development assistance.

"Our dsPIC digital signal controllers and firmware customization expertise complements Transphorm's GaN technology and helps accelerate development while simplifying the design," says Joe Thomsen, vice president of Microchip's MCU16 business unit. "Working together with Transphorm, we are proud to enable flexible and highly efficient power conversion to address a wide range of sustainability applications."

"High-voltage power systems such as EV chargers, uninterruptible power supplies (UPS), and solar inverters are quickly becoming rapid growth markets for GaN. Transphorm's GaN platform was developed with such applications in mind," says Philip Zuk, Transphorm's senior VP of business development & marketing. "Working with Microchip on the firmware side enables us to support important, sustainable customer power system projects in a highly efficient manner. It removes potential limitations that may be experienced

with firmware programming, simplifying development and speeding time to market," he adds. "This collaboration allows renewables and other industries to easily leverage all our GaN has to offer."

Firmware updates for the dsPIC33CK PIM will be available for download from Microchip's website.

Microchip's dsPIC DSCs are supported by a set of embedded design tools created to empower developers, even those with limited expertise. These tools provide intuitive graphical user interface for device initialization in Microchip's free MPLAB X Integrated Development Environment. The software tools are complemented by a full line of programmer, debugger and emulator accessories.

The TDINV3000W050B-KIT is available through distributors Digi-Key Corp and Mouser Electronics Inc.

The evaluation board is designed to be used when developing V2G (vehicle-to-grid) charging systems, solar or photovoltaic (PV) inverters, uninterruptible power supplies (UPS) and other high-voltage power applications.

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Silanna launches its first 100W multi-port fast charger reference design

AnyPort design with front-end PFC converter stage combines ACF controllers, high-power-density DC/DC converters, GaN power switch

Silanna Semiconductor of San Diego, CA, USA, which makes AC/DC and DC/DC power converter ICs, has expanded its family of fast charger reference designs with its first 100W multi-port offering. Built around its CO₂ Smart Power AC/DC controllers and high-frequency DC/DC converters, the RD-16 integrates a front-end PFC converter stage and provides a high-power-density, ultra-efficient, production-ready solution for multi-port 100W USB-PD applications delivering currents up to 5A.

Silanna says that the RD-16 is a gallium nitride (GaN)-based solution — using an Innoscience GaN power transistor — that can simplify and speed charger development by providing everything an engineer needs to rapidly prototype and test a fully functional 100W 2C1A multi-port unit. The design is based on the AnyPort architecture, which offers the flexibility to complete a charger design for a given power level prior to specifying and configuring the specific number and type of

output ports. By allowing a single base charger design to be deployed across a variety of end products with different output configurations, AnyPort can significantly reduce

the complexity of fast chargers and adapters with multiple Type-C and/or Type-A output ports.


The RD-16 brings together Silanna's newest fully integrated AC/DC active clamp flyback (ACF) controller (the SZ1131) and its 100W SZDL3105 and 65W SZPL3102S high-voltage, high-efficiency integrated buck converters, with maximum output currents of 5A and 3.25A, respectively (in 4mm x 4mm and 3mm x 3mm QFN packages, respectively). End-to-end peak efficiency exceeds 92% and is relatively flat across the universal input voltage range (90–265V_{ac}). Because the reference design exceeds conducted and radiated EMI requirements, it eliminates the need for pre-production validation and certification, speeding up the production cycle.

"Our aim is to provide designers with all the tools and support they need to rapidly develop high-efficiency, small-form-factor, low-component-count fast chargers," says Ahsan Zaman, director of product

marketing. "By combining our CO₂ Smart Power family of advanced AC/DC and DC/DC technologies with GaN power switching and our innovative and flexible AnyPort architecture, the RD-16 offers the fastest possible route from prototyping to full production for 100W fast chargers with any number or type of output ports."

The RD-16 is the latest addition to Silanna's family of production-ready reference designs that provide everything needed to develop high-density chargers with low operational and no-load/stand-by power consumption and minimum component count, bill-of-materials (BOM) cost and size. This family includes all-silicon 33W and 45W solutions and silicon- and GaN-based single- and multiple-output 65W USB-PD reference designs. Full availability of PCB Gerber and production files further reduces the time from prototyping to full production.

www.powerdensity.com/reference-design




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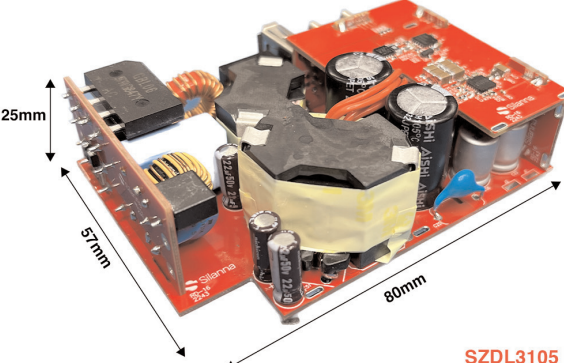
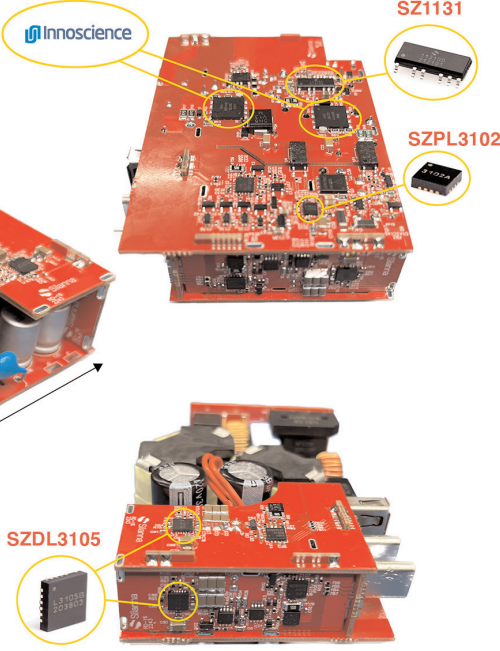
RD-16
100W 2C1A Reference Design

14W/inch³ Power Density (uncased)

Highest Efficiency + Power Density



powerdensity.com

ST extends VIPerGaN power converters to 65W & 100W

Power boosted from 50W for single-switch QR flyback converters

STMicroelectronics of Geneva, Switzerland has extended its high-voltage wide-bandgap power converter family by adding the VIPerGaN100 and VIPerGaN65 for single-switch quasi-resonant (QR) flyback converters up to 100W and 65W. The compact and highly integrated design targets switched-mode power supplies (SMPS) for USB-PD chargers, home appliances, smart-building controllers, lighting, air conditioning, smart metering, and other industrial applications.

Each device integrates a pulse-width modulation (PWM) controller and a 650V enhancement-mode gallium nitride (GaN) power transistor and allows secondary-side regulation using a standard opto-

coupler. Housed in a 5mm x 6mm QFN package, the small footprint and advanced integration ensure superior power density and save bill-of-materials (BoM) costs, it is claimed. Also, the wide-bandgap transistor technology enhances energy efficiency and simplifies thermal management.

With advanced power management and low quiescent current, the converters consume standby power of less than 30mW operating in adaptive burst mode. Each operates in quasi-resonant mode, with dynamic blanking time and valley synchronization to reduce switching losses and maximize efficiency at all input line and load conditions. This assists in reducing energy usage, helping to meet

eco-design codes targeting global energy savings and net-zero carbon emissions, says ST.

Integrated features to ensure safety and reliability include input voltage feedforward compensation to minimize peak power variation, output overvoltage protection, current sensing, input overvoltage protection, and brown-in and brown-out protection. Thermal shutdown is also included, as well as frequency jittering to suppress EMI.

The VIPerGaN100 and VIPerGaN65 are in production now, each in the 5mm x 6mm QFN package, priced from \$2.93 for VIPerGaN100 and \$2.62 for VIPerGaN65, for orders of 1000 units.

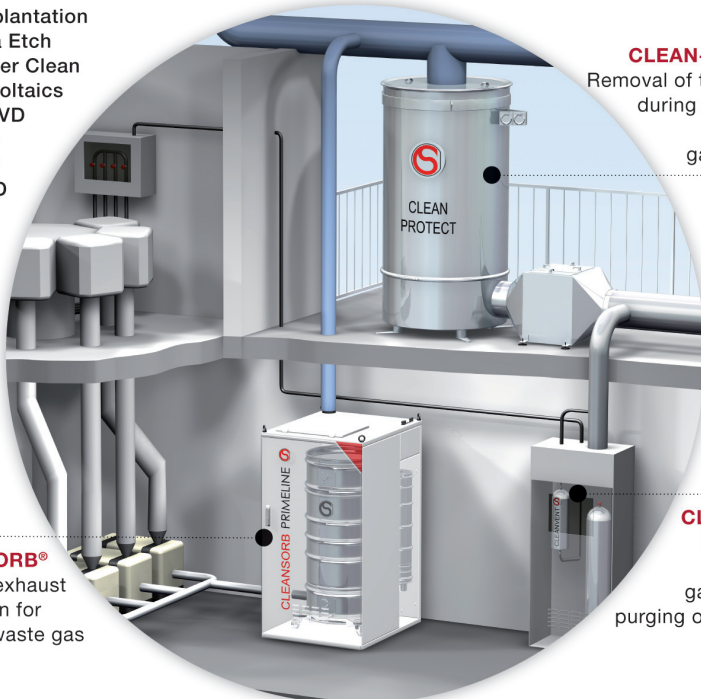
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Richardson to distribute Navitas' silicon carbide power semiconductors in Americas

Navitas Semiconductor has announced a distribution agreement with Richardson Electronics Ltd of LaFox, IL, USA covering SiC power semiconductors for the Americas.

Richardson will focus on Navitas' GeneSiC power MOSFETs and MPS diodes that are rated at 650V–6.5kV. Patented trench-assisted planar-gate technology delivers what is claimed to be the lowest on-resistance $R_{DS(ON)}$ at high temperature and the lowest energy losses at high speeds. "Navitas recognizes Richardson's

long-term partnerships, technical knowledge and robust customer support to American customers who demand high end power semiconductor products," comments Dr Ranbir Singh, Navitas' executive VP. "GeneSiC MOSFETs and MPS diodes are a perfect fit for Richardson's market strongholds of renewable energy, industrial, medical, transportation and energy storage," he adds.

"For years Richardson has developed an excellent portfolio of power management components and

engineered solutions," says Greg Peloquin, executive VP & general manager Power Microwave and Green Energy Solutions Group. "Adding Navitas as a key technology partner is an excellent addition to supporting our customers' needs," he adds. "Their products are world class and provide disruptive technology to our customers looking for superb hard-switching components with excellent lead-times."

www.rellpower.com

www.navitassemi.com

Navitas surpasses 75 million GaN power shipments

Navitas has surpassed the milestone of shipping over 75 million high-voltage GaN units.

Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power integrated circuits. Entering mass production in 2018, its proprietary GaNFast power ICs monolithically integrate GaN power and GaN drive plus control and protection circuits. Next, GaNSense power ICs added autonomous sensing and fast control, with single and half-bridge portfolios. Now, new GaNSense Control ICs combine high-voltage GaN power ICs with high-speed, low-voltage silicon system controllers for even higher integration, ease-of-use and system performance.

Navitas is addressing a 2 billion unit per year mobile fast, and now ultra-fast, charging market opportunity, with over 240 end-customer chargers reaching production. All of the top 10 mobile OEMs are in production or development with Navitas, including Dell, Samsung, Lenovo, LG, Xiaomi, Asus and OPPO, plus a broad range of after-market companies such as Anker, Belkin, Baseus and many more. As smartphone power demand has increased — driven by larger screens, bigger batteries, and 5G functionality —

users have insisted on faster charging and ultra-portability. Now, smartphones such as Realme's GT3 charge from 0–100% in just 9 minutes 30 seconds using a GaNFast 240W charger with power density of more than 2.4W/cc.

As millions of GaN ICs were shipped, Navitas introduced the world's only 20-year limited warranty, heralding GaN's entry into higher-power, more demanding applications, such as home appliances, data centers, solar, energy storage and electric vehicles (EV).

Navitas says that its dedicated Data Center Design Center has created a series of complete, multi-kW platform designs for AC–DC supplies that exceed Europe's strict 'Titanium-plus' high-efficiency standards, are half the size and lower cost than legacy silicon solutions, as confirmed by customers such as Compuware.

In home appliance and industrial markets, motor drives can be made more efficient, smaller and lighter by using GaN in applications such as vacuum cleaners, refrigerator compressors, washing machines and dryers. A typical example is the 400W drive using three GaNSense half-bridge power ICs, with over 70% reduction in power loss.

For residential solar inverters,

GaN can bring an estimated 25% system cost saving versus legacy silicon due to high-frequency operation and integration. In parallel, Navitas' GeneSiC silicon carbide MOSFETs are already in mass production for higher-power commercial string inverters, with customers such as Germany-based KATEK.

Navitas' SiC is also shipping into the EV market, and Navitas' GaN is in development for multi-kW on-board chargers (OBC) and DC–DC converters. For 'Vehicle-to-everything' (V2x) — i.e. using an EV to provide power to other loads, whether a home, clinic or other vehicle — Navitas' EV Design Center platform designs include a 6.6kW '3-in-1' design, with consolidated bi-directional OBC and DC–DC functions, that achieves up to 17% energy savings and a 1.6x increase in power density versus competing solutions.

"Next-gen GaNFast technology was the catalyst for a major upgrade in power electronics, and enabled our IPO within seven years of founding," says co-founder & CEO Gene Sheridan. "We see a GaN opportunity of \$13bn/year by 2026. Our mission is to 'Electrify Our World' and, as each GaN chip sold saves 4kg of CO₂, we've so far saved over 150,000 tons of CO₂ versus legacy silicon chips."

Navitas' Q4 revenue up 68% year-on-year, boosted by acquisitions

Q1 to be flat, before growth in EV, solar/storage, appliance/industrial and mobile/consumer markets

For fourth-quarter 2022, gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA has reported revenue of \$12.3m, up 21% on \$10.2m last quarter and 68% on \$7.3m a year ago. Full-year revenue grew by 60%, from \$23.7m in 2021 to \$37.9m in 2022. However, this takes into account revenue from silicon carbide (SiC) power semiconductor device designer and maker GeneSiC Semiconductor Inc of Dulles, VA, USA (acquired in mid-August).

On a non-GAAP basis, full-year gross margin has fallen from 45.4% in 2021 to 40.8% for 2022. Quarterly gross margin is down on 44.3% a year ago to 40.6% in Q4/2022. However, this is up from 38.4% last quarter, and exceeds the forecasted 40%.

Quarterly operating expenses have grown further, from \$10.1m a year ago and \$14.2m last quarter to \$17m. This increased full-year OpEx from \$35.3m in 2021 to \$56.2m for 2022.

Quarterly net loss has risen further, from \$7m a year ago and \$9.5m last quarter to \$9.7m in Q4/2022. Full-year net loss hence grew from \$24.8m to \$37.6m.

"2022 was a pivotal year for Navitas as we expanded beyond the mobile market into additional high-growth markets on a global scale," says CEO & co-founder Gene Sheridan. "We completed three strategic transactions adding SiC, digital iso-

lators [Belgium-based VDD Tech, acquired in last July] and Si analog controllers [Halo Microelectronics, acquired from a joint venture partner this January] to enable power management solutions across a broad range of next-generation, electrified applications," he adds.

Customer/product highlights in 2022 are listed as:

Electric vehicle:

- the firm's SiC technology has been adopted by over a dozen road-side charger customers and is being integrated in more than 50% of the US roadside chargers including Electrify America and EVgo;
- SiC is in development or production for on-board chargers with major customers including General Motors, BYD and Mercedes AMG;
- a joint EV design center has been opened with Geely — a rising China-based EV player with almost 10% of worldwide EV sales in 2022.

Solar/storage: SiC customers include AP Systems, Power Electronics, Chint, Growatt, Sungrow, and BYD with a total of over 20 major customers in production or development.

Home appliance/industrial: over 45 customer projects in production or development.

Data center: now 10 customer projects with all projects targeting production later this year or early 2024.

Mobile: nearly 100 new GaN fast and ultra-fast charger designs (Samsung, OPPO, Lenovo, Dell, Anker and more), including One-

Plus 10T 160W, the 210W GaNFast charger for Xiaomi's Redmi Note 12 (100% charge in just 9 minutes), and Realme GT3 with 240W ultra-fast GaNFast charger.

Major macro-economic growth drivers:

- the Inflation Reduction Act includes clean energy investments of over \$60bn in home appliance energy-efficiency improvements, renewables and EV infrastructure to accelerate these Navitas target markets;
- the European Union's 'Titanium Plus' standard took effect on 1 January, to drive data centers to higher efficiencies, increasing demand for GaN power ICs;
- secular global trends driving the transition of the silicon power semiconductor industry to GaN and SiC for sustainability, energy savings and electrification.

For first-quarter 2023, Navitas expects revenue to be roughly flat on a sequential basis but up 85% year-on-year. Gross margin is also expected to be relatively flat sequentially, but to expand incrementally throughout 2023. Operating expenses should be about \$18m in Q1, then grow throughout the year, albeit declining as percentage of revenue while the business scales.

"In 2023, we are well positioned for strong growth in all of our target markets including EV, solar/storage, appliance/industrial and mobile/consumer," reckons Sheridan.

www.navitassemi.com

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SweGaN to build new HQ and GaN-on-SiC epiwafer production facility

Completion planned for end-Q2/2023

SweGaN AB of Linköping, Sweden, which manufactures custom gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers (based on a unique growth technology) for telecom, satellite, defense and power electronics applications, is to build a new headquarters including a high-capacity semiconductor production facility in Linköping.

The new facility will be built at the Innovative Materials Arena (IMA), a cluster for innovative materials located in Linköping in Östergötland — a region renowned for its progressive materials industries.

Completion of the project is planned for the end of second-quarter 2023 with deployment of the company's manufacturing processes to produce GaN-on-SiC engineered epiwafers in high volume to achieve economies of scale. The facility has been designed to accommodate production capacity up to 40,000 100mm/150mm epiwafers per year.

This significant scaling initiative is backed by a Series A financing round announced in September 2022, and is closely aligned with the accelerated global demands for GaN-on-SiC epiwafers used in 5G base-stations, defense radars, low-orbit satellite communications, and



SweGaN's new headquarters and production facility in Linköping, Sweden, to be completed by the end of second-quarter 2023.

power switches for electric vehicles (EVs).

"The new SweGaN HQ and production facility provides substantial flexibility and means to support the company's expansion during its growth journey — in both capacity and space," says chief operating officer Henrik Tölander.

"This major step strengthens SweGaN's deep roots in Sweden and will bring the entire company together under one roof," he adds. "We also aim to create a stimulating and inspiring work environment for young talents, materials specialists, and all strategic roles alike to join our exciting growth journey and

build the company with us," continues Tölander.

"A new order is being established for semiconductor supply chains, and we are striving to be a go-to strategic partner for our customers in this new era," says CEO Jr-Tai Chen. "Harnessing the challenges and opportunities associated with the new era of semiconductor manufacturing, SweGaN's vision has become clearer than ever — to build a sustainable, smart and green manufacturing for the materials that can enhance connectivity, security, and mobility of the future."

www.swegan.se
www.innovativematerials.se

Gallium Semiconductor releases nonlinear model library for GaN product portfolio

22 models span broadband DFN plastic and ACC packaged products

Singapore-based Gallium Semiconductor, which designs and manufactures RF gallium nitride (GaN) solutions for 5G mobile communications, aerospace & defense, and industrial, scientific & medical (ISM) applications, has released a library of nonlinear models for its portfolio of GaN products. The library consists of 22 models covering all of Gallium Semi's broadband dual flat no-leads (DFN) plastic and

air-cavity ceramic (ACC) packaged products. All models are designed and validated with broadband S-parameters and load-pull measurements to cover a broad range of applications.

"It's critical for our customers to accurately simulate performance of our components in their system designs to achieve first-pass success," says Michael Guyonnet, VP of networks. "The release of our

comprehensive library of nonlinear models underscores our commitment to delivering exceptional and seamless customer service from design-in to production."

The library is available for both Cadence AWR Design Environment and Keysight PathWave Advanced Design System (ADS) software. The library is available free of charge for qualified customers.

www.galliumsemi.com/downloads

The UCS300-SC Wafer Cleaning System from Optimal Technologies provides unquestionable results

The fully automated ultrasonic cleaning system removes any contaminants and particles that have been deposited on the wafer surface, this is achieved through a precise combination of:

- Chemical cleaning stages
- Ultrasonics and agitation
- De-ionised water rinsing, incorporating our unique servo-driven slow lift-out mechanism
- Comprehensive drying system
- Proven Cleaning technology
- Batch processing up to 300mm



The high performance UCS300-SC provides unmatched cleaning capabilities to ensure maximum productivity and a contamination free surface every time

Keysight introduces new method to accelerate power amplifier digital pre-distortion test speeds

Iterative Learning Control algorithm shortens digital pre-distortion test times for PAs from hours to minutes

Keysight Technologies Inc of Santa Rosa, CA, USA has introduced the new Iterative Learning Control (ILC) test method that significantly shortens digital pre-distortion (DPD) test times for power amplifiers.

As a core component in wireless communication devices, characterization of power amplifiers (PAs) is a critical but time-consuming task that can take hours or even days during the R&D phase. By shortening the time it takes to complete the design and validation process, power amplifier manufacturers are able to accelerate their time-to-market.

The ILC test method shortens DPD test time to minutes and accelerates R&D time from test validation to product design and optimization. As a part of Keysight's comprehensive High Frequency Measurement Solution portfolio, the ILC test method runs on the N9055EM0E

Power Amplifier Measurement Application and uses the VXG Vector Signal Generator and PXA Signal Analyzer to provide what is claimed to be industry-leading test performance for signal generation and analysis.

The ILC DPD test method offers the following benefits:

- Faster test speeds — optimizes the N9055EM0E software to reduce the characterization of power amplifiers to minutes;
- Integrated user interface — shows both pre-DPD and post-DPD measurement results in one screen for easier operation and integration when characterizing a power amplifier with multiple test instruments;
- Measurement accuracy and performance — provides industry-leading performance when characterizing power amplifier by removing the limitations of signal analyzer and generator and deter-

mining the real-world performance of power amplifier designs.

Taiwan-based fabless semiconductor manufacturer Hexawave (an Ennostar Group affiliate) is first to deploy the ILC test method to characterize its new HWA1330 5G gallium arsenide (GaAs) PA up to 4W in the 3.3–3.8GHz frequency range. The ILC test method was critical in validating that the HWA1330 can meet design targets including more than 30% power-added efficiency (PAE), 35.5dB power gain, and below -50dBc adjacent-channel leakage ratio (ACLR) at 100MHz bandwidth and 8.5dB peak-to-average power ratio (PAPR) with DPD. "Keysight's innovative test method allows us to rapidly and reliably validate our 5G new radio (NR) power amplifier designs," comments Hexawave's president Dr Mong Lin.

www.keysight.com

Amtech books order for 20th wafer cleaning system for SiC applications

Booking from existing North American Entrepix OnTrak customer to ship in second-half 2023

Amtech Systems Inc of Tempe, AZ, USA — a manufacturer of capital equipment (including for thermal processing, chemical mechanical polishing (CMP) and wafer cleaning) and related consumables and services — has booked an order for the 20th new OnTrak double-sided wafer scrubber system sold into silicon carbide (SiC) manufacturing applications.

The booking came from an existing Entrepix OnTrak customer in North America and will ship in second-half 2023. Previous SiC-related wafer scrubbing system orders came from several customers



Entrepix DSS-200 system.

in Europe, Asia and North America, with the largest install base in Europe and North America respectively. The OnTrak double-sided scrubber is suited to compound semiconductor applications with configurations for

100–200mm wafers and accommodation for even smaller wafers with custom-designed carriers.

"Entrepix was an early mover into the SiC market. Even before the development of the new OnTrak double-sided wafer scrubber, they shipped many refurbished wafer cleaning systems into these fabs," says Amtech's CEO Michael Whang. "The booking of the 20th new OnTrak double-sided scrubber for use in silicon carbide processing shows the strength of Entrepix's position in this important market segment," he adds.

www.amtechsystems.com

NI acquires SET to accelerate power semiconductor and aerospace/defense test system development

Acquisition to expand NI's opportunity in SiC and GaN power semi reliability systems for automotive applications

Automated test & measurement system firm NI of Austin, TX, USA has acquired SET GmbH of Wangen, Germany, which develops aerospace & defense test systems as well as power semiconductor reliability test. Founded in 2001, SET has about 100 staff, who join NI. NI funded the transaction through cash on hand.

Together, the firms aim to reduce time to market for critical, highly differentiated solutions and accelerate semiconductor-to-transportation supply chain convergence with power electronic materials such as silicon carbide (SiC) and gallium nitride (GaN).

In 2020, NI announced a strategic minority investment in SET to help aerospace & defense companies solve soaring development costs and integration challenges. The collaboration enhanced a system-on-demand and model-based test approach delivered to shorten time-to-market schedules, reduce program risk, integrate

labs, and optimize data and assets. This offered mutual customers more time spent ensuring the quality and safety of future products and less on building test systems. These collaborative efforts will continue, with a focus on sustainable commercial aviation, space launch vehicles, and urban air mobility applications.

The acquisition will expand NI's opportunity in power semiconductor reliability systems for automotive applications, a high-growth area of investment. SET has been innovating new capabilities in the emerging automotive supply chain of power semiconductors since before NI's initial partnership in 2020. SET's participation in cross-industry and academic forums on reliability test techniques is said to have made significant contributions to the understanding of electric vehicle applications for power semiconductors.

"The automotive supply chain is going through a transformation

where both OEMs and semiconductor players are rapidly innovating on new technologies. The ability to adequately specify and predict how these new technologies behave inside new electric vehicles is critical for performance and safety," says Ritu Favre, executive VP & general manager of NI Business Units. "SET is a clear innovator in this area as well as an established provider in Avionics testing. NI is a global leader in automated test & measurement systems. By combining capabilities, NI and SET can offer more differentiated solutions to customers and grow together by leveraging NI's global scale," she adds.

"By offering new and dynamic test procedures, SET ensures the qualification of cutting-edge silicon carbide (SiC) power semiconductors for the automotive industry with high precision and reliability," says SET's founder Frank Heidemann.

www.smart-e-tech.de

www.ni.com

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Aehr receives \$6.7m order for FOX WaferPak full-wafer contactors

Lead silicon carbide test & burn-in customer boosting production of power devices for electric vehicles

Semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has received a \$6.7m order from its lead silicon carbide (SiC) test & burn-in customer for multiple WaferPak full-wafer contactors to meet its increased production capacity needs for silicon carbide power semiconductors for the electric vehicle (EV) market. This customer is a leading Fortune 500 supplier of semiconductor devices with a significant customer base in the automotive semiconductor market.

"We are excited about this customer's continued production ramp and new design wins using our wafer-level test & burn-in systems and WaferPaks," says president & CEO Gayn Erickson. "This WaferPak order is about half of the total WaferPak contactors needed for the FOX-XP wafer-level test & burn-in systems previously ordered by this customer and announced in January." The WaferPaks are expected to be delivered beginning this current fiscal quarter and through the fiscal first-quarter 2024, ending 31 August.

"FOX-XP system orders are required to increase general manufacturing capacity, while our WaferPak contactors are unique to each new design win. As our customers win new designs from their customers,

Aehr secures orders for new WaferPak contactors to fulfill these new wins," says Erickson. Over time, Aehr expects to see follow-on WaferPak business grow both in absolute dollars and also as a percentage of overall revenue.

"Based on feedback and forecasts from current and prospective customers in the last several months and particularly in recent face-to-face visits with current and prospective customers in the US, Europe and Asia, we are seeing increased market momentum and continued adoption of silicon carbide MOSFETs by electric vehicle automobile manufacturers that will require wafer-level burn-in. We also see upside growth potential for silicon carbide usage in electrification infrastructure, electric trains and other high-power DC-to-AC inverter applications," Erickson continues.

Aehr is increasing its inventory and adding additional manufacturing capacity of systems and WaferPaks in anticipation of the potential significant upside of the broad-based move of silicon carbide suppliers to wafer-level burn-in. "Future orders of our FOX-XP multi-wafer test & burn-in systems and WaferPak full-wafer contactors are anticipated to grow to meet the anticipated growth of SiC MOSFET test & burn-in requirements for electric vehicle DC-to-AC traction

inverters and electric vehicle chargers, as well as other power conversion applications such as solar inverters," says Erickson.

"Aehr Test's unique solutions allow our customers to test and burn-in their devices with 100% confidence and traceability, which are needed to address the reliability, safety, security and confidence for mission-critical applications such as semiconductors used in motor controllers and power conversion in electric vehicles," he adds. "We are very well positioned to capitalize on the long-term growth opportunities such as these silicon carbide devices within the electric vehicle as well as the infrastructure to support the electric vehicle market."

Available with multiple WaferPak contactors (full-wafer test) or multiple DiePak carriers (singulated die/module test) configurations, the FOX-XP system is capable of functional test and burn-in/cycling of integrated devices such as silicon carbide power devices, silicon photonics as well as other optical devices, 2D and 3D sensors, flash memories, gallium nitride (GaN), magnetic sensors, microcontrollers, and other leading-edge ICs in either wafer form factor, before they are assembled into single- or multi-die stacked packages, or in singulated die or module form factor.

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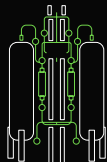
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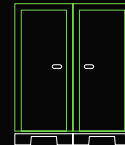
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CSconnected welcomes UK Government Science & Technology Framework, but environment needed for exploitation and commercialization of innovations

The UK Government's newly created Department for Science, Innovation & Technology (DSIT) has published its new Science and Technology framework that clearly identifies semiconductors and quantum technologies as two of the five technologies that are critical to the UK.

Introducing the framework, the Right Honorable Michelle Donelan MP, Secretary of State at DSIT, noted that "Britain has a long history of leadership and innovation" and that "investment in science and technol-

ogy is more important than ever."

The UK is home to the world's first compound semiconductor cluster. Representing the South Wales-based technology cluster and based in Cardiff, CSconnected says it welcomes the recognition of the importance of semiconductors and quantum as critical enabling technologies.

"Sadly, the UK's enviable reputation for developing technological innovations has too often not been matched by an environment that encourages exploitation and com-

mmercialization of those innovations," comments CSconnected's director Chris Meadows. "We look forward to the publication of the UK strategies for semiconductors and quantum technologies that we expect to help support the creation of conditions for establishing the UK as a clear global leader in next generation technologies."

The UK strategies for semiconductors and quantum technologies are expected to be issued in early 2023.

www.csconnected.com

CSA Catapult appoints chief technology officer

Compound Semiconductor Applications (CSA) Catapult (headquartered in Newport, South Wales) has appointed Nick Singh as its new chief technology officer (CTO).

Singh will lead the strategic and technical direction of CSA Catapult's four key technology areas — power electronics, RF & microwave, photonics and advanced packaging — as well as supporting the overall strategy of the organization.

Established in 2017 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a not-for-profit organization focused on accelerating the adoption of compound semiconductors for three key applications (the road to Net Zero, future telecoms and intelligent sensing). It works across the UK in a range of industry sectors from automotive to medical, and from digital communications to aerospace.

Singh began his career in electronics and semiconductors in the mid-1990s in France before moving to UK-based Oxford Instruments Plasma Technology where, for over a decade, he developed equipment and processes for epitaxy, deposi-

tion and etching of silicon, high-k dielectrics and compound semiconductors.

He continued his career in electronics at Scienta as group CTO, responsible for technology and applications developments in x-ray photoelectron spectroscopy (XPS), graphene, organic light-emitting diodes (OLEDs) and plastic electronics.

He also spent eight years as CTO of a start-up, which he helped scale up to deliver innovative net-zero solutions and oversaw the company's expansion overseas.

Most recently, Singh was CTO of PhotonFirst in the Netherlands, a pioneer of photonic integrated circuit (PIC) sensing and advanced packaging in markets such as aerospace, medical, automotive and energy.

Throughout his career, Singh has worked collaboratively with UK and European research institutions and innovation centers on technology subsidies and funded projects.

Singh has a degree in Electrical and Electronics Engineering as well as a PhD in Plasma Physics from University Paul Sabatier in Toulouse. He is a Fellow and Chartered Engineer of the UK's Institute of Engineering & Technology (IET)

and has authored and co-authored 50 papers and received four patents in semiconductors. Singh is also a thermodynamics expert with the Carbon Trust.

"The technologies that will underpin our future advances in electrification, intelligent sensing and telecoms are being built using compound semiconductors, so it is extremely exciting to be able to shape the technological capabilities of the Catapult to meet these important challenges," comments Singh. "We will play an integral role in supporting new supply chains and developing our technologies alongside clusters of expertise across the country, which will help us deliver on our ambition to position the UK as a global leader in developing and commercializing applications for compound semiconductors," he adds.

"Nick's wealth of knowledge, experience and leadership both here in the UK and across Europe will be an invaluable asset to the Catapult and I look forward to working with him closely on shaping our strategic and technical direction as we look ahead to the next five years of our journey," says CSA Catapult's CEO Martin McHugh.

www.csa.catapult.org.uk

Inventory build-up throughout supply chain to yield £30m year-on-year drop in IQE's first-half 2023 revenue Rebound expected in second-half 2023

In an update on current trading, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that, although it expects results for full-year 2022 to remain in line with the update provided on 16 January, it has since seen an acceleration of the anticipated trends, with weaker demand leading to inventory build-up throughout the supply chain. This reduction in customer orders and forecasts is expected to result in a decline in first-half 2023 revenue of about £30m year-on-year.

Similar trends are evident across the industry, with the US Semicon-

ductor Industry Association (SIA) reporting that global industry sales in January were down 18.5% year-on-year.

This near-term market softness is expected to be temporary, and IQE anticipates a return to year-on-year growth in second-half 2023 based on dialog with its existing customers and its pipeline of new opportunities.

IQE says that it continues to make positive progress towards its strategy as set out at the November 2022 Capital Markets Day, diversifying into high-growth markets including power electronics and micro-LEDs.

The firm adds that it has a strong pipeline of strategic and long-term partnerships and new business opportunities that will underpin growth in 2024 and beyond.

"The current inventory cycle is temporary," believes CEO Americo Lemos. "Ours is an industry that has consistently demonstrated growth over many decades. We expect IQE to return to growth in the second half of the year and remain excited about the future as we continue to execute our diversification strategy."

www.iqep.com

5N Plus appoints Blair Dickerson to board Materials producer gains sustainability, corporate communications and public policy expertise in natural resources sector

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada has appointed Ms Blair Dickerson to its board of directors.

"Blair has more than two decades of experience in natural resources, communications, public affairs and public policy work," notes board chair Luc Bertrand. "As a seasoned strategic communicator and public policy expert, we welcome her commitment to sustainability and depth of experience, particularly in the resource sector," he adds.

An advocate of sustainable business strategies and practices,

Dickerson has spent her career in stakeholder relations and communications both in government and with some of the world's largest resource companies.

Most recently, she was head of sustainability, corporate relations and communications at Vale Base Metals, where she led the integrated corporate affairs, communications, government relations and sustainability functions for the global Vale Base Metals business.

Prior to Vale, she worked at Rio Tinto where she was responsible for corporate relations and communications, starting in North America but also in Asia, Europe, the

Middle East and Africa. She also held the position of VP of external relations and communications at the Natural Science and Engineering Research Council of Canada.

Dickerson has an MBA from Queen's University and received her BA in Political Science from Carleton University. She also holds an accreditation as a certified sustainability practitioner from the Center for Sustainability and Excellence (CSE) and has served on the boards of the Canadian Chamber of Commerce, the Canadian American Business Council and the Mining Association of Canada.

www.5nplus.com

Riber receives order for MBE 6000 production system Existing client in Asia boosting capacity for electronic devices

Riber S.A. of Bezons, France — which designs and manufactures molecular beam epitaxy (MBE) systems and evaporators — says that an industrial customer in Asia has placed an order worth several million euros for a MBE 6000

production system, for delivery in 2023.

The customer already has one MBE 6000 system, and is now strengthening its production capacity for electronic devices.

With about 40 machines in oper-

ation worldwide, the MBE 6000 is claimed to be the benchmark MBE system for the mass production of electronic and optoelectronic components used in telecoms and in fiber-optic networks.

www.riber.com

Aixtron maintains annual revenue and earnings growth despite shipment push-outs and delays to export licenses

Demand for GaN and SiC power electronics to drive double-digit revenue growth for 2023

For fourth-quarter 2022, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported revenue of €183.2m, up slightly (by 1%) from the strong €180.9m a year ago and more than doubling from Q3/2022's €88.9m (and the best fourth-quarter in terms of shipments since 2011). The growth is attributed to unabated strong demand and stable supply chains plus shipment push-outs from Q3/2022.

"The current megatrends of sustainability, electrification and digitization create a continuously high demand in our core markets for our products. Accordingly, we were able to continue our strong growth from 2021 also in 2022," notes CEO Dr Felix Grawert.

"We have successfully mastered the global supply chain issues of the year 2022 and also maneuvered around some of the delays in export licenses that required us to shift some production slots back and forth within the year."

Full-year revenue grew by 8% from 2021's €429m to €463.2m in

2022, within the guidance range of €450–500m despite some customer-related delays in delivering systems.

On a geographic basis, Asia fell further, from 70% to 68% of full-year revenue (due to China plummeting from €211.8m to €150.8m, while Taiwan grew from €66.1m to €77.5m and Korea rocketed from €4.7m to €40.8m). Europe fell from 20% to 14%, while the Americas rebounded from 10% to 18% (almost doubling from €43.1m to €83.1m).

Of total annual revenue, 82% came from equipment sales (€380.4m, up 3.8% on 2021's €366.5m) and the remaining 18% (€82.8m) came from after-sales (consumables, spare parts and services).

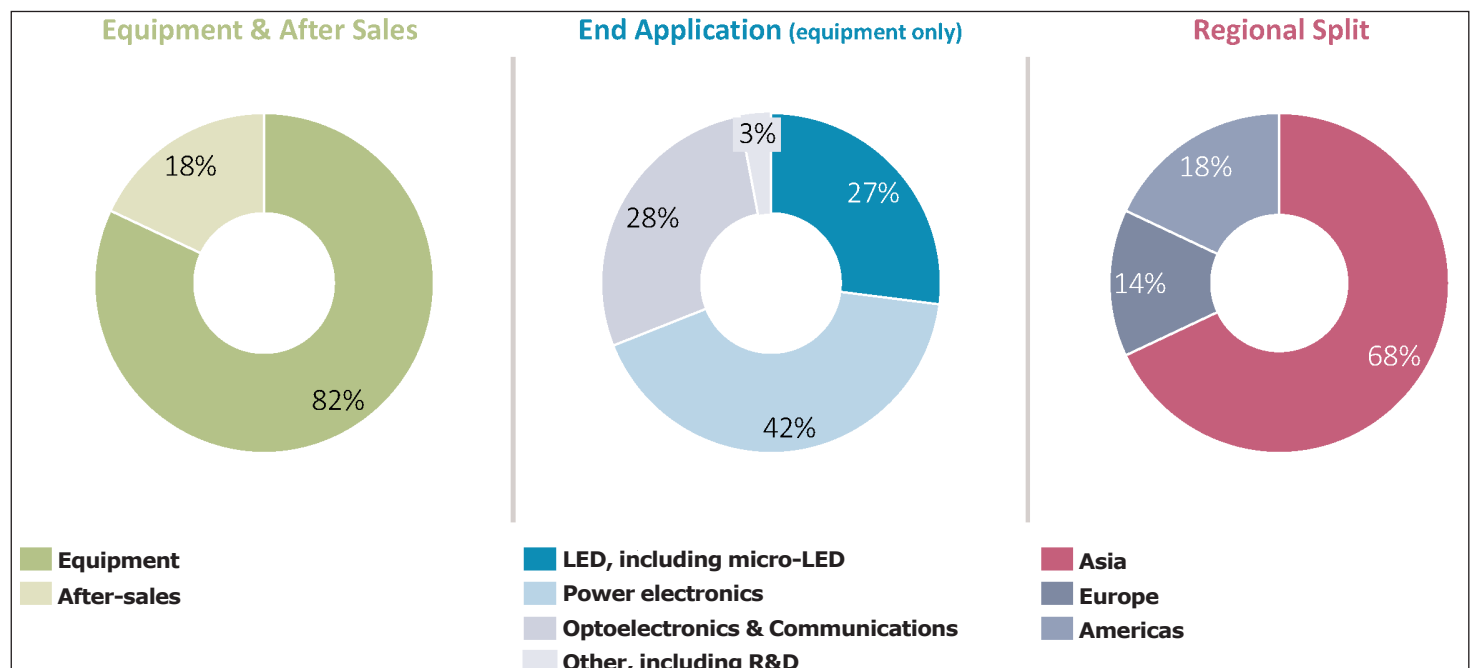
Growth was driven by the ongoing strong demand for efficient gallium nitride (GaN)- and silicon carbide (SiC)-based power electronics, particularly for ecologically sustainable applications, notes Aixtron.

Of the equipment revenue, metal-organic chemical vapor deposition (MOCVD)/chemical vapor deposition

(CVD) systems for making GaN- and SiC-based wide-bandgap Power Electronic devices again comprised the largest share, at 42% or €160.6m (up from 2021's 38%, or €139.7m). MOCVD systems for making Optoelectronics devices (solar, telecoms/datacoms and 3D sensing lasers for consumer electronics) comprised 28% or €106.2m (down from 2021's 37%, or €137m). MOCVD systems for making LEDs comprised 27% or €103.2m (rebounding from 2021's 23%), driven by growing demand for micro-LEDs.

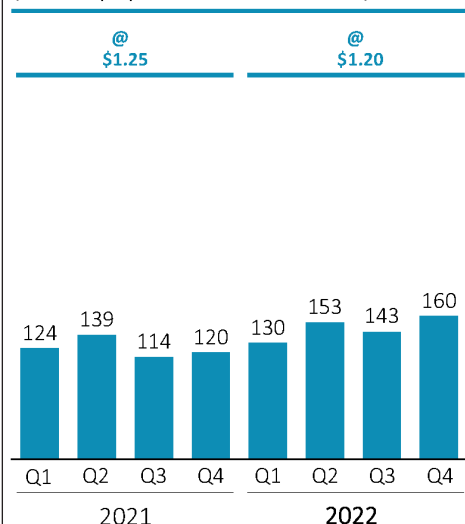
Full-year gross margin held steady at about 42% (above the original guidance of 41%). Quarterly gross margin was 45%, up from 44% for both Q3/2022 and a year ago, due mainly to improved product mix.

Full-year operating expenses rose from €82.5m in 2021 to €90.6m in 2022 (albeit rising only slightly from 19% to 20% of revenue), driven by higher variable compensation elements and higher personnel costs after increasing staffing by 25% (from 718 at the end of



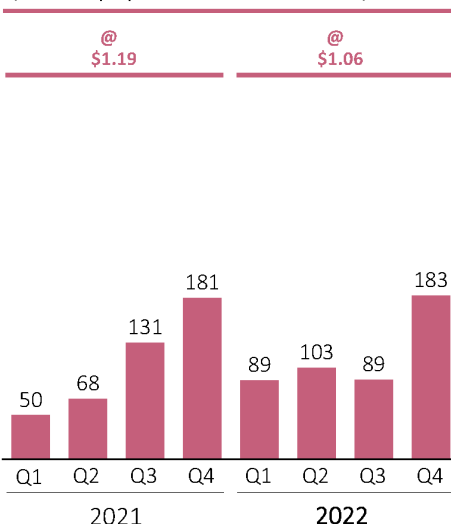
Order Intake

(incl. equipment & after sales)¹



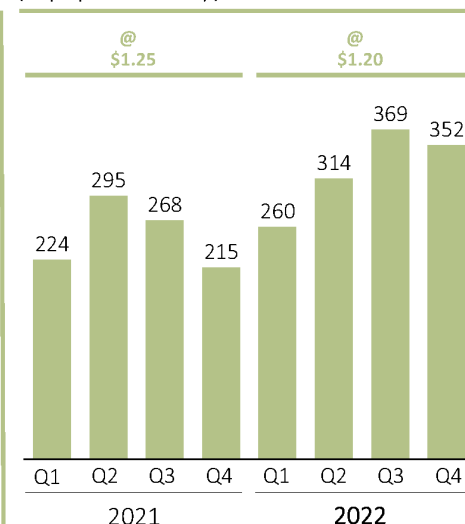
Revenues

(incl. equipment & after sales)²



Order Backlog

(equipment only)¹



¹ USD order intake and backlog were recorded at the prevailing budget rate (2021: \$1.25/€; 2022: \$1.20/€)

² USD revenues were converted at the actual period average FX rate (2021: \$1.19/€; Q1/2022: \$1.13/€; Q2/2022: \$1.08/€; Q3: \$1.02/€; Q4/2022: \$1.00/€)

2021 then 842 at the end of Q3/2022 to 895), combined with slightly higher R&D spending. The already high level of investment in R&D of €56.8m in 2021 was not only maintained but even slightly increased, to €57.7m (12% of revenue) in 2022.

Full-year operating result (EBIT, earnings before interest and taxes) rose from 2021's €99m to €104.7m in 2022 (with EBIT margin remaining 23%, at the top end of the original 21–23% guidance range). Fourth-quarter EBIT was again very strong at €57.1m, up from €16.2m in Q3/2022 and almost matching Q4/2021's €57.9m (which had more than doubled year-on-year from Q4/2020's €24.5m).

Full-year net profit grew from 2021's €94.8m (€0.85 per share) to €100.5m (€0.89 per share) in 2022. Quarterly net profit was €50.3m (€0.44 per share), up from €19.1m (€0.28 per share) in Q3/2022 but down only slightly from €51.9m (€0.46 per share) a year ago.

Build-up of inventories

Operating cash flow was -€0.1m in Q4/2022, compared with €0.5m in Q3/2022 and €25.9m a year ago. Hence, full-year operating cash flow has fallen from €66.4m in 2021 to €37.1m for 2022.

Capital expenditure (CapEx) has risen further, from just €4.4m a year ago and €8m in Q3/2022 to

€12.6m in Q4/2022, taking full-year CapEx from 2021's €17.7m to €29.5m for 2022, largely comprising investments in new-generation MOCVD tools. In particular, in anticipation of a further increase in demand, Aixtron increased its investments in property, plant and equipment (especially in R&D-related laboratory equipment and expansions) from 2021's €16.4m to €27.4m in 2022.

Quarterly free cash flow has hence gone from €21.5m in Q4/2021 to -€7.5m in Q3/2022 then -€11.3m in Q4/2022. Full-year free cash flow has fallen from 2021's €48.7m to €7.7m for 2022, due mainly to temporary working capital effects such as high accounts receivables as a result of the very late shipments in December 2022 as well as further a build-up of inventories from €120.6m at the end of 2021 and €209.2m at the end of September to €223.6m (due to the push-out of shipments and preparation for the large number of shipments hence scheduled for subsequent quarters).

Cash and cash equivalents (including financial assets) has fallen further, from €352.5m at end-2021 and €339.2m at the end of Q3/2022 to €325.2m at the end of 2022.

In view of the very positive business development in 2022, at the Annual General Meeting (AGM) of

shareholders on 17 May Aixtron's Executive Board and Supervisory Board will therefore propose to pay a dividend of €0.31 per share (compared with €0.30 per share in 2021). The total payout of €34.8m (up from €33.7m in 2022) corresponds to a payout ratio of about 35% of net income for the year.

Second largest order intake in company's history

Fourth-quarter 2022 order intake was €160.3m, up 12.3% on €142.8m in Q3/2022 and up 34% on €119.7m in Q4/2021. Full-year order intake grew by 18% from 2021's €497.3m to €585.9m in 2022 (the second highest in the firm's almost 40-year history, after 2010, and exceeding the original guidance range of €520–580m and above the mid-point of the revised guidance range of €540–600m).

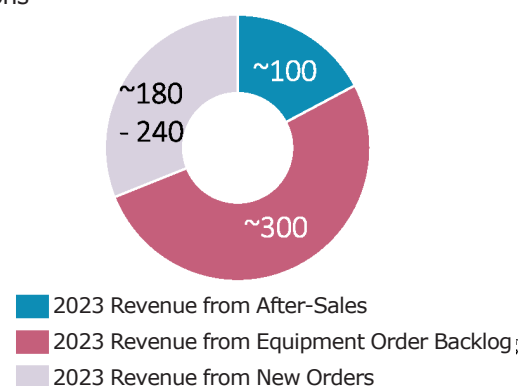
Aixtron says that this demonstrates the enduring trend towards efficient GaN and SiC power electronics, which grew from under 45% of order intake in 2021 to well over half in 2022. In particular, orders related to SiC power electronics devices more than tripled year-on-year, boosted from Q3 onwards by Aixtron's new G10-SiC multi-wafer (9x6" or 6x8") CVD system — launched in mid-September — which already comprises the vast majority of SiC orders, having a strong impact on overall growth. ➤

2023 Guidance¹

Total Order Intake	EUR 600m - 680m
Revenues	EUR 580m - 640m
Gross Margin (%)	Around 45%
EBIT Margin (%)	25% - 27%

Revenue Guidance FY/2023

€ millions



► Driven by the overall positive order development, equipment order backlog grew by 64% from €214.6m at the end of 2021 to €351.8m at the end of 2022.

Indicating the higher levels of shipments that are expected to be made, advance payments received from customers have risen further, from €121.8m at the end of Q3/2022 (almost a third of the order backlog) to €141m at the end of Q4/2022 (about 40% of the order backlog), almost doubling year-on-year from €77m at the end of 2021.

Double-digit growth expected for 2023

Based on the budgeted exchange rate of \$1.15/€ (versus \$1.20/€ in 2022), for full-year 2023 Aixtron expects over 9% year-on-year

growth in order intake to €600–680m.

Based on the equipment order backlog (convertible into 2023 revenue) of about €300m as of 1 January, joined by a forecasted €180–240m in new order intake that should be convertible into revenue during 2023, plus a forecasted €100m in after-sales revenue, Aixtron expects double-digit growth in full-year revenue to €580–640m in 2023 (including the shift of some units assembled in 2022 and shipped in 2023). The firm also expects full-year gross margin of about 45% and EBIT margin of 25–27% for 2023.

“The order situation, especially for GaN and SiC power electronics, is developing very positively,” notes

Grawert. “Since the third quarter of 2022, our new G10-SiC deposition tool has made a significant contribution to this as it generated very strong demand. And it is providing a key to the transition to electromobility and CO₂ reductions in the mobility sector,” he adds.

“We are also already receiving very positive feedback on our new system for optoelectronics and micro-LEDs, the new G10-AsP,” continues Grawert, who describes it as a “major step forward in both the area of micro-LEDs but also in the segment of high-performance lasers and VCSELs... We are convinced that micro-LED displays will be the next generation of display technology”.

www.aixtron.com

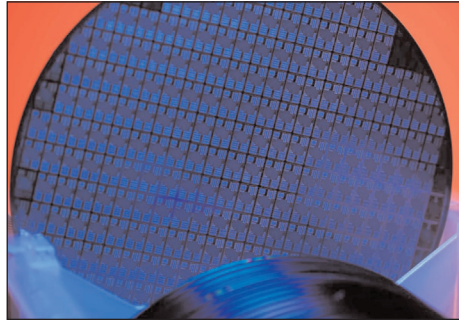
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Oxford Instruments accelerating qualification programs for Plasma Polish production ramp in 2023

Solution in qualification with several SiC device and substrate makers

UK-based Oxford Instruments says that, with intensive qualification projects underway with several leading manufacturers, it has been confirmed that its Plasma Polish technique can be applied, with great effect, to improve silicon carbide (SiC) substrate surface and reduce subsurface damage for multiple production processes, where SiC crystal quality is a critical yield-limiting factor.

Launched at the International Conference on Silicon Carbide and Related Materials (ICSCRM 2022) in Davos, Switzerland last September, the 200mm-compatible SiC substrate polishing technique is being tested with commercial partners at several points in the SiC device fabrication supply chain, such as boule growth, pre- and post-epi and in between epitaxial layers, to meet higher-voltage device requirements. In addition, the repeatability and damage-reducing benefits of Plasma Polish have also been demonstrated with 12 suppliers across the USA, Europe, Middle-East & Africa (EMEA) and Asia, with the process therefore proving to be an effective solution on any given SiC material.



Qualification of the technique has demonstrated what is described as state-of-the-art surface and subsurface damage reduction capability, targeting maximum power device yield. In addition to technical advantages, Plasma Polish brings opportunities to reduce the polishing cost of SiC substrates across multiple steps in the supply chain, while also reducing the environmental impact of the process, says the firm. An alternative approach to chemical mechanical polish (CMP), Plasma Polish lends itself to the production of high-yield, cost-effective power devices — addressing a key challenge to SiC adoption.

Oxford Instruments says that, with significant market interest in Plasma Polish coming from key customers throughout the SiC supply chain, it is at advanced

stages of qualification with multiple companies and is ramping up Plasma Polish module production.

“The engagement we have had with customers so far has been phenomenal, and we are continuously confirming the benefits Plasma Polish offers to solve current and future technical challenges hampering SiC adoption,” says Bas Derksema, global sales & marketing director at Oxford Instruments Plasma Technology (OIPT) of Yatton, near Bristol, UK. “Both gallium nitride and silicon carbide are key to Oxford Instruments’ growth plans in the wide-bandgap power space, and we have production solutions and a very exciting leading-edge development pathway aligned to our customers’ current and future challenges,” he adds.

“Our new Severn Beach production and research facility, coming online in the next 12 months, increases our production capacity by over 50%, with a doubling of application lab space, which will allow us to continue developing market-leading innovative solutions, and ramp up our production capacity to respond to growing market demand.”

www.plasma.oxinst.com

Veeco releases new sustainability report

Epitaxial deposition and process equipment maker Veeco Instruments of Plainview, NY, USA has released its latest Sustainability Report highlighting its continued progress towards environmental, social and governance (ESG) initiatives. The firm says that this Sustainability Report, reflecting 2022 data, demonstrates an ongoing commitment to building, and improving on, its sustainability strategy.

“Even in the face of significant social and global economic challenges, we made great progress towards advancing our ESG initiatives,” says

CEO Bill Miller. “Looking back from where we started, we have made meaningful advances related to climate and renewable energy goals, product responsibility, data and transparency, diversity and inclusion, philanthropy and building a strong company culture,” he adds. “I’m grateful to the global Veeco United team for their dedication to these efforts and we look forward to sharing our continuing progress on these important initiatives.”

The 2023 Sustainability Report features, among other updates, details pertaining to goals including

baselines and the steps being taken to achieve them. A detailed account of the firm’s ongoing implementation of water reduction initiatives, a hazardous chemical management program, enhanced disclosures aligned with the Sustainability Accounting Standards Board (SASB), and year-over-year improvements in the rate of renewable energy procurement and emissions intensity are just a few of the developments that point to Veeco’s alignment with stakeholders and commitment to corporate responsibility, says the firm.

www.veeco.com

Crystal IS and Asahi Kasei set 160mW output record for single-chip UVC LED in 260–270nm germicidal range

Tokyo-based Asahi Kasei and its subsidiary Crystal IS Inc of Green Island, NY, USA, which makes proprietary ultraviolet light-emitting diodes (UVC LEDs), have demonstrated their next-generation Klaran single-chip UVC LED which emits at 160mW in the ideal germicidal range of 260–270nm. Setting a new record for single-chip device output in a commercial device, this marks a 60% increase over prior Crystal IS devices while retaining the optimal wavelength for germicidal efficiency.

The higher-output device will be used to accelerate the adoption of UVC LEDs and hasten the widespread replacement of low-pressure mercury lamps, say the firms. While the new device retains the Klaran's compact 3.5mm x 3.5mm package and

solder pad design to allow backward compatibility with existing customer designs, the higher output will allow UVC LEDs to meet the performance and cost targets needed to expand into new applications in high-flow water and air treatment.

The new single-chip UVC LED design uses a rigid fused silica lens and a thin layer of proprietary UVC transparent resin developed by Asahi Kasei specifically to withstand the intense UVC output. In contrast to soft molded lens, the rigid fused silica lens allows higher transmission of the UVC light, which ensures stable long-life performance and high temperature stability. Asahi Kasei says it leveraged its long-running expertise in the field to develop the proprietary resin after a careful and

lengthy evaluation of commercially available adhesives resulted in no suitable candidate.

"This new high-output and long-life Klaran device is made possible by the strong cooperation between Crystal IS and Asahi Kasei innovation teams," notes president & CEO Eoin Connolly. "With this new device in our portfolio, Klaran UVC LED devices make another significant step forward in replacing low-pressure mercury lamp technology and promoting the transition to non-mercury/non-ozone generating devices."

Engineering samples of the new 160mW single-chip UVC LED can be requested now from Crystal IS. Commercial product release is expected later in 2023.

www.cisuv.com/products/klaran

CrayoNano's CrayoLED H-series UV-C LEDs enter 100mW and 5% efficiency performance class

CrayoNano AS of Trondheim, Norway — which develops and manufactures semiconductor components based on patented and proprietary nanomaterials technology — has announced improvements to the performance of its CrayoLED H-series UV-C LEDs. Entering the 100mW and 5% wall-plug efficiency (WPE) class at a standard operating current of 350mA, the LED is targeting the disinfection market.

The CrayoLED UV-C LED is said to offer reliable and long-lasting solutions for demanding disinfection applications. The high-power performance class of 100mW can effectively inactivate bacteria, viruses and other illness-inducing pathogens in a relatively short amount of time, improving system efficiency and future disinfection automation.

The improved wall-plug efficiency of 5% means that the CrayoLED is more energy-efficient and gener-

ates less heat, resulting in a longer lifetime. The externally confirmed L70 TM-21 extrapolated lifetime is more than 10,000 hours at 350mA, a defining industry-required standard. The CrayoLED would have an effective lifespan of up to 5–10 years in commercial and residential point-of-use (POU) and point-of-entry (POE) water disinfection systems, which typically use UV-C LEDs for several minutes per operation cycle, for a total annual usage of 1000–2000 hours. The CrayoLED is hence said to provide a reliable and long-lasting solution for water disinfection.

The long lifetime and high power output of 100mW reduce the need for frequent replacement, facilitating the adoption of UV-C LED disinfection in municipal water treatment facilities. These facilities require reliable and powerful solutions to handle higher water flows and to reduce maintenance needs.

The combination of the CrayoLED's

UV-C LED longevity and performance makes it an efficient and effective solution for water treatment applications, says the firm.

"Our dedication to continuous development and commitment to quality and performance has culminated in more than 30% improvement since the product's launch," notes chief revenue officer Michael Peil. "Entering the performance class of 100mW, 5% wall-plug efficiency, high drive current capacity without compromising our values of quality first — make the CrayoLED a reliable, efficient and robust solution, suitable to enable mass UV-C LED adoption into disinfection applications," he reckons. "With these results, we look forward to further characterization of our LEDs at a higher drive current capacity."

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

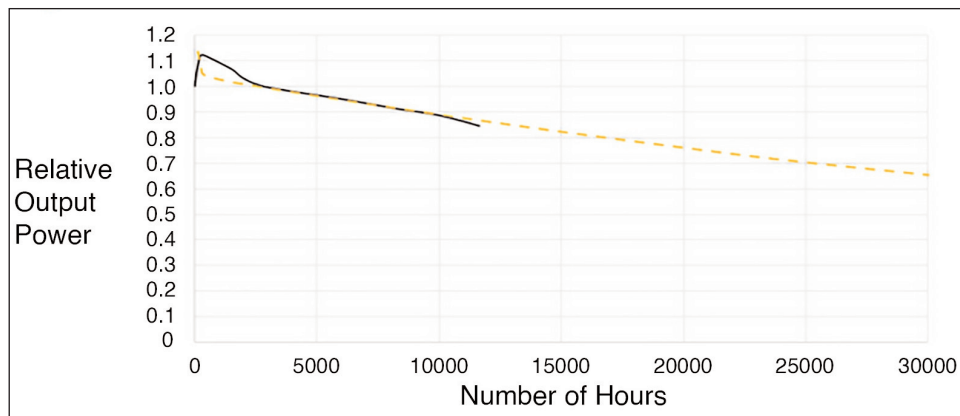
https://crayonano.com/uv-c_led

Crystal IS and Asahi Kasei announce lifetime characterization data for Klaran LA UVC LED

Projected L70 lifetime rating of 25,000 hours

Tokyo-based Asahi Kasei and its subsidiary Crystal IS Inc of Green Island, NY, USA, which makes proprietary ultraviolet light-emitting diodes (UVC LEDs), have released lifetime characterization data after more than 10,000 hours of testing its Klaran LA UVC LED, which supports a projected L70 lifetime of 25,000 hours. This advancement retains true disinfection with a refined wavelength optimal for germicidal efficiency, with a lifetime exceeding that of low-pressure mercury lamp technology, promoting the transition to non-mercury/non-ozone generating devices.

The characterization data on its Klaran LA UVC LEDs was released to assist partner companies in water, air and surface treatment to take full advantage of its UVC LED capabilities in their designs. This data shows how a set of Klaran LA LEDs operating at a current of 350mA and with a junction temperature of 53°C (soldering point temperature of 35°C — see Figure) would have a projected L70 lifetime value over 25,000 hours (L70 refers to the point in time when an LED produces 70% of its initial light output). This data was observed on the Crystal IS



Lifetime test at 350mA, 35°C.

in-house VEKTRIX Integrated Thermal Control Systems, demonstrating the firm's commitment to providing ample characterization data under various test conditions to aid in customers' designs. The VEKTRIX system enables Crystal IS to perform lifetime testing of large quantities of LEDs at multiple temperatures and driving currents.

"Klaran LA's lifetime performance is the result of Asahi Kasei product innovation using the Crystal IS proprietary aluminium nitride substrate and reinforces the company mission to replace low-pressure mercury lamps in consumer and industrial applications that depend

on reliable and effective disinfection performance," says Crystal IS' president & CEO Eoin Connolly. "Our rigorous testing on thousands of Klaran devices and ISO 9001 quality system provide the data-driven proof of the reliability and performance of our Klaran products," he adds.

The Klaran product line leverages the unique properties of Crystal IS aluminium nitride to provide premium germicidal UVC LEDs and associated modules to treat water, air and surfaces for healthcare, consumer appliances and commercial water treatment.

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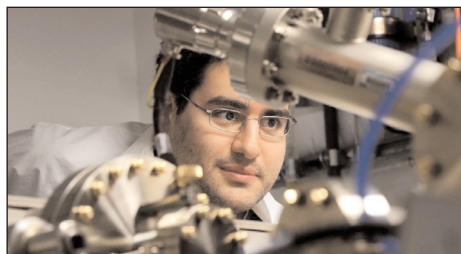
NS Nanotech opens Canadian R&D center in Montréal

Center to leverage licenses to McGill University's nano-LED technology patents for next-generation displays

NS Nanotech Inc of Ann Arbor, MI, USA has formed NS Nanotech Canada in Montréal, Québec, an R&D center focused on enabling the commercialization of next-generation nano-LED technologies for televisions, mobile phones, smart watches, augmented-reality headsets, and other applications.

Leveraging exclusive licenses to a portfolio of patents owned by McGill University, the research center will further NS Nanotech's long-term mission to develop the first efficient sub-micron-scale nano-LEDs.

NS Nanotech is developing next-generation technologies for large displays, micro-displays, and ultraviolet UVC disinfection applications including COVID-19 prevention. NS Nanotech Canada signed an initial agreement with McGill University to start collaboration with research scientists there including professor Songrui Zhao, said to be one of the world's leading nano-LED researchers. Zhao holds numerous patents and is advancing the state of the art in molecular beam epitaxy (MBE) and other foundational technologies designed to enable orders-of-magnitude



improvements in costs and efficiency over existing LEDs.

"The \$120bn global display market is based on 20th-century technologies limited by several major shortfalls in cost and performance that NS Nanotech is working to overcome," says NS Nanotech's CEO & co-founder Dr Seth Coe-Sullivan. "McGill University is a global center of excellence in nano-technologies that confront these shortfalls head on, and together we have the potential to disrupt massive emerging global markets for multi-color micro-LED displays and UVC-LED disinfection solutions."

Derrick Wong MSc-MBA, a part-time lecturer and mentor at McGill University, is the newly appointed chief operating officer at NS Nanotech Canada, and the senior research scientist is Dr David Laleyan, a McGill graduate who received his

Ph.D. from the University of Michigan in 2020. The firm intends to add several additional researchers this year for continuing collaborations with McGill University in 2023 and beyond.

Support from industrial development authorities

NS Nanotech's expansion in Montréal has been supported by Montréal International and Investissement Québec.

"The semiconductor industry is highly strategic, and we are proud to contribute to its growth in Greater Montréal by supporting NS Nanotech's Montréal project," says Alexandre Lagarde, VP, foreign investment at Montréal International.

"The new research center demonstrates the unique appeal that our researchers and post-secondary institutions, such as McGill University, represent for investors developing key projects. Furthermore, our highly qualified talent pool, particularly in STEMs and artificial intelligence, are key to the development of nanotechnologies," he adds.

www.nsnanotech.com/post/ns-nanotech-opens-

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Porotech opens new UK and Taiwan facilities

Initial applications include display screens, augmented reality glasses and transparent displays

Porotech (a spin off from the Cambridge Centre for Gallium Nitride at the UK's University of Cambridge that has developed porous GaN material) has celebrated the opening of new facilities in Cambridge, UK on 16 February and in Hsinchu, Taiwan on 20 February with an evening for industry professionals, university professors and local government representatives to discuss the future of the firm and its technology.

Porotech says that its new DynamicPixelTuning (DPT) technology can produce substantial gains in resolution, brightness and efficiency for every type of display while overcoming roadblocks in the commercial viability of micro-LED displays.

At the UK event Warren East, former CEO of Rolls Royce Holdings, delivered an opening speech before joining Porotech's co-founder & CEO Dr Tongtong Zhu in the official ribbon-cutting ceremony. "Porotech has some fundamental building blocks here to be hugely success-



Porotech's team in Cambridge, UK.



Porotech's team in Hsinchu, Taiwan.

ful," commented East. "Its innovation, the application of their hard work, and their ability to remain agile in how they approach the market and their customers means all the more likely that something impressive will spring out of this building."

Guests were invited to tour the new facilities and observe demonstrations of the technology in action, including display screens, augmented-reality (AR) glasses and transparent displays.

"We are not focused on a particular market, we are looking beyond that," commented VP & head of Taiwan Dr Kunal Kashyap during the Taiwan event.

www.porotech.com

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BluGlass secures \$10.2m via share placement; launches \$2.7m entitlement offer for existing shareholders

BluGlass Ltd of Silverwater, Australia — which manufactures gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has secured \$10.2m in commitments from international and Australian institutional and sophisticated investors via a strongly supported share placement at an issue price of \$0.06 per share.

BluGlass is also undertaking a non-renounceable entitlement offer to raise up to a further \$2.7m (before costs), enabling shareholders to participate on the same terms as the placement.

Funds will be used for additional fab equipment to scale and speed product delivery, and expand BluGlass' product offering to increase market competitiveness.

"The support of institutional and sophisticated investors provides confidence in our technical and commercial roadmaps, and we are pleased to welcome new and returning global funds to the register," says chair James Walker. "The BluGlass team remains

focused on growing market traction, generating recurring revenues, and delivering value for our customers and shareholders," he adds.

"This funding will accelerate our commercialization progress with advanced in-house capabilities enabling us to scale and speed our product delivery to meet significant unmet market needs," says CEO Jim Haden. "The market's response to our initial products has been very encouraging, and we are looking to capitalize on this momentum to rapidly build our customer base and laser diode bookings," he adds.

"We're also investing in our GaN laser offering to leverage our competitive advantages, address new markets and applications, and take market share," Haden continues. "At the same time, we're continuously improving the power and efficiency of our products toward world-class standards, which will support growth in orders and revenue."

Placement

The placement comprises an offer of 169,992,032 new fully paid ordinary shares in BluGlass at an

issue price of \$0.06, representing a 20% discount to the last closing share price on 8 March and a 21.7% discount to the 15-day volume-weighted average market price of the shares. New shares under the placement will rank equally with BluGlass' existing ordinary shares.

Bell Potter Securities Ltd is lead manager and bookrunner to the placement and entitlement offer.

Entitlement offer

For the entitlement offer, eligible shareholders may apply for 1 new share for every 30 fully paid ordinary shares held at 7pm (Sydney time) on 16 March at an issue price of \$0.06.

All shareholders at the record date with a registered address in Australia or New Zealand will be eligible to participate. Eligible shareholders may take up their entitlement to acquire new BluGlass shares in full, in part, or not at all.

The entitlement offer is non-renounceable, so eligible shareholders who do not wish to subscribe for some, or all, of their entitlement may not sell or transfer their rights.

www.bluglass.com

BluGlass grows customer base with two additional purchase orders for commercial lasers

Additional customer orders in progress

BluGlass says that it continues to grow its customer base, receiving two additional purchase orders for both its single-mode and multi-mode violet 405nm and blue 450nm GaN lasers in flexible form factors.

The orders are from established organizations developing advanced quantum, energy and industrial applications, and include a leading international energy research institution. Customers will use BluGlass' lasers for testing and qualification within their own applications.

"We are quickly gaining traction with our first GaN laser products, with strong interest from customers across our product suite and target markets," says CEO Jim Haden. "These orders validate our go-to-market approach and reinforce the urgent need for suppliers to address growing unmet needs in the industry," he adds. "Our lasers are being implemented by customers looking to develop and test innovative new products across next-generation energy production, quantum, artificial

intelligence (AI), and advanced manufacturing. Our flexibility is seeing customers wanting to work with us, and our first 450nm order in custom form factors is testament to this."

Initial order volumes are small and financially not material. However, once BluGlass' lasers have been qualified within the applications, they are expected to grow in volume and frequency. Additional customer proposals are progressing across multiple market segments.

BluGlass appoints president Jim Haden as CEO

Appointment follows acquisition of Silicon Valley fab, launch of first laser products and initial customer orders

BluGlass Ltd of Silverwater, Australia — which makes gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has appointed Jim Haden as CEO.

Since joining the firm as president in September 2021, Haden has brought BluGlass' GaN laser technology to market, significantly improving laser performance and reliability to successfully launch its first suite of products and secure initial customer orders.

Haden was instrumental in the acquisition of a purpose-built laser production fab, which is enabling BluGlass to vertically integrate its downstream manufacturing processes, expedite development and production, and improve laser quality while reducing manufacturing costs.

BluGlass notes that Haden is an industry veteran with more than three decades of laser expertise

and a track record of transitioning advanced technology businesses from research & development and early-stage product development to profitable, high-growth commercial entities. Haden has held senior leadership positions at several of BluGlass' potential customers and competitors, including senior technical & operations adviser at Kyocera SLD, chief operating officer at nLight Inc, director of operations & product line management at Coherent Inc, director of operations at Spectra Diode Lasers (acquired by JDS Uniphase for US\$41bn), and director of operations at JDS Uniphase (which is now Lumentum).

In his most recent role at Soraa Laser Diode (now Kyocera-SLD), Haden was responsible for guiding operations and development teams to stabilize, improve and ramp high-power blue GaN lasers. This product development delivered a leading automotive customer and rapid revenue growth, assisting in

their acquisition by Kyocera in January 2021.

"Jim's technical expertise, industry network, and commercialization know-how has been instrumental in transforming BluGlass from our R&D origins to a commercial provider of GaN lasers," comments chair James Walker. "We are now a genuine player in a fast-growing market with very few competitors and high barriers to entry. Our unique value proposition caters to our customers' biggest challenges, and feedback on our newly launched products has reaffirmed we have the right team and strategy in place to become a market leader," he reckons.

"As CEO, Jim will have greater operational control across our three production facilities in Sydney, Silicon Valley and Nashua, and will be responsible for the continued transition to revenue generation and sustainability," Walker concludes.

www.bluglass.com.au

NUBURU appoints chief marketing & sales officer

High-power industrial blue laser technology firm NUBURU Inc of Centennial, CO, USA has appointed Dr Matthew Philpott as chief marketing & sales officer. He will lead the team to further develop NUBURU's product roadmap and to accelerate market penetration across all segments.

Founded in 2015, NUBURU is a developer and manufacturer of industrial blue lasers that leverage their high-brightness, high-power design to produce fast, high-quality laser materials processing, including laser welding and additive manufacturing of copper, gold, aluminium and other industrially important metals. The firm's industrial blue lasers are claimed to produce defect-free welds up to eight times faster than the

traditional approaches — all with the flexibility inherent to laser processing.

Philpott brings "a proven track record of globally coordinated, exponential growth and a vision for customer success which addresses the full customer experience from process development to mass production," says CEO & co-founder Dr Mark Zediker. "Matthew will help drive our ambitious growth plans and accelerate NUBURU's commercial efforts," he adds.

"NUBURU's technology is critically important today as mass production inherently demands zero rework, and a stable process window which can easily be adopted to unpredicted production challenges," comments Philpott. "Customers demand parts-per-million yields,

not simply a best effort," he adds.

"As NUBURU's blue lasers offer precision, speed, near-defect-free and a multi-emitter redundancy that is unmatched by current state-of-the-art solutions, the timing is perfect."

Philpott brings over 20 years of laser industry experience from Coherent Corp, where he was most recently director of global business development. He led a multi-national electric vehicle welding team, taking Coherent from a new entrant to being a globally recognized top supplier for battery and EV production. Philpott holds a B.S. in Chemistry from Furman University and a Ph.D. in Physical Chemistry from the University of Washington.

www.nuburu.net

OpenLight announces availability of first PDK sampler

Lab-testing flexibility and enhanced PIC design accuracy to accelerate time to market

To enhance familiarity with process technologies and increase the accessibility of photonic integrated circuits (PICs), OpenLight of Santa Barbara, CA, USA (which launched as an independent company in June 2022, introducing the world's first open silicon photonics platform with heterogeneously integrated III-V lasers) has announced general availability of its process design kit (PDK) Sampler.

After announcing general availability of its PDK last November, the PDK Sampler is a unique, die-level PIC that contains OpenLight's standard PDK components, enabling customers to comprehensively test PDK elements in their own lab and validate models to enable first-pass success in a PH18DA tapeout. Components include OpenLight's heterogeneous laser, optical ampli-

fier, 100G PAM4 EAM modulator, and other active and passive components on Tower's PH18DA process.

The adoption of new process technologies often involves a steep learning curve and is a frequent challenge for customers, especially with recent advancements in the silicon photonics arena, notes OpenLight. This new industry offering is said to provide a short-cut for customers to test individual PDK elements immediately by getting direct lab data prior to taping out a custom PIC design. By being able to test PDK components in their own labs, customers can gain increased confidence in the Tower PH18DA process and can optically and electrically probe PICs.

"With this 'one-of-everything' PIC made available through Tower

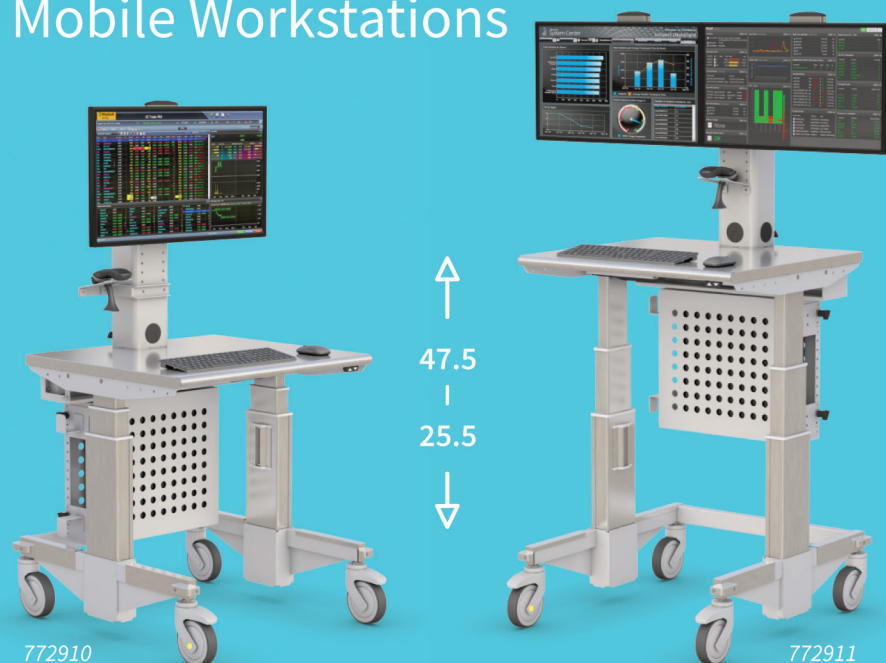
Semiconductor, customers have a better vantage point to sample every PDK component available through our open platform," says OpenLight's CEO Dr Adam Carter. "OpenLight's mission is to be the first to enable the industry with the right design tools and accelerate the use of PICs at scale in a wide variety of markets and applications," he adds.

"OpenLight continues to complement Tower's existing open foundry offering," says Dr Marco Racanelli, senior VP & general manager of Tower Semiconductor's Analog business unit. "As OpenLight's partner, this move will make Tower's PH18DA process more accessible for mutual customers and help them make the most of our technology."

www.openlightphotonics.com

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Tower announces first heterogeneous integration of quantum dot lasers on SiPho foundry platform

Gallium arsenide quantum dot laser integrated on Tower's PH18DB high-volume silicon photonics foundry

Specialty analog foundry Tower Semiconductor Ltd of Migdal Haemek, Israel, in collaboration with Quintessent Inc of Santa Barbara, CA, USA, which specializes in laser integration with silicon photonic integrated circuits (PICs), have announced what they claim is the first heterogeneous integration of gallium arsenide (GaAs) quantum dot (QD) lasers and a foundry silicon photonics (SiPho) platform (PH18DB). This PH18DB platform is targeted at optical transceiver modules in data centers and telecom networks, as well as new emerging applications in artificial intelligence (AI), machine learning (ML), light detection & ranging (LiDAR) and other sensors. According to the market research firm LightCounting, the silicon photonics transceiver market is expected to rise at a compound annual growth rate (CAGR) of 24%, reaching a total addressable market (TAM) of \$9bn in 2025.

The new PH18DB platform offers GaAs-based QD lasers and semiconductor optical amplifier (SOA) fabricated on Tower's high-volume base PH18M silicon photonics foundry technology, which includes low-loss waveguides, photodetectors and modulators heterogeneously integrated on a single silicon chip. This platform will enable dense PICs that can support higher channel count in a small form factor. Open foundry availability of this 220nm silicon-on-insulator (SOI) platform will provide access to a broad array of product development teams to simplify their PIC design through the use of laser and SOA pcells, in addition to the feature-rich baseline PH18 process.

Initial process design kits (PDK) for PH18DB have been made available in partnership with the US Defense Advanced Research Projects Agency (DARPA) under the Lasers for Universal Microscale

Optical Systems (LUMOS) program, which aims to bring high-performance lasers to advanced photonics platforms for commercial and defense applications, and multi-project wafer (MPW) runs are planned for 2023 and 2024.

The PH18DB platform complements Tower's previously announced, and now prototyping, PH18DA platform, which offers heterogeneously integrated indium phosphide (InP) lasers, modulators and detectors.

These two heterogeneously integrated SiPho foundry platforms offer what is described as a rich set of devices and options to designers across the broad spectrum of leading-edge applications. Tower continues to offer its silicon-only PH18MA platform, now in high-volume production, for applications that do not require heterogeneous integration of III-V active elements.

www.quintessent.com
www.towersemi.com

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Vector Photonics commercializing uncooled 1W, 1310nm CW PCSEL for cloud data centers

Increased power versus DFBs yields manufacturing and energy-saving benefits, reducing number of lasers required

Vector Photonics Ltd is to begin commercializing an uncooled, 1W, 1310nm continuous-wave (CW) photonic-crystal surface-emitting laser (PCSEL), targeted at interconnects, silicon photonics and co-packaged optics (CPO) in next-generation cloud data-center applications.

A 1W laser is said to offer significant increases in optical power over incumbent distributed feedback (DFB) technology, with manufacturing and energy-saving benefits. The 1W laser leverages Vector Photonics' existing PCSEL

commercialization work.

"An uncooled 1W PCSEL is a game-changer for cloud datacoms applications," believes chief technology officer Dr Richard Taylor. "Currently, next-generation data-center interconnects must deliver 800Gbps, increasing to 1.6Tbps and then 3.2Tbps over the next decade. The 1W PCSEL enables this development, with a significant reduction in the quantity of lasers required over DFB technology. The interconnects, silicon photonics chips and CPO systems, where they are used, become significantly

easier to make, with the likelihood of improved yield and reliability. In addition, the 1W PCSEL has a symmetrical far-field, which requires less operational power to achieve the necessary performance," he adds.

"The full impact of a 1W PCSEL is yet to be quantified," Taylor continues. "However, these high-power lasers will change the entire architecture of datacoms chips and systems. Further, significant benefits include reduced power consumption, heat, latency and manufacturing costs."

www.vectorphotonics.co.uk

Vector Photonics' board gains executive chair

Adrian Meldrum to contribute to corporate strategy, planning and implementation as firm commercializes PCSELS

Vector Photonics Ltd (which was spun off from Scotland's University of Glasgow in 2020, based on research led by professor Richard Hogg) says that Adrian Meldrum has joined its board of directors as executive chair, contributing to corporate strategy, planning and implementation.

Meldrum has a proven track record in the photonics industry in senior leadership, sales, marketing, new product introduction (NPI), and operations roles, in start-ups,

private and public listed companies. The appointment comes as Vector Photonics moves into the next phase of commercializing its unique all-semiconductor photonic-crystal surface-emitting laser (PCSEL) technology.

"Adrian brings 25 years of industrial photonics, telecommunications, and semiconductor experience," notes CEO Neil Martin. "He has been CEO, CCO, business development director, commercial director and general manager in high-

revenue, high-growth and high-profit, multi-million-pound-turnover global companies, including Gooch & Housego, Oclaro Inc, IQE and Bookham Inc. He also brings invaluable, stakeholder and investor communications experience, including with the NASDAQ and AIM stock markets."

Meldrum has a first-class BSc (Hons) degree in Physics and Mathematics from Manchester Metropolitan University.

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Alfalume samples 1.3 μm high-power uncooled InAs/GaAs quantum dot DFB lasers

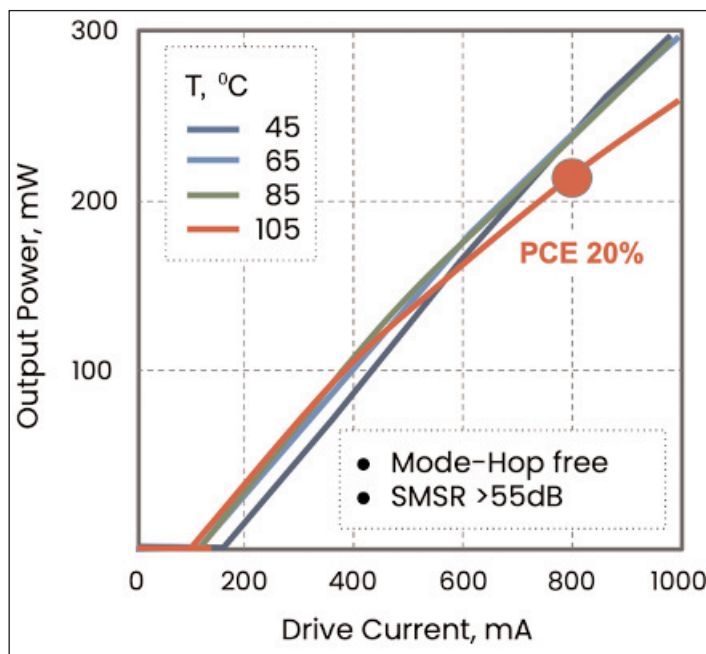
In partnership with quantum dot (QD) diode laser manufacturer Innolume of Dortmund, Germany, Alfalume Inc of Santa Clara, CA, USA has announced sample availability of its O-band high-power indium arsenide/gallium arsenide (InAs/GaAs) quantum dot distributed feedback (DFB) lasers, which offer what is claimed to be best-in-class output power, wall-plug efficiency and temperature range as well as fundamentally better reliability of QD lasers compared with quantum well (QW) counterparts.

Alfalume's QD lasers are said to provide significant benefits for high-speed datacom transceivers, including record high power and conversion efficiency at temperatures above 85°C without requiring thermoelectric coolers, optical-isolator-free operation, and lower cost due to significantly reduced component costs and better assembly yields.

"Our QD laser technology matches the operation temperature of photonics to the highest operating temperature of modern electronics," says Alfalume's CEO Alexey Kovsh. "There is no other technology today which can provide the power level of O-band DFB lasers above 200mW with power efficiency of 20% at 105°C with the ability to operate efficiently up to 150°C," he claims. "Our uncooled lasers are ideal for pluggable transceivers offering the highest efficiency at high temperatures."

The QD DFB lasers offer the following performance characteristics:

- 250mW @85°C, which can be split into four or eight channels for 800G and 1600G DR8 modules;
- 20% power conversion efficiency at 105°C;
- insensitive to feedback: up to -15dB, enabling operation without an optical isolator;
- high side-mode suppression ratio (SMSR): >55dB;



Dependence of laser output power on drive current.

- low relative intensity noise (RIN): below -155dB/Hz;
- beam divergence of 35 x 7°, allowing low-loss coupling with a low-cost cylindrical lens.

For 800G/1600G-DR8 modules, a single QD laser can be used for all eight channels, resulting in lower component counts, better assembly yield and lower-cost optical transceivers. QD lasers are suitable for both silicon photonics and all new electro-optic (EO) modulation technologies including thin-film lithium niobate (TFLN) and

barium titanate (BTO)/silicon. In addition, QD lasers are suitable for remote laser modules for co-packaged optics (CPO) and light detection & ranging (LiDAR) applications.

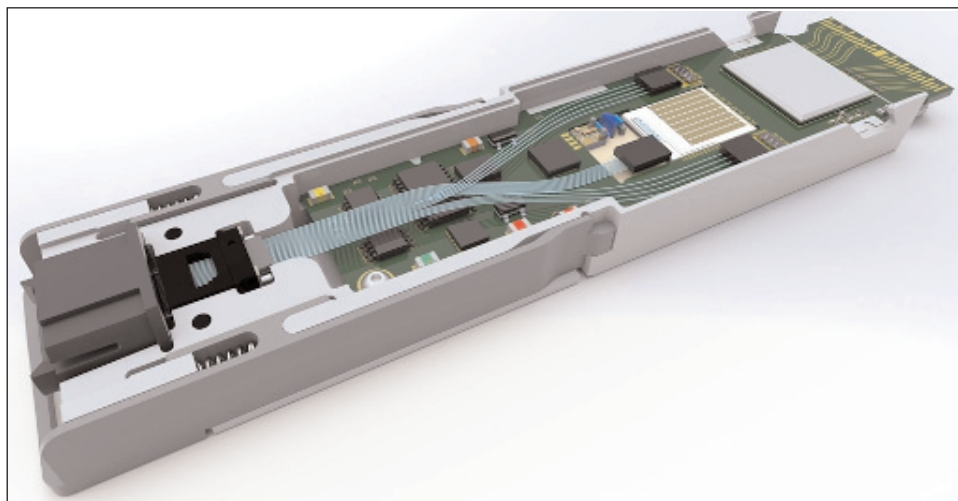
"The power of a single Innolume laser allows us to have a significant power margin for our DR8 lithium niobate modulators," comments Xinlun Cai, CEO of China-based Liobate Technolo-

gies Ltd. "This enables better manufacturing yield and lower-cost transceivers."

At the Optical Fiber Communication Conference (OFC 2023) in San Diego (5-9 March), Alfalume exhibited and presented at the following events:

- Workshop: 'Quantum Dots – The Resurrection?';
- Executive Forum/Lighting Startup Round;
- Panel 'Hot Start-Ups at OFC 2023'.

www.ofcconference.org
www.alfalume.com



Reference optical transceiver design OSFP-800G-DR8 by Axalume Inc.

Avicena demonstrates optical link operating at record temperature of 235°C

LightBundle's GaN micro-LED arrays open up automotive, industrial and aerospace & defense applications

At the Optical Fiber Communication conference (OFC 2023) in San Diego (7–9 March), Avicena Tech Corp of Sunnyvale, CA, USA (which develops ultra-low-energy optical links based on micro-LEDs) demonstrated what is said to be the highest-temperature optical link, operating at up to 235°C using its LightBundle communication architecture and technology. The LightBundle architecture is said to unlock the performance of xPUs, memory and sensors, removing key bandwidth and proximity constraints while simultaneously offering an order-of-magnitude reduction in power consumption.

Most optical links use edge-emitting lasers or vertical-cavity surface-emitting lasers (VCSELs), but these typically exhibit dramatic performance and lifetime reductions at operating temperatures above 85°C and are thus unable to meet the 5–10-year field lifetime requirements of many higher-temperature applications. The lifetime limitations of these communications lasers are related to fundamental properties of the gallium arsenide (GaAs) and indium phosphide (InP) from which nearly all are made, and thus have proved very difficult to improve significantly despite decades of effort.

In contrast, Avicena's LightBundle links use micro-LEDs made from gallium nitride (GaN), and are much less sensitive than GaAs and InP lasers to operating temperature, specifically regarding performance and reliability. Combined with high energy efficiency and low cost, these attributes have allowed GaN LEDs to transform the lighting industry over the past decade. LightBundle technology is based on arrays of GaN micro-LEDs that leverage the LED lighting and display ecosystems, and can be integrated directly onto high performance CMOS ICs. Each micro-LED array is connected via a

multi-core fiber cable to a matching array of CMOS-compatible photodiodes (PDs).

Now, Avicena has demonstrated LightBundle links operating at up to 235°C. This brings the benefits of optical interconnects to the harsh environments encountered in a wide variety of automotive, industrial, aerospace and defense applications, while also offering other benefits of the LightBundle architecture.

"We have already demonstrated the benefits of LightBundle links in data center, HPC [high-performance computing] and ML/AI [machine learning/artificial intelligence] with bleeding-edge power and density requirements," says Chris Pfister, VP of sales & marketing. "We have now shown that the unique benefits of the GaN materials system in micro-LEDs extends to applications with operating temperatures that have traditionally been beyond the capabilities of optical interconnects. This is igniting interest among our partners and customers in numerous market segments in the automotive, defense and aerospace industries."

We have already demonstrated the benefits of LightBundle links in data center, HPC and ML/AI with bleeding-edge power and density. We have now shown that the unique benefits of the GaN materials system in micro-LEDs extends to applications with operating temperatures that have traditionally been beyond the capabilities of optical interconnects

LightBundle technology

Today's high-performance ICs use SerDes-based electrical links to achieve adequate IO density. However, the power consumption and bandwidth density of these electrical links degrade quickly with length. Conventional optical communications technologies developed for networking applications have been impractical for inter-processor and processor-memory interconnects due to their low bandwidth density, high power consumption, and high cost. Moreover, co-packaging existing laser sources with hot application-specific integrated circuits (ASICs) causes reliability problems unless external laser sources (ELS) are used, which increases complexity and cost.

"All of this is now changing," says chief technology officer & co-founder Rob Kalman. "We are developing ultra-low power, high-density optical technology based on GaN micro-LED arrays optimized for high-speed interconnects. Our technology and inventions build on recent display industry advances and would have been impractical just a few years ago," he adds. "Our innovative LightBundle architecture supports hundreds of lanes with per-lane speeds of 10Gbps or more to enable multi-Tbps links meeting the most demanding emerging compute interconnect needs. This also frees system designers to innovate beyond the bounds of today's proximity constraints."

Avicena says that the low power, high density and low latency of LightBundle is well matched to chiplet interfaces like UCIE, OpenHBI and BoW, and can also be used to rethink and enhance system architectures that are limited by the reach of existing compute interconnects like PCIe/CXL, and HBM/DDR/GDDR memory links.

www.avicena.tech

Avicena partners with ams OSRAM on production of ultra-low-energy chip-to-chip optical interconnects

Joint development agreement to develop high-volume manufacturing for LightBundle

Avicena Tech Corp of Sunnyvale, CA, USA (which develops ultra-low-energy optical links based on micro-LEDs) has partnered with ams OSRAM GmbH of Premstaetten/Graz, Austria and Munich, Germany to develop high-volume manufacturing of gallium nitride (GaN) micro-LED arrays for its LightBundle communication architecture.

The need for next-generation computing power is driven by strong AI/ML (artificial intelligence/machine learning) and HPC (high-performance computing) application demand – for products like ChatGPT, DALL-E, autonomous vehicle (AV) training, and many others. Attempts to scale existing architectures are running into physical limits, leading to slower-throughput-growth, power-hungry and hard-to-cool systems. The LightBundle architecture is said to unlock the performance of xPUs, memory and sensors, removing key bandwidth and proximity constraints while simultaneously offering an order-of-magnitude reduction in power consumption.

“We acquired our fab from Nanosys in October to accelerate our development efforts and support low-volume prototype manufacturing,” notes Avicena’s founder & CEO Bardia Pezeshki. “However, we are addressing very sizeable markets requiring high-volume manufacturing. We are very pleased to partner with one of world’s top GaN LED companies to provide a path to satisfy the expected high

volumes required by our customers, including hyperscale data-center operators and the world’s leading IC companies,” he adds.

“Avicena’s LightBundle technology provides an opportunity for GaN micro-LEDs to impact numerous key applications including HPC, AI/ML, sensors, automotive and aerospace,” says Robert Feurle, executive VP & managing director, OS business unit at ams OSRAM. “As a global leader in GaN LEDs, we are excited to partner with Avicena to transform these very large and important markets.”

LightBundle technology Today’s high-performance ICs use SerDes-based electrical links to achieve adequate IO density. However, the power consumption and bandwidth density of these electrical links degrade quickly with length. Conventional optical communications technologies developed for networking applications have been impractical for inter-processor and processor–memory interconnects due to their low bandwidth density, high power consumption, and high cost. Moreover, co-packaging existing laser sources with hot application-specific integrated circuits (ASICs) causes reliability problems unless external laser sources (ELS) are used, which increases complexity and cost.

LightBundle links use densely packed arrays of GaN micro-LEDs to create highly parallel optical interconnects with typical through-

puts of >1Tb/s at energies of <1pJ/bit. A LightBundle cable uses a highly multi-core multi-mode fiber to connect a GaN micro-LED transmitter array to a matching array of silicon photodetectors (PDs). Arrays of hundreds or thousands of LightBundle’s micro-LEDs and PDs can be integrated with standard CMOS ICs, enabling the closest integration of optical interconnects with electrical circuits. In addition to high energy efficiency and high bandwidth density, these LightBundle links also exhibit low latency since the modulation format of the individual links is simple NRZ instead of PAM4 (which is common in many modern optical links but has the disadvantage of higher power consumption and additional latency).

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

Avicena at OFC 2023

Avicena showed the LightBundle architecture and technology at the Optical Fiber Communication Conference & Exhibition (OFC 2023) in San Diego, CA, USA (7–9 March).

www.ofcconference.org

www.ams-osram.com

www.avicena.tech

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Casela launches 1310nm CW-DFB lasers for silicon photonics-based transceivers

Casela Technologies of Palo Alto, CA, USA has launched its 1310nm-band high-power, continuous-wave (CW) distributed feedback (DFB) lasers, which have what are claimed to be record high-power conversion efficiency and optical powers for silicon photonics-based transceivers.

Digital transformation, 5G, passive optical network (PON) and cable fiber initiatives continue to drive bandwidth growth for optical communications. East-west traffic inside data centers continues to increase bandwidth demand year-on-year at 40–50%. 400G is the current state of the art, but there is already a roadmap for 800G and then 1.6T. Silicon photonic-based transceivers are the leading solution for transceivers used inside data centers and for client optics in service provider networks, says Casela. These optical transceivers and new co-packaged systems-on-chip (SoC) architectures require very efficient,

high-power, low-noise lasers at various wavelengths. With increased baud rate and lane count (4x or 8x) and bandwidth growth from 400G to 1.6T, optical power requirements have increased.

Casela's new 1mm- and 2mm-long DFB lasers achieve 125mW to 200mW optical power when uncooled and 300mW to 400mW when cooled, respectively, enabling the use of a single laser for DR4 and DR8 transceivers. High optical powers are achieved at what are claimed to be industry-leading power conversion efficiencies of 30% when cooled and 20% when uncooled, operating at the maximum rated power. Key features include large modes with near-circular profiles that improve coupling efficiency to fibers or silicon-based waveguides and reliable operation proven during accelerated life testing. The same high-efficiency, high-power laser design is also available at other WDM, LAN-WDM and CWDM4 wavelengths.

The new laser was displayed at the Optical Fiber Communication (OFC) event in San Diego (5–9 March).

At OFC in Session M4C.1, the technical details of the lasers were presented by co-founder & chief technology officer Milind Gokhale in 'Record high-efficiency high-power uncooled 1.31μm CW-DFB lasers'.

"Casela was founded by industry veterans to focus on an innovative path to higher laser powers and efficiency demanded by new requirements in data centers and system-on-chip (SOC) applications," says CEO Dr Bo Lu. "With the demonstration and publication of our industry-leading laser results at OFC 2023, we are announcing our new laser platform and products for transceiver and co-packaged optics applications. Casela's high-output laser performance has been validated by multiple customers and will be available in high-volume production in second-half 2023."

www.caselatech.com

Casela demonstrates external laser source module for 1310nm and CWDM4 wavelengths

Casela has launched multi-fiber external laser source (ELS) modules operating at 1310nm and CWDM4 wavelengths. The module uses blind mate optical and electrical connectors supporting OIF's (Optical Internetworking Forum's) external laser small-form-factor pluggable (ELSFP) implementation agreement.

The module was 'live' at the OIF Co-Packaging (CPO) Interoperability Demonstration at the Optical Fiber Conference (OFC) in San Diego (5–9 March). In addition, Casela provided the light source for OIF's joint CEI and co-packaging demo, with a linearly driven optical module powered optically by an ELSFP through polarization-maintaining fiber. Casela's ELSFP was part of

the Front panel I/O, and ELSFP Connectivity Options demo to show multi-vendor compatibility.

These uncooled ELSFP modules deliver greater than 100mW into each of eight polarization-maintaining fibers to power up integrated, high-data-capacity silicon photonics systems such as CPO and SOC-based artificial intelligence (AI) accelerators. The modules use Casela's recently announced 200mW uncooled DFB lasers that operate with >20% power conversion efficiency up to 70°C module temperature. These high-power, high-efficiency lasers eliminate the need for a thermoelectric cooler (TEC), delivering best-in-class low-power consumption for an external laser source.

Modules can be specified with 2x DR4, 2x FR4 or other WDM wavelength combinations. These lasers are available for sampling now, with production commencing in fourth-quarter 2023.

Working with OIF, Casela plans to help accelerate the adoption of high optical power, high lane count and high-speed connectivity in fully integrated modules.

Also at OFC, OIF hosted its largest ever demonstration of multi-vendor interoperability, featuring four fundamental technology areas: 400ZR optics; co-packaging architectures; Common Electrical I/O (CEI) channels; and Common Management Interface Specification (CMIS) implementations.

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Sivers demos CW-WDM MSA-compliant DFB laser arrays 8-wavelength DFB laser array powers Ayar Labs' SuperNova light source

At the Optical Fiber Communication Conference (OFC 2023) in San Diego, CA, USA (7–9 March), IC and integrated module supplier Sivers Semiconductors AB of Kista, Sweden said that its subsidiary Sivers Photonics of Glasgow, Scotland, UK has successfully demonstrated its CW-WDM MSA-compliant distributed feedback (DFB) laser arrays with the SuperNova remote optical source of silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA, supporting next-generation applications including artificial intelligence (AI) connections, disaggregated data centers, 6G, and phased-array sensory systems.

The joint demonstration showcased the 8-wavelength DFB laser array from Sivers Photonics, powering Ayar Labs' SuperNova light source. The live demonstration showed two SuperNova modules, each with 64 total wavelengths, running without active cooling.

Built on the InP100 product platform at Sivers 100mm UK wafer

foundry, the DFB laser array is fully compliant with CW-WDM MSA (Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement) standards, with an output power of more than 65mW per channel CW operation and 400GHz channel spacing around 1300nm. These devices are compatible in a variety of integration platforms, such as silicon photonics and co-packaged optics (CPO).

The SuperNova optical source from Ayar Labs provides up to 16 wavelengths of light, powering up to 16 ports. Combined with Ayar Labs' TeraPHY optical I/O chiplet, this complete solution delivers up to 4 terabit per second bi-directional data throughput, with nanosecond latency, whilst consuming a fraction of the power required for traditional electrical I/O.

Revenue generated by the CPO market is expected to rise at a compound annual growth rate of 65% from about \$6m in 2020 to \$2.2bn in 2032, according to the 'Co-Packaged Optics for Data Centers

2022 Report' from market research firm Yole Development. This growth will be driven by CPO's substantial energy savings (>30%) and capital expenditure savings, measured in dollars/Gbps, over pluggable optics.

"Our DFB arrays contribute to Ayar Labs' industry-first milestone using the GlobalFoundries SiPh platform, which will help unleash the power of next-generation computing," says Sivers Semiconductors' group CEO Anders Storm.

"As communication traffic grows rapidly, we are pleased to enable Ayar Labs to deliver the optical interconnects needed for these data-intensive applications," says Sivers Photonics' managing director William McLaughlin.

"Their InP100 laser arrays are a vital part of the technology helping to drive adoption of in-package optical I/O," comments Matt Sysak, VP of laser engineering at Ayar Labs.

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www.sivers-semiconductors.com

www.cw-wdm.org

www.ayarlabs.com

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Quantifi Photonics launches first CW-WDM MSA-compliant laser test source

Laser 1300 Series powered by Ayar's SuperNova multi-wavelength, multi-port light source

Quantifi Photonics Ltd of Auckland, New Zealand (which provides high-density test equipment for silicon photonics, co-packaged optics and pluggable optics) has launched the Laser 1300 Series of compact, scalable CW-WDM MSA-compliant laser test sources, designed to enable the CW-WDM ecosystem and accelerate the adoption of multi-wavelength technology across emerging applications such as artificial intelligence (AI), high-performance computing (HPC) and high-density optics.

The new Laser 1300 Series integrates the SuperNova laser technology of silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA and provides a multi-port, multi-wavelength light source within a standardized PXIe module, offering synchronized triggering, a small footprint, simple integration, and Quantifi Photonics' CohesionUI software interface. The first model to be announced, the Laser-1301, features eight channels, with eight CW-WDM MSA-compatible wavelengths.

The Laser-1301 can be paired with the firm's existing PXIe-based products to build out a complete CW-WDM8 test solution. This includes the Laser-1226 and Laser-1227 (modules with individually controllable wavelengths at the MSA grid), Passive-1024 (CW-WDM8 multiplexer), Passive-1025 (CW-WDM8 demultiplexer), and the OSA-1001 (an optical spectrum analyzer that covers the CW-WDM range).

Designed to meet specifications of the Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement (CW-WDM MSA), the Laser 1300 Series allows the characterization of photonic



Quantifi Photonics Laser-1301 PXIe module.

integrated circuits (PICs) for AI, HPC and high-density optics applications while also providing a scalable, reproducible light source for mass-production testing. The Laser 1300 Series complies with the CW-WDM MSA specifications that standardizes multi-wavelength optical sources.

"It's well known that the external light source is a critical component of the co-packaged optics ecosystem," notes Kees Propstra, VP marketing & general manager Quantifi Photonics USA. "By combining the SuperNova CW-WDM-compliant light source with our proven PXIe-based optical test platform, we can offer a CW-WDM-capable test platform to serve the growing demand in the market and enable the testing and validation of PIC-based optical interconnects and accelerate adoption across the industry."

Ayar Labs' SuperNova light source, introduced in 2021 and developed along with its TeraPHY optical I/O chiplet, provides chip-to-chip connectivity at a fraction of the power of traditional electrical

connections while dramatically improving performance, latency and reach.

"Optical I/O promises to solve the performance-per-watt challenges of next-generation AI and HPC applications, breaking copper's impending power and performance wall," says Matt Sysak, VP of laser engineering at Ayar. "Test and measurement is an important consideration as the industry ecosystem accelerates development of these next-generation systems, and we're eager

to work with Quantifi Photonics to demonstrate the robustness of our solutions," he adds.

"This is a great example of what the CW-WDM MSA wanted to accomplish by publishing the first specification; the development of commercial laser sources for high-wavelength-count applications," says CW-WDM MSA chair Chris Cole. "We are now ready to start considering our next step, which is the development and publication of link specifications."

Quantifi Photonics displayed the Laser 1300 Series at the Optical Fiber Communication Conference and Exhibition (OFC) in San Diego, CA, USA (7-9 March) and also demonstrated a range of PXIe-based lasers, OSAs (optical subassemblies), power meters, polarization controllers and BERTs (bit-error-rate testers) designed to enable efficient, high-volume testing of silicon photonics, co-packaged optics and next-generation pluggable optics.

www.cw-wdm.org

www.quantifiphotonics.com

www.ayarlabs.com/supernova

Ayar demos first 4Tbps optical solution, paving way for next-generation AI and data-center designs

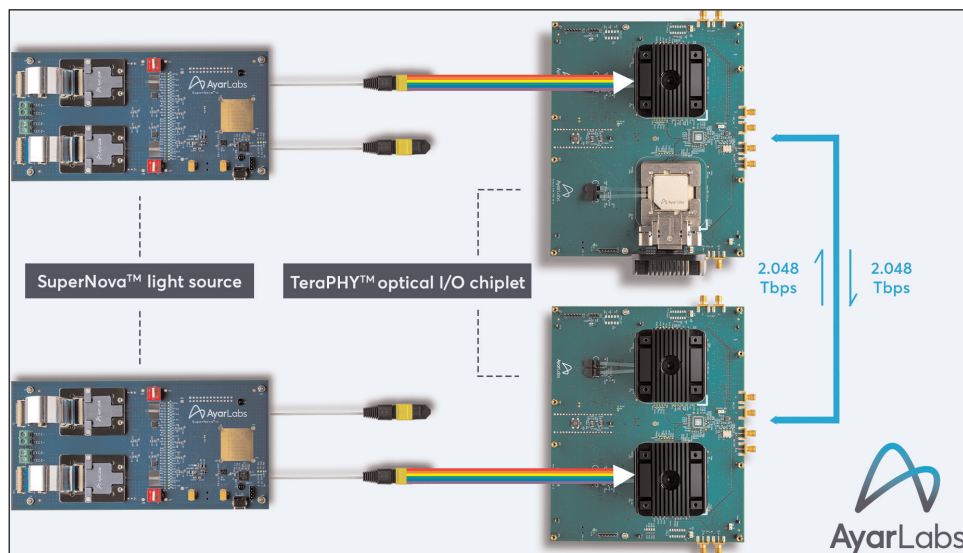
Now shipping in-package optical I/O solutions with sub-10ns latency and sub-10W of power needed for semiconductor, AI/HPC and aerospace customers to support next-gen data-intensive workloads

Silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA gave the public demonstration of what it says is the industry's first 4 terabit-per-second (Tbps) bidirectional wavelength division multiplexing (WDM) optical solution at the Optical Fiber Communication conference (OFC 2023) in San Diego (5–9 March). The firm adds that it is currently working with high-volume manufacturing and supply partners including GlobalFoundries, Lumentum, Macom, Siverson Photonics and others to deliver the optical interconnects needed for data-intensive applications.

Also at OFC, partner Quantifi Photonics launched a CW-WDM-compliant test platform that integrates Ayar's SuperNova light source.

Ayar says that in-package optical I/O uniquely changes the power and performance trajectories of system design by enabling compute, memory and network silicon to communicate with a fraction of the power and dramatically improved performance, latency and reach versus existing electrical I/O solutions. Delivered in a compact, co-packaged CMOS chiplet, optical I/O becomes foundational to next-generation artificial intelligence (AI), disaggregated data centers, dense 6G telecoms systems, phased-array sensory systems and more.

"In-package optical I/O solutions have the potential to transform how semiconductor, AI, HPC and aerospace customers process their next-generation, data-intensive workloads," comments Craig Thompson, VP of business development for Networking at NVIDIA. "NVIDIA's accelerated computing platform is enabled by advanced technologies such as WDM optical interconnects to equip tomorrow's



innovators with the extreme performance they need."

At OFC, Ayar is giving a first public demonstration showing its optical I/O solution moving data from one TeraPHY optical I/O chiplet to another at 2.048Tbps each direction powered by its SuperNova light source. SuperNova powers eight fiber links (using 64 highly accurate wavelengths operating at 32Gbps, for eight wavelengths and 256Gbps per individual fiber) running error free at lower than 10ns of latency and without needing forward error correction (FEC). This allows for a total bandwidth of 2.048Tbps each direction, or 4.096Tbps bidirectional. More importantly, the data transfer is using less than 5pJ/bit (10W), a high level of energy efficiency, providing the power density and performance per watt needed to achieve AI models with trillions of parameters, advanced HPC designs and more.

"Ayar Labs continues to showcase our technology leadership with this live silicon demonstration, an industry-first milestone on the path to overcoming the impending power and performance wall of electrical design, and unleashing

the power of next generation compute," says CEO Charlie Wuischpard. "As we bring together all the supply, manufacturing, test and compute pieces needed for high-volume deployment, we also show today that we continue to lead in pure technical achievement."

According to the report 'Co-packaged Optics for Datacenter', revenue generated by the co-package optics (CPO) market for high-performance computing (HPC) is increasing at a compound annual growth rate (CAGR) of 74% from about \$5m in 2022 to \$2.3bn in 2033, says Martin Vallo, senior analyst, Photonics, at Yole Intelligence (part of Yole Group). "Projections of rapidly growing training dataset sizes underline that data will become the main bottleneck for scaling machine learning (ML) models. As a result, we might see a slowdown in artificial intelligence (AI) progress," he adds. "Using optical I/O in ML hardware can help overcome the unfavorable result of this analysis. This could be the main driver for the adoption of optical interconnects for next-gen HPC systems."

www.ofcconference.org

POET & Vanguard Automation collaborate on co-packaged optics and AI–ML applications

Integration of micro-lenses on Optical Interposer to maximize coupling efficiency while maintaining wafer-level passive assembly

POET Technologies Inc of Toronto, Ontario, Canada — designer and developer of the Optical Interposer and photonic integrated circuits (PICs) for the data-center, telecom and artificial intelligence (AI) markets — and Vanguard Automation GmbH of Karlsruhe, Germany (developer of 3D-nanoprinted Photonic Wire Bond and Micro-Lens technology and maker of software-defined equipment for photonic integration and packaging) are collaborating to enable the integration of micro-lenses on the POET Optical Interposer to maximize coupling efficiency while maintaining POET's wafer-level passive assembly process.

"The number-one requirement for the POET Optical Interposer is to maintain a passive, wafer-level assembly process for POET-designed optical engines and light

source products. It is the key to our ability to offer significant scale and cost benefits to our customers," says POET's chairman & CEO Dr Suresh Venkatesan. "Our Optical Interposer, together with Vanguard Automation's Facet-Attached-Micro-Lenses, creates a powerful platform for electro-optical engines for transceivers, co-packaged optics, light engines and sensing devices. Incorporating micro-lenses improves the coupling efficiency of light as it passes from one photonic device to another, which in turn reduces power consumption of the combined solution. The precise alignment and printing of the micro-lenses at wafer level offers significant scalability and enhances our ability to address new markets with a uniquely powerful solution," he adds.

"The ability to print Facet-Attached-Micro-Lenses at wafer level with POET's Optical Interposer technology offers a unique electro-optical platform and combines the complementary strengths of both companies," says Vanguard Automation's CEO & managing director Thorsten Mayer.

POET and Vanguard will initially collaborate to integrate the micro-lenses on POET's LightBar products, aimed at AI–ML accelerators and bio-sensing applications to validate power efficiency improvements and the viability of chip-scale, wafer-level manufacturing using micro-lenses. POET expects to start sampling LightBar products incorporating Vanguard Automation's micro-lenses to customers in second-half 2023.

www.vanguard-automation.com

POET Infinity chiplet-based transmitter platform launched for 400G, 800G & 1.6T data-center solutions

The Optical Fiber Communication Conference and Exhibition (OFC) in San Diego, CA, USA (7–9 March) saw a live demonstration of early samples of POET Infinity, a chiplet-based transmitter platform for 400G, 800G and 1.6T pluggable transceivers and co-packaged optics solutions.

The chiplet incorporates 100G PAM4 directly modulated lasers, DML drivers and an integrated optical multiplexer for a complete 400GBASE-FR4 transmitter on a chip. Small size and a daisy-chain architecture enable side-by-side placement of multiple chiplets to achieve 800G and 1.6T speeds. Pluggable transceiver customers can use two chiplets to achieve 800G in a 2xFR4 transmitter in a QSFP-DD or OSFP package, or four

chiplets for 1.6T 4xFR4 solutions in an OSFP-XD package. The Infinity product line carries forward POET's differentiation of all passive alignments and monolithically integrated waveguides, multiplexers and demultiplexers, which translates to lower cost, power and ease-of-assembly benefits to customers.

"We are thrilled with the early test results of this unique platform that is expected to be widely embraced by transceiver module manufacturers and the data-center market," says chairman & CEO Suresh Venkatesan. "DML lasers have proven to be the most reliable and cost-effective solution for high-volume deployments, and the POET Optical Interposer enables close integration of electronics and photonics within the chip and the

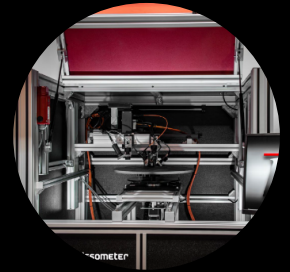
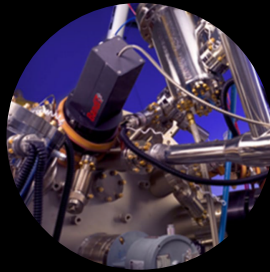
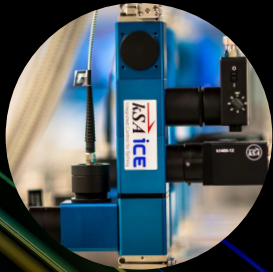
module for exceptional performance at super-high data rates," he adds. "We are grateful to Lumentum for all of the support they have provided to POET to make their most advanced 56GBaud DML lasers a key part of our market-leading project."

At the OFC exhibition, POET highlighted the size of the Infinity optical chiplets in an 800G QSFP-DD transceiver module containing an 800G receive optical engine with integrated transimpedance amplifier (TIA) and two chiplets along with an 800G digital signal processor (DSP) on a QSFP-DD printed circuit board and mechanical housing, demonstrating the ease of assembly and close integration of the transceiver components.

www.ofconference.org

www.poet-technologies.com

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QSFP-DD MSA to extend module bandwidth to 1.6Tbps New specification to leverage upcoming 200Gbps serial PAM4 SerDes

At the Optical Fiber Communications Conference (OFC 2023) in San Diego, CA, USA, the Quad Small Form Factor Pluggable Double Density Multi Source Agreement (QSFP-DD MSA) has announced plans to develop a new specification extending the bandwidth of the form factor to 1.6Tbps. The new specification will leverage the industry's focus on next-generation systems that will utilize 200Gbps serial PAM4 SerDes technology currently under development.

The new specification will maintain the form factor's eight lanes to provide an aggregate bandwidth capacity of 1.6Tbps. The 1.6Tbps module port will maintain backward compatibility with the entire family of QSFP and QSFP-DD modules and cables. This will provide the high degree of flexibility that end users and system designers have come to expect from QSFP and QSFP-DD, easing end user's migration to the industry's speed transitions. The

new specification will also maintain the QSFP-DD's riding heatsink feature that enables system designers the ability to efficiently cool higher-power modules that may be required in next-generation equipment.

The new QSFP-DD1600 specification will target the existing port density enjoyed by systems utilizing QSFP-DD today and meet the faceplate bandwidth that is expected from next-generation ASICs in the future.

"QSFP-DD's backwards compatibility has been critical to our operational approach to upgrading the network," says Jamie Gaudette, partner

The new QSFP-DD1600 spec will target the existing port density enjoyed by systems utilizing QSFP-DD today and meet the faceplate bandwidth that is expected from next-gen ASICs

network engineering manager at Microsoft, "We encourage the MSA's work on QSFP-DD1600," he adds.

"The system design flexibility that QSFP-DD enables greatly reduces the challenges in building systems with high-power modules," says MSA co-chair Mark Nowell. "The riding heatsink, besides enabling backwards compatibility, is an asset to system designers."

QSFP-DD continues to lead market adoption for 400G across applications and is set to continue to do so at 800G. This new specification will extend that to 1.6Tbps with broad support from component manufacturers to end users. The QSFP-DD MSA is supported by more than 60 companies addressing the technical challenges of achieving a double-density interface and ensuring mechanical, electrical, thermal and signal-integrity interoperability for the next generation of networking equipment.

www.qsfp-dd.com

ELPHiC samples high-speed EML at 224Gb/s-per-lane for data centers Indium phosphide integration fits eight lasers into standard 1.6Tb/s module

Fabless firm ElectroPhotonic-IC Inc (ELPHiC) of Ottawa, Ontario, Canada, which provides indium phosphide (InP) optoelectronic chips, has announced sample availability of its high-speed electro-absorption modulator laser (EML) for data-centers applications for 800Gb/s and 1.6Tb/s modules. This follows the sampling of its 10G 1271 laser and its integrated PIN-TIA receiver for passive optical network (PON) applications that has showed very high reliability.

ELPHiC has developed an optoelectronic integration technology, leading to a new generation of InP chips enabling very high-speed modulators integrated with lasers and electronics. The new process

also leads to higher performance, lower power consumption, and increased reliability for these EMLs.

"By integrating key optical and electronic elements on the same InP semiconductor substrate with the analog amplification circuitry, we create an architectural shift in building optics chipsets that significantly improve performance and power, lower cost, and reduce module form factor," says Jim Hjartarson, CEO. "Our patented PIN architecture also allows for sensitivity levels comparable to those of APDs [avalanche photodiodes]," he adds.

"This revolution for 800G products will be similar to what we saw for the 400G products four years ago: moving from an eight-laser product

to a four-laser product per module, leading to the subsequent cost reduction," says Christian Ilmi, VP worldwide sales. "Furthermore, it will enable the module manufacturers to fit eight lasers in a standard 1.6Tb/s module, which is not feasible today with the current laser technology," he adds.

"Finally, the promise of monolithic integration of optical devices and electronics are coming to market," believes Joe Costello, chairman of the board. "With the benefits of ELPHiC's technology, the performance of optical links in PON, data centers and other emerging innovative markets will take a giant leap forward".

www.elphic.com

OpenLight demos 224G InP-based modulator for Tower's PH18DA platform

New modulator doubles PIC speed for datacoms

OpenLight of Santa Barbara, CA, USA (which launched as an independent company in June 2022, introducing the world's first open silicon photonics platform with heterogeneously integrated III-V lasers) says that it has developed and demonstrated a 224G indium phosphide (InP)-based modulator available for Tower Semiconductor's PH18DA platform. Measured as part of a fully operational photonic integrated circuit (PIC), OpenLight extended the speed of its PAM4 modulator and demonstrated a PAM4 224G eye.

The new 224G modulator is integrated on a demonstration PIC with a heterogeneous integrated laser and other required silicon photonics (SiPh) components to enable a full transmitter. Fabricating these components on a heterogeneous SiPh platform enables significant gains in yield, decrease of production complexity, and improved performance, says OpenLight.

Datacom customers can now extend their multi-lane DR- and FR-based datacom designs to 224G per wavelength, doubling overall speed without increasing PIC cost.

"This new modulator doubles the speed of every PIC," says CEO Dr Adam Carter. "For instance, our

800G DR8 PIC which was recently announced can become a 1.6T PIC (8x200G). Alternatively, a 400G DR4 PIC can now deliver 800G with four lanes. Our latest offering allows datacom customers to not only prepare for the future, but also keep up with the growing need for increased connectivity speeds," he adds.

"Our partnership with OpenLight continues to increase the accessibility of PICs across industries," says Dr Marco Racanelli, senior VP & general manager of Tower Semiconductor's Analog business unit. "OpenLight's technology through Tower Semiconductor allows customers to achieve 224G operation on a silicon photonics platform and achieve the same benefits offered by on-chip lasers and optical gain without the need for separate lasers and costly attachment methods," he adds.

"200G modulation is a key building block and critical path to the delivery of next-generation Ethernet speeds based upon 200G/lane," says Jim Theodoras, VP of Research & Development at HGGenuine USA. "This is not just a 200G modulator, but one that is available in a hybrid photonic integrated circuit. Next-generation Ethernet cannot

be delivered at the power and densities being requested by datacom customers without photonic integrated circuits, and we are happy to partner with OpenLight on their industry-leading PIC technology that will enable not just 1.6T today, but also 3.2T in the near future," he adds.

"As the demand for higher data rates continues to grow unabated, the development of advanced technologies to meet these needs becomes ever more crucial," notes Sameh Boujelbene, VP Datacenter and Campus Ethernet Switch market research at Dell'Oro Group. "200G/channel optical links will be crucial in bringing 1.6Tb and 3.2Tb optical links at the right density and power consumption in parallel with the release of next-generation SerDes for use in a variety of architectures to support the massive bandwidth scaling required for cloud, AI/ML and HPC applications."

OpenLight is now offering early-access packages for its 224G modulator, enabling customers to begin designing PICs based on the latest modulator offering. Evaluation vehicles will be made available later this year for customers to enable testing of OpenLight's 224G modulator.

www.openlightphotonics.com

Mitsubishi Electric develops 200Gbps (112Gbaud PAM4) EML chip supporting four CWDM signals

Hybrid waveguide structure enables 800Gbps/1.6Tbps in data centers

Tokyo-based Mitsubishi Electric Corp has developed a 200Gbps (112Gbaud four-level pulse-amplitude modulation (PAM4)) electro-absorption modulator laser diode (EML) chip that doubles the speed of the firm's existing 100Gbps EML chip due to a proprietary hybrid waveguide structure. Support for coarse wavelength division multiplexing (CWDM) of four wavelengths

realizes 800Gbps transmission using four chips or 1.6Tbps using eight chips.

Improved operational speed (up to 200Gbps), high extinction ratio and high optical output power are achieved due to Mitsubishi Electric's unique hybrid waveguide structure, which combines a buried heterostructure laser diode for high optical-output power and a high-

mesa waveguide electro-absorption modulator.

The greatly improved performance is expected to raise the transmission speed of optical transceivers used in data centers to respond to mushrooming data-traffic demand due to the rapid growth of video distribution services and cloud computing.

www.MitsubishiElectric.com/semiconductors

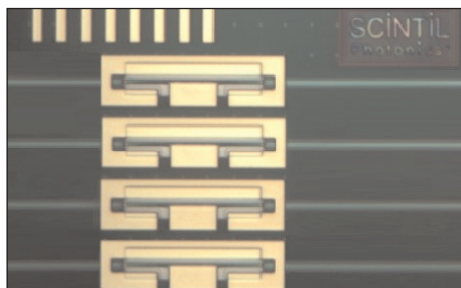
Scintil demonstrates first single-chip 100GHz DFB comb laser source

HPC and AI to gain improved computing system performance and power efficiency

At the Optical Fiber Communication conference (OFC 2023) in San Diego, CA, USA (5–9 March), Scintil Photonics of Grenoble, France and Toronto, Canada, a fabless developer of silicon photonic integrated circuits (integrated laser arrays, 800Gb/s transmitters and receivers, tunable transmitters and receivers, as well as optical I/O for near-chip and chip–chip communication), demonstrated its latest technology, a single-chip multi-port 100GHz distributed feedback (DFB) comb laser source for high-performance computing (HPC) and artificial intelligence (AI) applications,

The SCINTIL Comb Laser Source is said to be the first fully integrated single chip that achieves 100GHz frequency spacing (half to one-quarter of the spacing available today). One of its key advantages is its very narrow controlled channel spacing, an important capability for increasing the number of optical carriers in a single fibre.

“Increasing computing capacity requires connecting larger networks of computing units with higher transmission rates,” says CEO Sylvie Menezo. “To achieve this with sustainable energy efficiency, fiber-optic transmission links are used with multiple optical carriers multiplexed on one single fiber,” she adds. “We have succeeded in implementing a comb laser source



Overhead view-of 4-frequency-comb laser.

with only 100GHz spacing between each optical carrier. This offers at least twice the number of optical carriers compared to what appears to be available today, and therefore enables doubling the transmission speed. Leading customers are currently evaluating our solution.”

The increasing demand for high-performance computing and AI applications has led to the need for faster and more efficient optical interconnects. The SCINTIL 100GHz-Comb Laser Source enables the use of uncooled dense wavelength division multiplexing (DWDM) links in short-reach transmissions, with optical carriers twice as dense (100GHz versus 200GHz spacing).

“The Scintil integrated team did an excellent job at every step, from the design of the chip to the packaging and the electronics for a complete solution, with additional locking functions,” says Menezo. “Thanks to our CMOS commercial

foundry, we anticipate ramping up volume by Q4/2024. We think that our technology will be a game-changer in the field of interconnects for high-performance computing and AI applications.”

Technical features

The DFB comb laser source is designed to fuel optics co-packaged with host ASICs. Features include:

- multiple optical carriers spaced by 100GHz and all combined and available on either one or multiple output ports;
- configurations that can offer transmissions of 16 optical carriers x 64Gbps per fiber, which are suitable to support next-generation optical compute interconnect links;
- easy locking capabilities, providing system makers with unmatched characteristics for control and performance.

Demonstrators are already available and product prototypes will be ready by the end of Q4/2023.

Also at OFC, Scintil presented a paper ‘Fully Integrated III–V-on-Silicon Multi-Port DFB Laser Comb Source for 100GHz DWDM’.

In other developments, Scintil is expanding its Grenoble office, with openings for a chief financial officer with administrative functions, a senior product development engineer, and a semiconductor packaging engineer.

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www.scintil-photonics.com

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Record 400G transmission across 2400km Corning TXF fiber with Infinera's ICE-X QSFP-DD coherent pluggable

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems, has delivered record 400Gb/s single-wavelength transmission with its ICE-X 400G QSFP-DD intelligent coherent pluggable solution across 2400km of Corning's TXF optical fiber (twice the previous record distance).

The demonstration by Infinera and Corning Inc highlights the wide range of applications that can be addressed with this cost-effective and power-efficient solution, better enabling network operators to meet growing bandwidth demands.

The demonstration featured Infinera's ICE-X 400G intelligent coherent pluggable solution hosted in UfiSpace's 400G disaggregated core and edge routers across 2400km of Corning's TXF fiber, an ultra-low-loss, silica-core fiber with large effective area. The demon-

stration leveraged the features supported by Infinera's line of ICE-X intelligent coherent pluggables, including integrated system-level intelligence, programmable modulation, tunable baud rate, efficient spectrum utilization, and 0dBm launch power.

"This achievement underscores the value of Infinera's fully vertically integrated and highly programmable line of ICE-X pluggables," says Infinera's chief technology officer Robert Maher. "It also highlights the value of integrated system-level intelligence in enabling industry-leading point-to-point ZR+ performance even when deployed in third-party elements. ICE-X enables network operators to leverage cost-efficient and power-efficient pluggable solutions across a broad range of network applications without sacrificing performance, manageability, or network

resiliency," he adds.

"We are pleased to collaborate with Infinera once again to prove how combined leading-edge technologies can work together to maximize capacity and reach," says Sharon Bois, division VP, product line & marketing, Corning Optical Fiber and Cable. "Our TXF fiber enables network operators to transmit more data over longer distances and help connect the unconnected, all while lowering their overall network costs."

This data transmission was demonstrated at the Optical Fiber Communication Conference & Exposition (OFC 2023) in San Diego, CA, USA (7-9 March) in Infinera's booth using its ICE-X 400G XR intelligent pluggables hosted in UfiSpace's 400G disaggregated core and edge router over 2400km of Corning TXF optical fiber.

www.infinera.com

Arelion and Infinera set benchmark for 400G ZR+ deployments in live network field trial

Infinera and Arelion of Stockholm, Sweden have announced record-setting transmission of 400Gb/s wavelengths using a QSFP-DD pluggable coherent transceiver over 1800km of SMF-28 fiber in a live production network. The milestone in point-to-point optical networking was achieved by leveraging Infinera's ICE-X 400G ZR+ intelligent pluggable coherent transceiver across Arelion's production transmission network on routes between Dallas, Memphis and Chattanooga.

The field trial also demonstrated the powerful programmability of Infinera's ICE-X intelligent pluggable coherent solution. By adjusting the modulation of the optical signal in the same pluggable coherent solution, the firms also demonstrated long-distance performance at 300Gb/s and 200Gb/s

using a QSFP-DD pluggable. These achievements were made possible by leveraging Arelion's open and disaggregated networking approach over its live network with concurrently deployed wavelengths, including those of third-party solution providers. Disaggregation will enable Arelion to continue to integrate the latest optical pluggable components to dynamically scale its network and provide its customers with cost-efficient, high-capacity bandwidth services over long distances.

"We are pleased to once again partner with Infinera," says Arelion's senior network architect Georgios Tologlou. "We were early investors in optical pluggable components to drive demonstrable value and cost-efficiency for our customers. Lab trials with perfect fiber are one thing. But we are not

afraid to test these pluggables in live networks over the same fiber we're using for live traffic, so we were happy to demonstrate the real-world potential of Infinera's new coherent pluggable technology when implemented through Arelion's open and disaggregated network architecture," he adds.

"Through collaboration with Arelion, this record-breaking achievement represents a significant milestone in the evolution of coherent optical solutions," believes Tom Burns, general manager of the Optical Modules and Coherent Solutions Group at Infinera. "The trial demonstrates the level of performance that can be achieved in a QSFP-DD form factor powered by Infinera's ICE-X technology and coupled with the power of open optical networking principles applied in Arelion's live network."

Lumentum introduces full-band tunable optical transceivers

Live demos of TSFP28, 10G OTN and coherent CFP2 BiDi transceivers

At the Optical Fiber Communication conference (OFC) in San Diego (5–9 March), Lumentum Holdings Inc of San Jose, CA, USA highlighted its portfolio of full-band optical tunable transceivers in a live product demonstration, including 10G optical transport network (OTN) SFP+, 25G T-SFP28 and 100G coherent CFP2-DCO bi-directional (BiDi) transceiver modules.

Driven by the evolving needs of 5G deployments and distributed access architectures (DAA), full-band tunable optical transceivers offer compelling advantages compared with fixed-wavelength transceivers.

“With our latest products, we simplify, expand and deliver cost-effective solutions essential for growth at the network edge, including for telecommunications carriers in the cable MSO and 5G space as they speed up connectivity in their deployments,” says Justin Abbott, director of product line management, Transmission.

Lumentum’s 25G T-SFP28 product incorporates MSA-compliant SmartTunable technology to simplify field deployment tasks by adopting

self-tuning algorithms. It leverages the firm’s substantial installed base of manufacturing capacity to meet the rapid growth anticipated from 5G applications. The 25G TSFP28 is expected to be in production and available to customers by end-March.

Lumentum is also introducing what it says are the first 100G CFP2-DCO BiDi and 10G OTN modules to address capacity and reach challenges within DAA rollouts. The 100G CFP2-DCO BiDi is a unique product that allows capacity increases that utilize only a single fiber. The 10G OTN SFP+ provides a solution that can reach up to 100km, compared with other solutions that are limited to 80km. Increasing the span length allows network operators to realize significant cost savings in architectures where long spans are needed, such as in rural broadband deployment.

Live tunable demonstrations at OFC

Lumentum demonstrated its full-band tunable optical transceiver modules for dense wavelength-division multiplexing (DWDM) applications, which meet the

rapidly evolving demands of the network edge. These modules can be used in extended operational and environmental applications. The demonstration includes:

- 25G T-SFP28: a unique industrial (–400°C to +850°C) temperature-capable 25G T-SFP28 DWDM transceiver that adopts the benefits of smart tuning and remote sensing for autonomous commissioning and remote network management.

- 10G OTN SFP+: an OTN SFP+ transceiver with an integrated forward error correction (FEC) engine that supports extended-reach applications without an erbium-doped fiber amplifier (EDFA). The transceiver can interoperate with any open DWDM line system and transparently carry a native 10G LAN PHY payload with a carrier-grade DWDM OTN interface.

- 100G coherent CFP2-DCO BiDi: a reflection-tolerant coherent optical transceiver for bi-directional DWDM transmission over a single fiber, addressing the challenges of link capacity, simplification and cost.

www.ofcconference.org

www.lumentum.com

Excellent Core Partner Award from FiberHome

Lumentum one of seven recipients in telecom optical components

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has received the 2022 Excellent Core Partner Award from China-based information and communication network products and solution provider FiberHome Telecommunications Technologies Co Ltd.

The award is the highest honor given by FiberHome, with only a small percentage of its 1000+

suppliers selected for their outstanding business performance. Lumentum was also one of seven recipients in the telecom optical components space, recognized as a critical supplier of innovative optical technology and products for high-speed communications networks.

“I am proud to be part of an incredible team that strives to make our customers’ mission of advancing digital connections a reality, by consistently exceeding expectations and providing a

comprehensive, innovative, vertically integrated portfolio,” says Lumentum executive VP & chief operating officer Vince Retort.

Lumentum provides FiberHome with a wide range of solutions, including transmission and transport modules that support flexible network management. Its products include wavelength-selective switching, 100G/200G/400G/800G modules and components, tunables and passives. FiberHome deploys Lumentum’s solutions globally to enable high-speed data networks.

Lumentum appoints sustainability & innovation expert as independent board member

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has appointed Pamela Fletcher as an independent member of its board of directors, expanding the membership to nine members, eight of whom are independent.

“She brings a wealth of knowledge and expertise in key sectors of interest to us, as well a fresh perspective on critical growth levers such as sustainability and innovation,” comments president & CEO Alan Lowe. “She will provide valuable insights as we execute against our long-term growth strategies and expand our global footprint,” he adds.

“Lumentum has a dynamic portfolio of innovative photonic solutions that underpin the explosive growth we are seeing in applications for cloud computing, advanced manu-

facturing, and 3D sensing,” says Fletcher. “I look forward to working together with the senior leadership team to capitalize on these trends and continue to increase shareholder value.”

Lumentum says that Fletcher is an executive with over three decades of experience across the automotive and transportation industries, with a proven track record of leading innovation, creating new, high-growth businesses, driving market expansion, and growing new revenue streams.

Fletcher is currently senior VP, chief sustainability officer & corporate innovation at Delta Air Lines Inc, where she leads Delta’s Sustainability and Innovation organizations in service of the firm’s net-zero future. Prior to Delta Air Lines, she had a 15-year career at General Motors, where she held senior leadership positions such as VP of Global Innovation and VP of Electric Vehicles,

among other roles.

Fletcher is an innovator in the transportation sector, having been named in Motor Trend’s 2018 and 2019 ‘Power List’; on Automotive News’s 2020 list of ‘100 Leading Women in the North American Auto Industry’; and on Crain’s 2021 list of ‘100 Most Influential Women’. In addition to her role at Delta, she serves on the Board of Advisors for the College of Engineering at the University of North Carolina Charlotte.

Fletcher holds a Bachelor of Engineering degree from Kettering University and a Master of Engineering degree from Wayne State University. She has also completed Executive Education programs at Northwestern University’s Kellogg School of Management, Harvard Business School, and the Stanford University Graduate School of Business.

www.lumentum.com

MACOM showcases optical and high-speed analog and mixed-signal solutions at OFC

Newest products targeted at PON, wireless and wireline telecom and cloud data-center networks

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) hosted live demonstrations of its products at the Optical Networking and Communications Conference (OFC) in San Diego (7–9 March), where the firm’s optical and high-speed data IC design, product management and applications engineering teams are providing in-depth explanations of MACOM’s semiconductor solutions and benefits.

The demonstrations featured new product additions to MACOM’s portfolio of optical and high-speed

analog and mixed-signal solutions. Live demos include:

- MACOM PURE DRIVE 100Gbps per lane linear drive: This solution removes DSP from optical modules and demonstrates what is claimed to be an industry-leading low-power, low-latency solution for 100G/lane optical communications for both single-mode and multi-mode fibers.
- 800G (8x100G) multimode QSFP-DD: Showcasing MACOM’s low-cost, low-power PAM-4 analog chipset for short-reach multi-mode applications and interoperability with DSP-based partners.
- 800G/400G (100Gbps per lane)

active copper cable (ACC) equalizers: MACOM’s active copper cable extends and doubles the reach of passive copper for data-center applications, offering lower power and lower latencies.

- 50G PON downstream link: MACOM’s complete, end-to-end solution for 50G PON, including 50G NRZ DSP with integrated EML driver, 50G APD and TIA receiver.

- Optical clock recovery test module for 400G/800G applications: MACOM’s high-accuracy custom test solutions for NRZ and PAM-4 signal clock recovery for optical module production.

www.ofcconference.org

Lightsource bp orders 4GW of First Solar modules

First Solar Inc of Tempe, AZ, USA says that San Francisco-based Lightsource bp (a 50:50 joint venture with bp that develops and manages solar energy and energy storage projects) has ordered 4GW_{DC} of its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules, for delivery between 2026 and 2028 for projects in the USA. This latest deal follows a prior order by Lightsource bp in 2021 for up to 4.3GW_{DC}, putting the firm on a path to becoming one of the world's largest users of First Solar's solar technology.

"The US solar industry is at a pivotal moment, poised to expand at an exponential rate with the Inflation Reduction Act serving as the catalyst," says Kevin Smith, chief executive officer, Americas, Lightsource bp. "We are seizing the opportunity by not just growing our 20GW development pipeline across the United States but also creating sizeable demand for our US-based partner First Solar which, in turn, is investing in innovation and manufacturing, and supporting thousands of direct and indirect American jobs."

The deal includes orders for Series 6 Plus and next-generation Series 7

modules. Designed and developed at its R&D centers in California and Ohio, First Solar's PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance.

Lightsource bp has committed to recycling solar panels across all of its projects. As part of this, it will use First Solar's recycling program to manage modules at the end of their operating lives. First Solar operates a recycling program that provides closed-loop semiconductor recovery for use in new modules, while also recovering other materials including aluminium, glass and laminates.

Additionally, Lightsource bp has set targets to reduce Scope 1, 2 and 3 greenhouse-gas (GHG) emissions. First Solar has also set targets to reduce its Scope 1 and 2 GHG emissions. First Solar is reckoned to be the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics.

"Our relationship with Lightsource bp is a partnership in growth," says First Solar's chief commercial officer Georges Antoun. "We enable their

growth with certainty through long-term pricing and supply commitments, and advanced technology, while they enable ours by providing the certainty of demand we need to invest in manufacturing."

First Solar is expanding its US manufacturing capacity, with a third factory expected to come online in Ohio in first-half 2023 and a fourth under construction in Alabama expected to be commissioned by 2025. Both will produce the Series 7 modules ordered by Lightsource bp. First Solar's new \$1.1bn Alabama factory and \$185m expansion of its existing manufacturing footprint in Ohio are expected to bring its total investment in American manufacturing to over \$4bn. The firm's annual US nameplate manufacturing capacity is forecast to expand to 10.6GW_{DC} by 2026.

First Solar estimates that its new investments in Alabama and Ohio will add at least 850 new manufacturing and over 100 new R&D jobs, taking its total number of direct jobs in the USA to over 3000 in four states by 2025 (believed to make it one of the largest employers in the American solar manufacturing sector).

www.lightsourcebp.com/us

Silicon Ranch commits to extra 1.5GW of PV modules

Silicon Ranch of Nashville, TN, one of the USA's largest independent power producers, has procured an additional 1.5GW of modules from First Solar. The Series 6 Plus modules were designed and developed at First Solar's R&D facilities in California and Ohio, and in the USA are manufactured in Ohio.

The deal expands on a master supply agreement that includes a 4GW transaction announced in April 2022 and, more recently, a 700MW commitment announced in October. Whereas the prior agreements will supply Silicon Ranch projects through 2025, this latest expansion will serve projects in 2026 and 2027.

Over the past year, Silicon Ranch has committed to support domestic manufacturing and to lower the carbon impact of production through significant agreements with First Solar and Nextracker. The expanded partnership with First Solar enables Silicon Ranch to continue sourcing US solar technology from a manufacturer with facilities across the country. First Solar recently announced plans to build its fourth US module manufacturing facility in Alabama, further bolstering the domestic solar supply chain in the south-eastern United States, a region in which Silicon Ranch pioneered utility-scale solar development with the first

large-scale solar projects in Tennessee, Georgia, Mississippi, Arkansas and Kentucky.

"Silicon Ranch is a trusted partner that shares our position on supporting the domestic economy, and this expansion of our partnership supports the accelerated deployment of Responsible Solar in America," says First Solar's chief commercial officer Georges Antoun.

Silicon Ranch owns, operates and maintains over 150 solar generating facilities in 15 states, from New York to California. Earlier this year, the firm announced that it had conducted a \$600m equity raise.

www.siliconranch.com
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Amorphous p-NiO/n-Ga₂O₃ crystal solar-blind detection

Researchers claim record UV detectivity and open-circuit voltage.

University of Science and Technology of China (USTC) claims record detectivity and open-circuit voltage for its nickel oxide/gallium oxide (NiO/Ga₂O₃) heterojunction solar-blind photodetector (SBPD) [Mengfan Ding et al, IEEE Electron Device Letters, published online 8 December 2022].

Such compact devices are of interest for high-performance, portable, low-power solar-blind ultraviolet (UV) detection systems for secure communication and flame detection, among other applications. Ga₂O₃ has an

ultrawide bandgap in the range 4.7–5.3eV (264–234nm photon wavelength). The bandgap is well away from the visible range 1.65–3.26eV (750–380nm).

The researchers used the NiO/Ga₂O₃ heterojunction combination to produce a p–n junction due to the difficulty in achieving p-type conductivity in Ga₂O₃. Amorphous p-NiO has a relatively high hole mobility. The researchers demonstrate that “amorphous p-NiO has potential to construct an excellent staggered band alignment and superior interface with crystalline

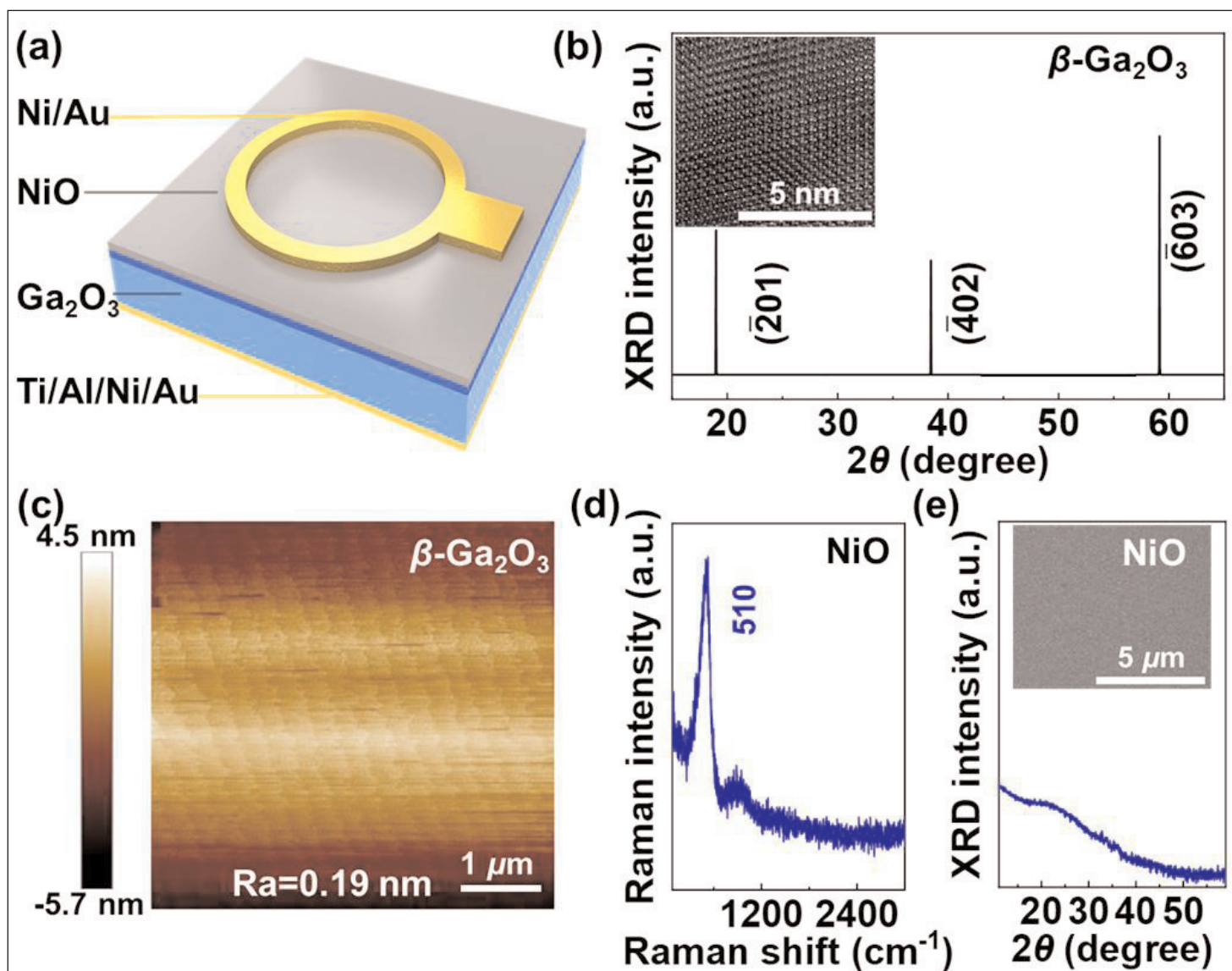


Figure 1. (a) Device schematic diagram. (b) X-ray diffraction (XRD) pattern and transmission electron microscope (TEM) images (inset) and (c) atomic force microscope (AFM) image of β -Ga₂O₃ single crystal. (d) Raman spectrum and (e) XRD pattern and scanning EM (SEM) image (inset) of amorphous NiO film.

Ga₂O₃,” avoiding carrier-blocking trap states.

The substrate for the device (Figure 1) was β-Ga₂O₃ with a 1μm halide vapor phase epitaxy (HVPE) epitaxial layer with electron (n) concentration of 2x10¹⁶/cm³. The backside ohmic electrode of titanium/aluminium/nickel/gold (Ti/Al/Ni/Au) was applied and annealed after some dry etching. Surface damage from these processes was repaired using a Piranha solution consisting of 2:1 sulfuric acid:hydrogen peroxide (H₂SO₄:H₂O₂). This produced “an atomically flat Ga₂O₃ upper surface with clear step structure and low roughness (0.19nm),” according to the team.

The p-type amorphous NiO was the result of room temperature RF sputtering. The Ni/Au top ohmic ring electrode was applied using electron-beam evaporation. The illumination window area was 1.2x10⁻³/cm².

The rectifying on/off dark current ratio of the diode between +3V and -3V was 10⁴. The use of NiO, rather than directly applying Ni to the Ga₂O₃ to form a Schottky junction, enhanced the reverse-bias response to 254nm radiation by four orders of magnitude.

The researchers investigated the performance with varied NiO oxygen content and thickness. The team comments: “The device with 30nm NiO film has the best performance due to the balance of NiO film transmittance and depletion region width of device.” It was also found that higher oxygen content gave better performance, “mainly due to the higher hole concentration”.

The 0V response to UV is of particular interest since it enables self-powered setups (Figure 2). The dark current noise was at the picoamp scale.

The photo-dark current ratio (PDCR) reached 3x10⁶ under a 254nm illumination intensity of 955μW/cm² with approximately linear performance. At the same intensity, the open-circuit voltage (V_{oc}) reached 1.3V, “exceeding almost all the reported Ga₂O₃ heterojunction photodetectors,” according to the team (Figure 3).

The responsivity peaked at an “ultrahigh” 5A/W at 222μW/cm², where the specific detectivity (D*) was 1/6x10¹⁴ Jones. The spectral performance of R peaked at 245nm, with a cut-off around 260nm. The rejection ratio of 460nm visible light was 2x10⁴. The response time to changes in intensity was better than 1ms. ■

Function	Material	Al content	Thickness
Contact	p-GaN	0%	
Contact	p-AlGaN	graded	50nm
Cladding	p-AlGaN	100%-70%	320nm
Waveguide	AlGaN	63%	120nm
Cladding	n-AlGaN	75%	400nm
Substrate	AlN		

Figure 2. (a) NiO/Ga₂O₃ heterojunction photodetector current-voltage performance under 254nm illumination with different intensities. (b) Dependence of PDCR and R at 0V on light intensity. (c) Voc as function of light intensity. (d) Normalized spectral response at 0V.

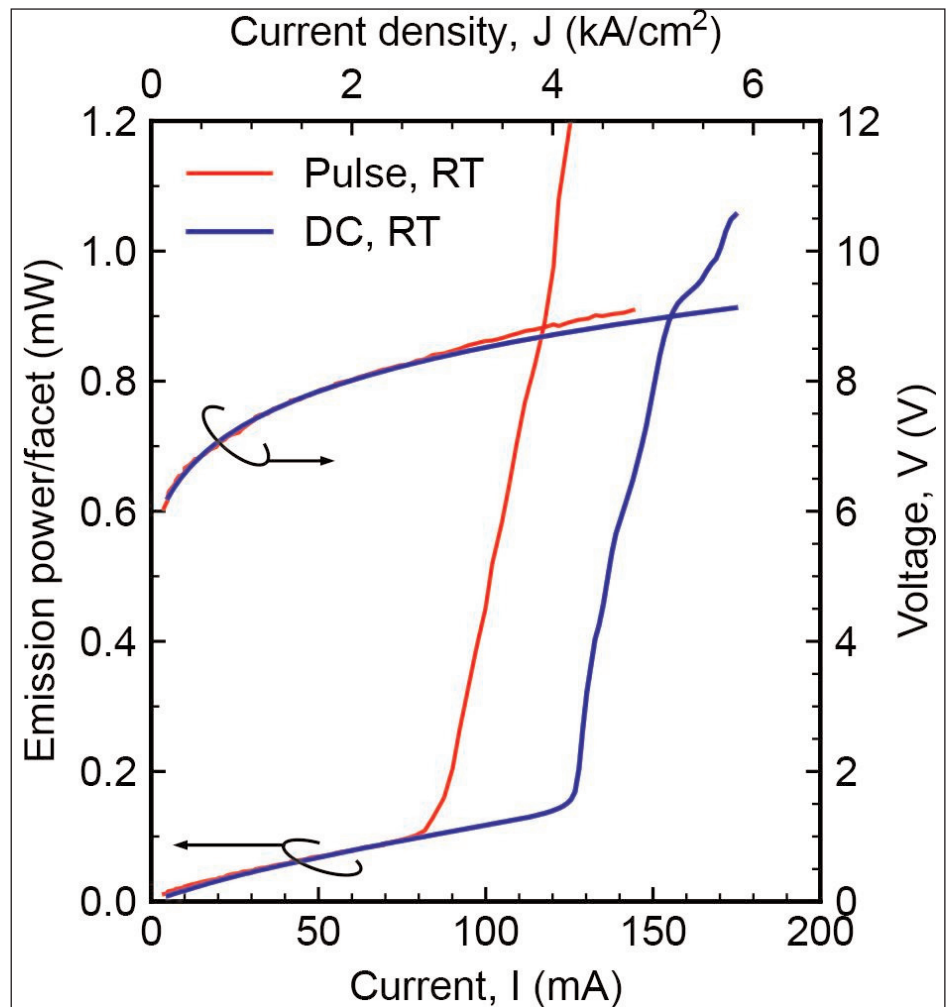


Figure 3. Benchmark plots of (a) PDCR versus R and (b) D* versus 1/(Decay time) from representative self-powered Ga₂O₃ SBPDs. Red star represents USTC work.

<https://doi.org/10.1109/LED.2022.3227583>

Author: Mike Cooke

Enhancing interband cascades for longer wavelengths

Researchers report cw operation beyond 12 μm and pulsed operation up to 160K.

University of Oklahoma and Sandia National Laboratories in the USA report on enhancing the performance of type-II interband cascade lasers (ICLs) in the wavelength range 10–13 μm [Jeremy A Massengale et al, *Semicond. Sci. Technol.*, v38, p025009, 2023].

Such devices offer efficient performance in the 3–8 μm mid-wavelength infrared (MWIR) range, using mainly antimonide layers on gallium antimonide (GaSb) substrates. However, efficiency drops in the long-wavelength IR (LWIR) range of 8–15 μm . This can be ameliorated somewhat by using indium arsenide (InAs) substrates. Further enhancements for longer wavelengths have also been developed, and the Oklahoma/Sandia team performed a wide-ranging exploration of their potential.

The mid- and long-wavelength ranges have many applications for gas/chemical sensing, imaging, and industrial process control. Also, there are atmospheric windows at 3–5 μm and 8–12 μm , offering potential for free-space communications.

The researchers used a type-II W-shaped structure for the quantum well (QW) active region where the electrons and holes recombine into photons (Figure 1). In two structures a pair of indium arsenide phosphide (InAs_{0.5}P_{0.5}) barriers around the well was used to alleviate reduced wavefunction overlap at long wavelengths.

“This phosphorus-containing alloy has a lower valence band edge than that of the commonly used aluminium antimonide (AlSb) barrier and serves to lower the electronic state in the InAs QW, resulting in a reduced interband transition energy for photons at longer wavelengths,” the team explains. The team also designed and produced two structures without the InAsP insertions.

The InAsP barriers allowed the InAs electron wells to be reduced by 30–35% in thickness, compared with structures without. The researchers estimate the resulting increase in wavefunction overlap to be from

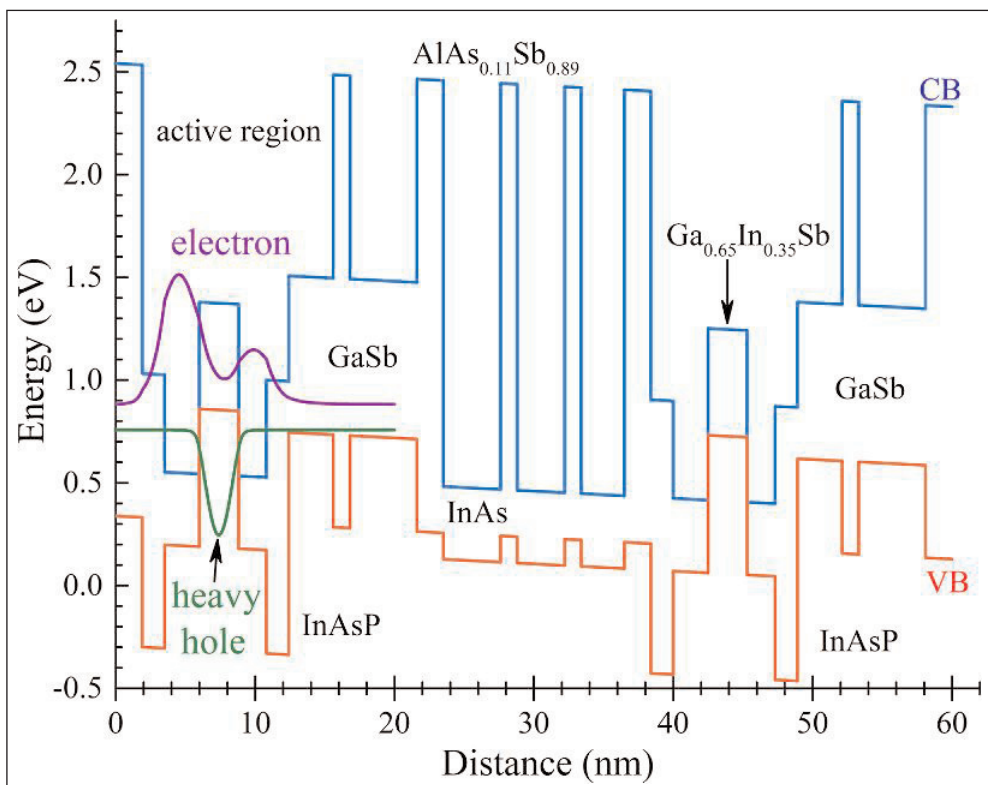


Figure 1. Band-edge diagram for one cascade period of structures including InAs_{0.5}P_{0.5} barriers in QW active region.

around 15–17% to 18–19%, resulting in higher efficiency in recombining into photons.

The ICL core was wrapped in InAs separate-confinement layer (SCL), InAs/AlSb superlattice (SL) intermediate cladding layer, and heavily doped n⁺-InAs plasmon cladding layer for optical confinement. However, the n⁺ doping was reduced by 13% from previous work in an effort to reduce free-carrier absorption of the laser light that would reduce laser efficiency.

The structures were grown by solid-source molecular beam epitaxy at 440°C. One exception to the solid-source precursors was the use of cracked phosphine (PH₃) for the phosphorus component.

The materials were fabricated into broad-area lasers of 100 μm and 150 μm widths. The cleaved laser bars were about 1.5mm long. There was no facet coating.

Among the achievements of the resulting devices, the team reports: “ICLs that included the active-layer design change exhibited cw operation beyond 12 μm , which is the first demonstration of broad-area ICLs operating in cw mode at such long wavelengths.”

Also, the devices demonstrated improved thermal

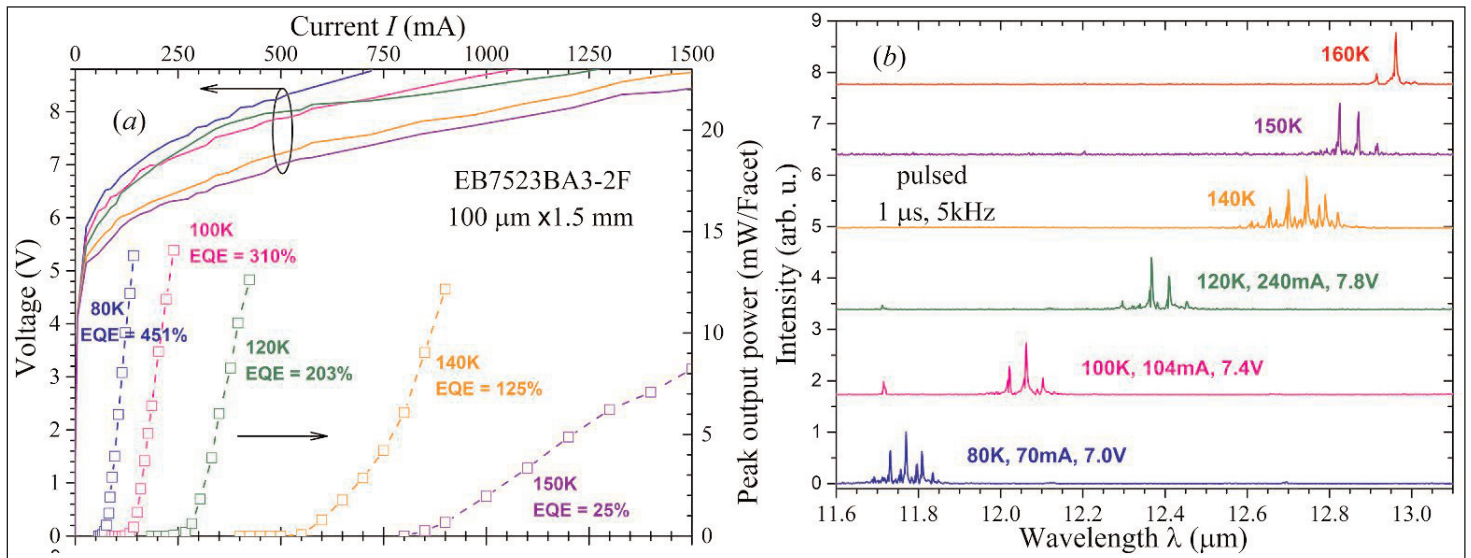


Figure 2. (a) Current–voltage–power characteristics and (b) emission spectrum between 80K and 160K in pulsed mode for device with InAsP barriers.

performance, operating at up to 40K higher than previously. The best device in this respect emitted at 12.97μm wavelength in pulsed mode at 160K (Figure 2). The threshold current density was 1267A/cm².

A device without the InAsP barrier achieved an output power of 32mW/facet in cw mode, “higher than any interband laser has achieved at such a long wavelength,” according to the team (Figure 3). The wavelength at

80K was 10.9μm, and the threshold current density 26.7A/cm². The cw lasing continued up to 102K, and in pulsed-mode up to 137K. At this temperature, the threshold was 325A/cm², and the wavelength had redshifted to 11.5μm, the longest reached for the devices with a regular W-QW without InAsP barrier. ■

<https://doi.org/10.1088/1361-6641/acac4e>

Author: Mike Cooke

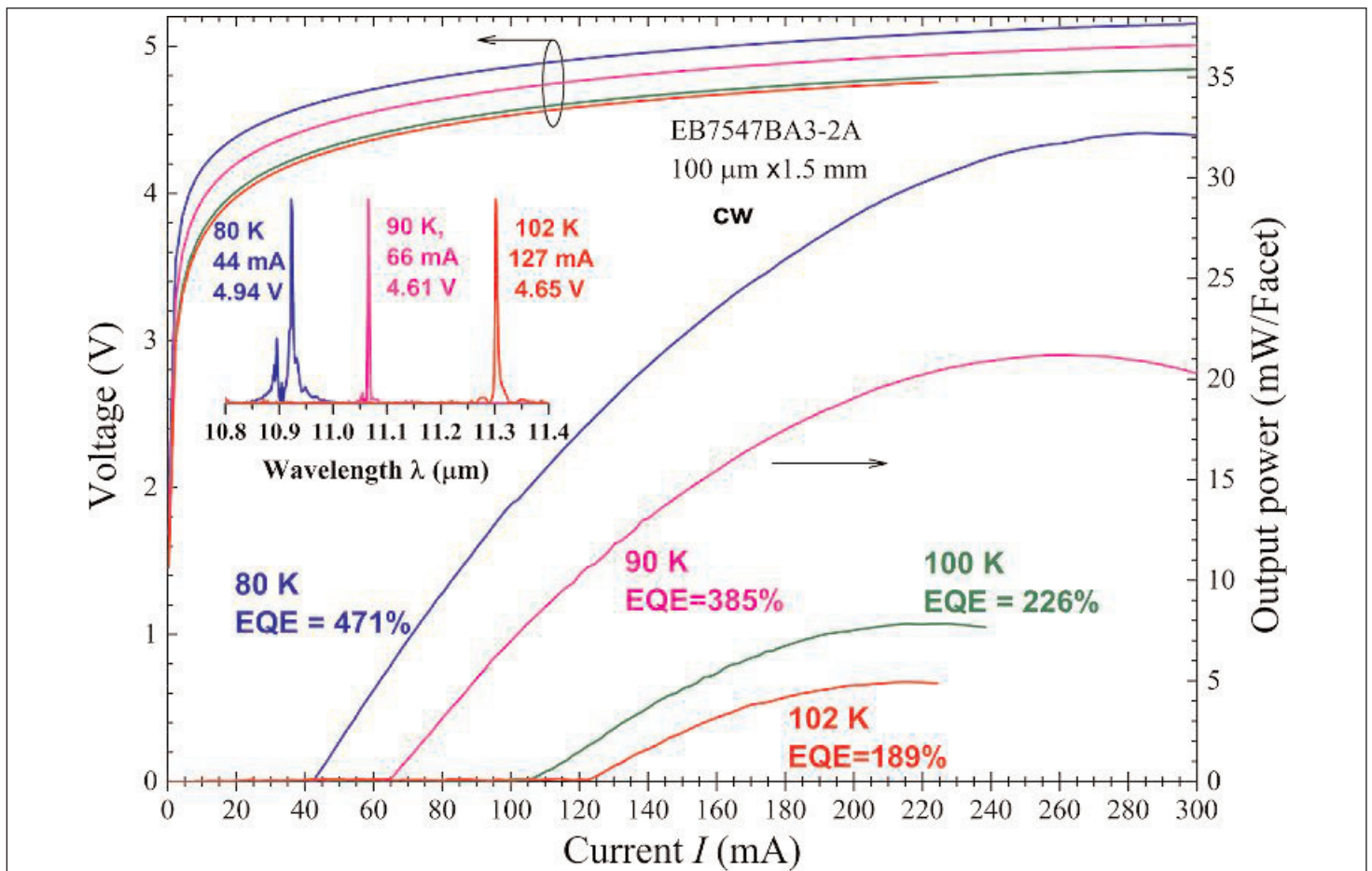


Figure 3. Current–voltage–power characteristics in cw mode for device without InAsP barriers.

Room-temperature continuous-wave UV-C laser diode

Reduced self-heating enables lasing without cooling measures.

Asahi Kasei Corporation and Nagoya University in Japan have reported on continuous wave (CW) lasing at room temperature in 274nm-wavelength aluminium gallium nitride (AlGaN) [Ziyi Zhang et al, Appl. Phys. Lett., v121, p222103, 2022]. The lasing wavelength is in the ultraviolet C (UV-C) 100–280nm wavelength range, with photon energies of 12.4–4.43eV. The 274nm wavelength corresponds to 4.53eV.

The researchers report: “Although UV-C laser diodes have been demonstrated in prior work, CW lasing was not possible without cooling.” Hoped-for deployments of such devices include instrumentation, laser machining, and disinfection. Such applications require substantially increased efficiency and lifetime before commercialization would be possible.

The material for the laser diode (Figure 1) was grown pseudomorphically on a 2-inch (0001) Al-polar AlN substrate (Figure 2), using metal-organic chemical vapor deposition (MOCVD). The waveguide layer included two 4.5nm quantum wells as an active photon-emitting layer. While the n-type used a traditional silicon-doping strategy to tip the equilibrium to conduction by electron carriers, the bulk of the p-type doping was achieved through distributed polarization doping (DPD), which uses the varying charge polarization of AlGaN with different Al-contents to create hole conduction. Only the GaN cap layer was doped with magnesium (Mg) impurities to achieve p-type conduction. The use of DPD avoids the decreasing effectiveness of Mg as a p-type dopant

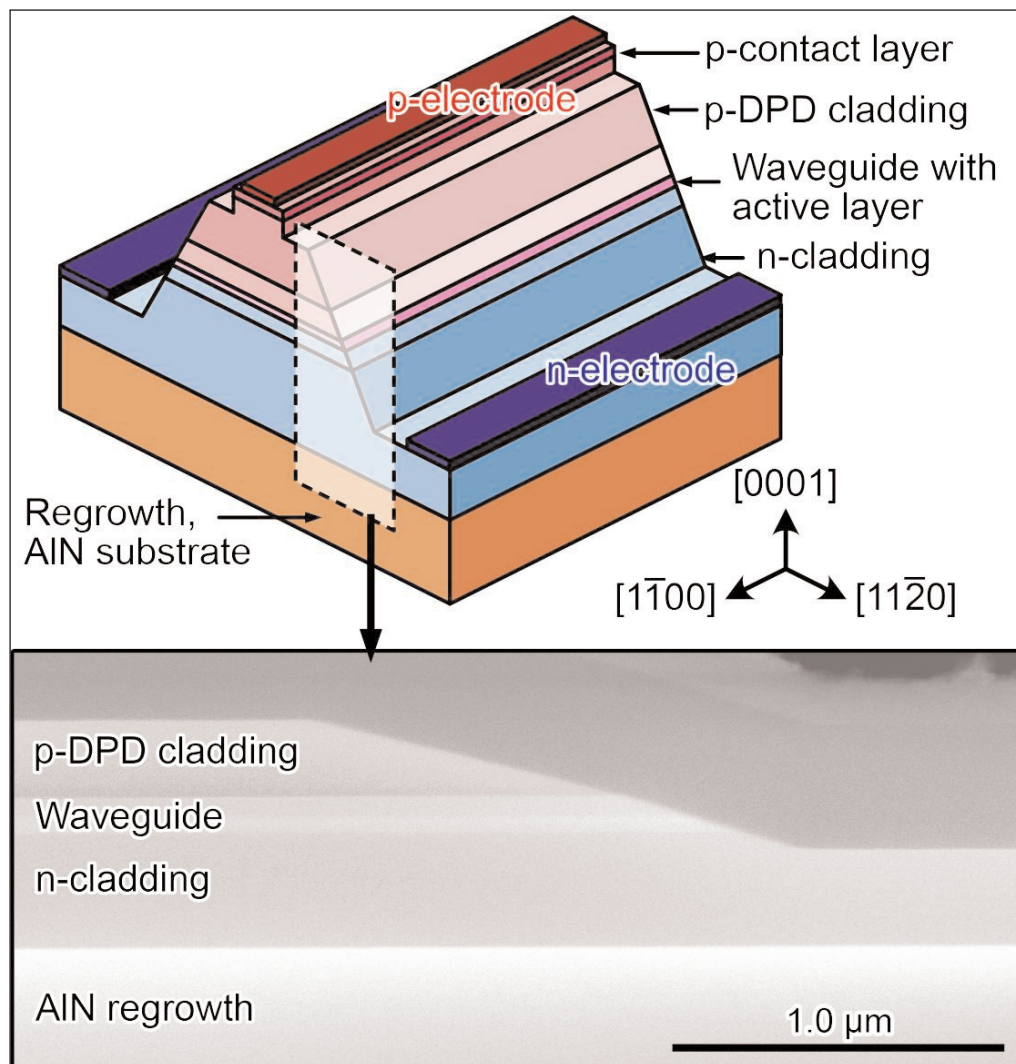


Figure 1. Schematic fabricated UV-C laser diode structure and cross-sectional scanning electron microscope (SEM) image of sloped mesa edge.

in high-Al-content AlGaN. X-ray analysis confirmed the pseudomorphic nature of the AlGaN, showing the layers to be fully strained to match the AlN substrate lattice.

The material was fabricated into 600μm-long devices. The sides of the laser diode mesa was bevelled at a 15° angle with the width of the top p-electrode of 5μm. The researchers explain the purpose of the bevel: “This angle was sufficiently shallow to effectively suppress dislocation formation that can result from the concentrated shear stress generated at the mesa

edge." This allowed the p- and 2xn-electrodes to be placed nearer to the mesa edge than previously, shortening the current flow path through the n-cladding and thus reducing series resistance. The cleaved end facets were coated to provide more than 90% reflectivity.

Pulsed operation (100ns at 0.02% duty cycle) was used to test the characteristics without thermal degradation. The peak wavelength at room temperature was 274nm and the thermal shift between -5°C and 65°C was 32pm/K, under current injection 10% above threshold. The characteristic temperature for the shift in threshold current (T_0) was 70K. The horizontal and vertical far-field pattern (FFP) spreads were 6° and 30° , respectively, at 1mW output power.

The horizontal pattern showed multiple peaks, presumably from different transverse modes. The multiple transverse modes also result in kinks in the emission power-current behavior, probably due to the stimulated emission hopping between these transverse modes.

The team comments: "It is expected that the linearity of L-I characteristics above the threshold current will be improved by reducing the number of allowed transverse modes, for instance, by using a narrower ridge and gain geometry or by eliminating higher-order modes by employing absorbing layers."

One effect of using DPD p-doping, it is thought, was the series resistance being almost constant over the temperature range, unlike devices with Mg-doped cladding. The activation energy of Mg-doping is very high, resulting in large changes (reductions) in resistance of the cladding as the temperature increases.

The performance under continuous wave/direct current (CW/DC) operation with no thermal control at room temperature was compared with the pulsed results (Figure 3). The threshold current is 125mA, corresponding to $4.2\text{kA}/\text{cm}^2$ density. The CW voltage at threshold was 8.7V.

The input power at threshold is estimated to increase the junction temperature by 28K above ambient through self-heating, consistent with the increased threshold current. This suggests that CW lasing requires reduced thermal resistance to heat dissipation and reduced heat generation from the series resistance, along with higher T_0 . The reduction in series resistance to 8.4Ω , from 12Ω in the team's previous work, was key to achieving CW lasing at room temperature.

The team also thinks that better understanding

Function	Material	Al content	Thickness
Contact	p-GaN	0%	
Contact	p-AlGaIn	graded	50nm
Cladding	p-AlGaIn	100%-70%	320nm
Waveguide	AlGaIn	63%	120nm
Cladding	n-AlGaIn	75%	400nm
Substrate	AlN		

Figure 2. Material details.

of the factors impacting T_0 could increase it towards the 150K level of commercial indium gallium nitride laser diodes. Such factors could include "broadening of the gain spectrum (decreasing the gain), thermally activated carrier escape, free-carrier absorption, and Auger recombination". ■

<https://doi.org/10.1063/5.0124480>

Author: Mike Cooke

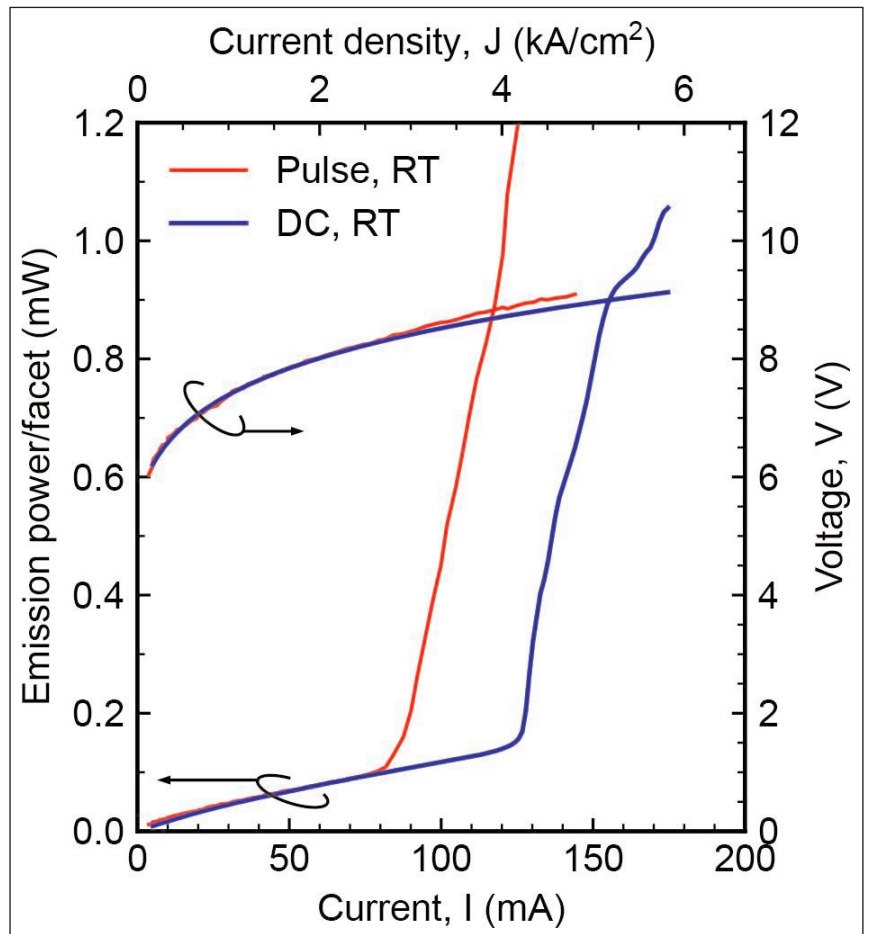


Figure 3. Emission power-current-voltage (L-I-V) characteristics of UV-C laser diode under pulsed and DC operation at room temperature.

InGaN micro-LEDs for full-color passive-matrix displays

V-grooves enable a current-variable emission wavelength, from red to blue.

Matthew Hartensveld of Innovation Semiconductor Inc reports on a demonstration of indium gallium nitride (InGaN) micro-light emitting diodes (μ LEDs) integrated in a full-color 5x5 passive matrix [IEEE Electron Device Letters, volume 44, issue 3 (March 2023), p460-463].

The color tunability was arranged through deliberate incorporation of spontaneously-formed V-grooves in the μ LED wafers, as previously reported here [Mike Cooke, Semiconductor Today, 12 August 2022], based on Hartensveld's work last year.

The V-grooves cut through the light-emitting InGaN/GaN multiple quantum wells (MQWs) locally altering the band structure. When incorporated into μ LEDs the color of the emitted light changes according to the injected current density.

Such optoelectronic behavior is of much interest for full-color display deployment in high-resolution augmented reality (AR) and other systems. Using one device type covering the full color range, rather than integrating a series of separate devices, usually in incompatible III-V technologies, to cover red-green-blue (RGB) emissions, should reduce complexity and hopefully lead to lower production costs and so on.

The μ LED wafers included buffer layers strained to optimize V-groove formation in the overlying InGaN/GaN MQW structure.

The wafer growth was on sapphire, using metal-organic chemical vapor deposition (MOCVD). The structure was designed to target green wavelength emission in the planar region away from the V-grooves.

As usual, there were n-GaN contact and p-GaN layers below and above the MQWs, respectively. Electrons were blocked from overshooting the MQW by a p-type aluminium gallium nitride (p-AlGaN) electron-blocking layer (EBL) between the MQW and p-GaN.

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) found a random V-groove density of $4 \times 10^8/\text{cm}^2$.

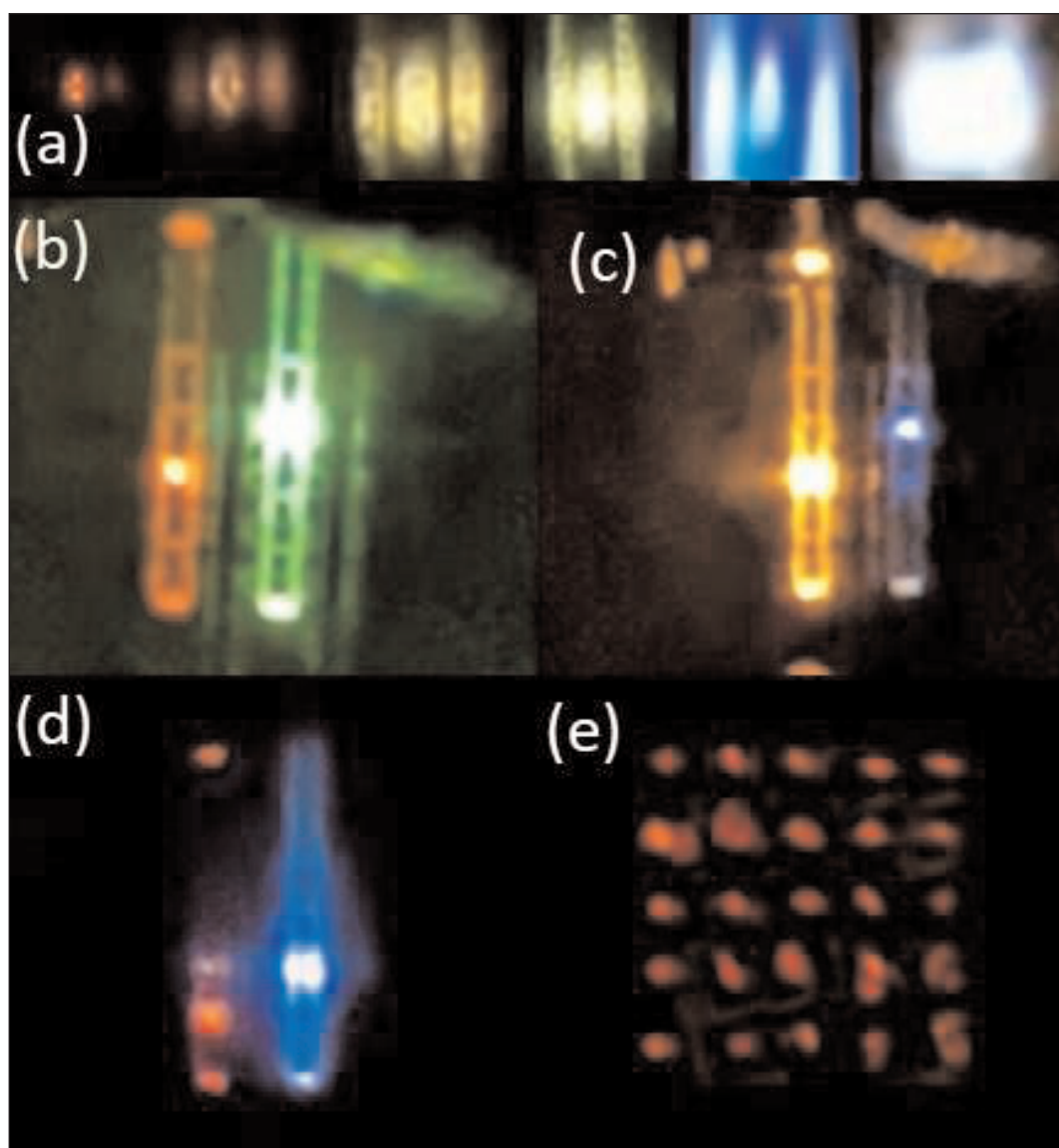


Figure 1. (a) Formation of n-GaN columns with μ LEDs, (b) oxide deposition and contact cut formation for anode and cathode connections, (c) formation of ITO anodes and Ti/Al contact pads, (d) optical image of 5x5 array, (e) SEM image of 5x5 array.

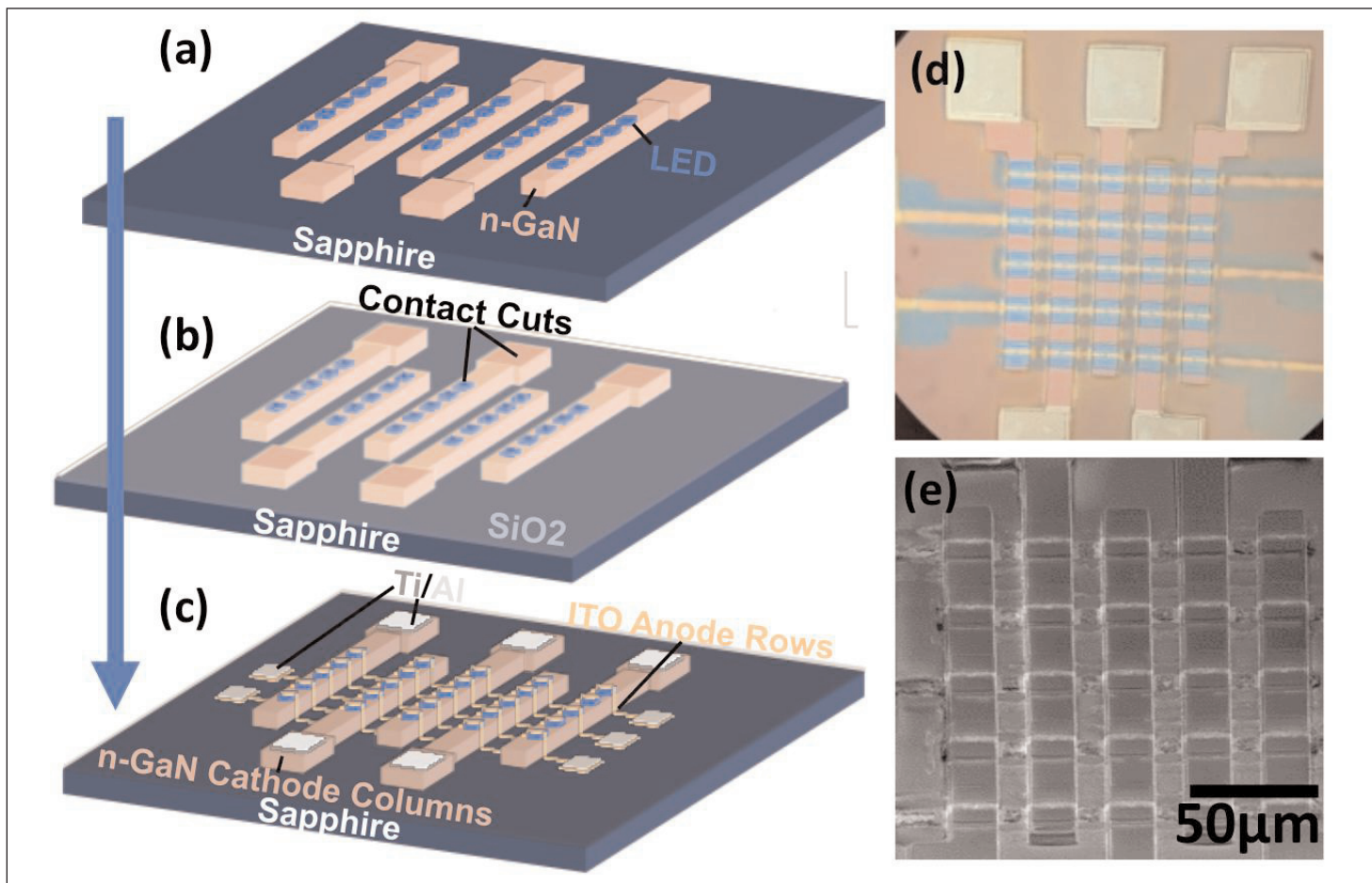


Figure 2. (a) Differing colors generated from a single μ LED; the last image in the strip is 'white' generated by mixing blue and yellow emissions appropriately. (b) Red and green, (c) yellow and blue, and (d) red and blue emission from two μ LEDs, (e) 5x5 μ LEDs in red sequentially generated through individual driving and image captures.

The passive array fabrication began with mesa isolation into cathode-connected $25\mu\text{-wide}$ columns by etching down to the sapphire substrate, forming the base of the 5x5 array of $20\mu\text{m}^2$ μ LEDs (Figure 1). The n-contacts and individual μ LEDs were created by etching cuts through the anode isolation, provided by 300nm plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2). The anode contacts were realized by sputtering and etching 100nm indium tin oxide (ITO) transparent conductor and deposition of and lift-off of titanium/aluminium row lines and n-contact pads.

The turn-on voltage at 8V was high compared with the $\sim 1.5\text{V}$ for previous reports on V-groove μ LEDs. Hartensveld blames "lack of optimized metallization for both the n-type and p-type contacts, where there is an added voltage drop particularly from the p-type contact."

In particular, ITO is n-type conducting, giving a tunnel junction injection of holes into the μ LED. "If the ITO deposition and annealing process is not optimized, the reversed p-n junction between the n-type ITO and p-GaN must be first overcome, leading to the voltage drop," Hartensveld explains. In addition to improved annealing, a different choice of metal electrode, e.g. nickel/gold, could enhance efficiency.

The first emissions after turn-on were red but, at higher voltages and hence current injection, the color changed successively until reaching blue. The current density for 640nm red emission was $\sim 1 \times 10^{-5} \text{mA/cm}^2$; and that for 425nm blue $\sim 8 \times 10^{-4} \text{mA/cm}^2$.

Of course, the higher voltage/current leads to higher brightness. Normalizing to the red brightness level could be achieved through pulsing the drive current for the shorter wavelengths of green and blue, at a duty cycle around 1% and 0.1%, respectively. "Color uniformity in the critically important color red was demonstrated across the array," Hartensveld reports.

The color gamut of the devices is somewhat let down in the green region. Hartensveld comments: "Due to the single μ LED color tunable pixels compared with the conventional three fixed μ LED approach, a parabola-shaped coverage of the color space is created. Both blue and red have good positioning near the edges of the chart, with further optimizations possible for green." ■

www.innovationsemi.com/

<https://doi.org/10.1109/LED.2023.3237512>

https://semiconductor-today.com/news_items/2022/aug/innovationsemi-120822.shtml

Author: Mike Cooke

Surge handling of GaN polarization superjunctions

Research shows that polarization superjunction diodes can be highly cost-effective and reliable.

University of Sheffield in the UK and Japan-based Powdec K.K. have presented surge current capabilities of 1.2kV gallium nitride (GaN) polarization superjunction (PSJ) diodes "for the first time" [Alireza Sheikhan et al, Jpn. J. Appl. Phys., v62, p014501, 2023].

The team comments: "The results show that GaN PSJ diodes can be highly cost-effective and reliable for high-frequency, high-efficiency power electronic designs."

The researchers add: "One of the key parameters of power diodes is their surge current capability, which is a requirement in cases such as fault occurrences within a system or inrush current during starting phase."

It is hoped that GaN-based circuits will enable faster power switching, allowing the use of smaller magnetic components, such as inductors and transformers, at higher power density. The implementation of superjunction conductivity modulation schemes, as commercially implemented in silicon, allows devices to beat the theoretical material limits of simple one-dimensional device models.

The researchers used an aluminium gallium nitride (AlGaN) layer sandwiched between two GaN layers to create two-dimensional hole (2DHG) and two-dimensional electron (2DEG) gases at the respective GaN/AlGaN interfaces due to piezoelectric and spontaneous charge polarization fields due to the ionic nature of the III-N chemical bonds (Figure 1). "The device uses the concept of polarization charge balance to achieve a flat distribution of electric field resulting in an enhanced blocking voltage capability," the team explains.

The anode (A) and cathode (C) contacts were interdigitated with 47 and 48 fingers, respectively, resulting in a 2.39mm diode width. The anode contact was doped with magnesium (Mg) to give p-type conductivity. The anode electrode was nickel/gold (Ni/Au), and the cathode had added titanium (Ti) and aluminium.

The drift region was 20µm long (Lpsj). This parameter controls the voltage-blocking capability of 1.2kV and gives a breakdown around 2kV.

Reverse bias removes the polarization charges from the drift region, with the holes leaving through the anode and the electrons leaving through the cathode.

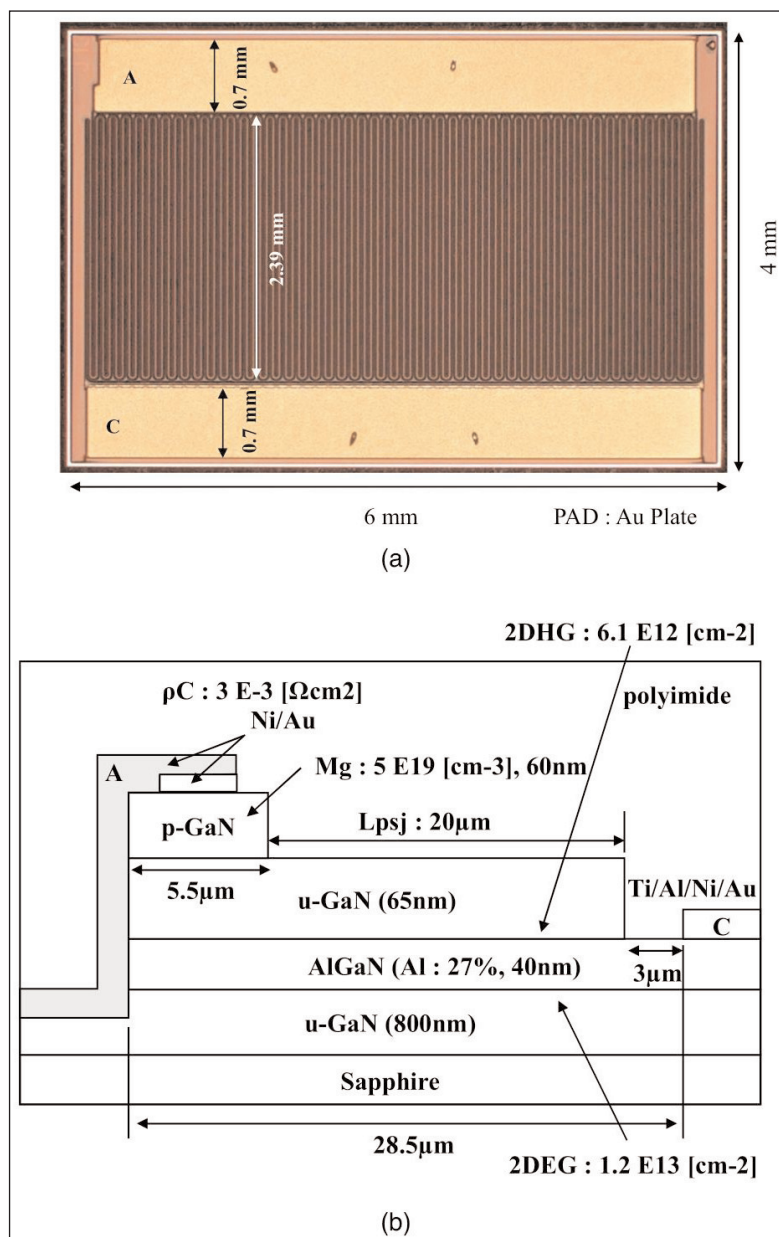


Figure 1. (a) Top view of 1.2kV GaN PSJ diode chip and (b) cross-sectional schematic structure.

The researchers comment: "The absence of polarization charges results in an even distribution of electric field, enabling extremely high reverse voltage blocking capability superior to conventional GaN HEMTs."

The depletion of the drift region was seen in 1MHz capacitance measurements, which showed a decrease from 12nF at 1V reverse bias in two steps before 5.5V, which was attributed to the 2DEG being removed first

and the 2DHG second. Capacitance at 1200V was 34pF.

In forward bias, current flows through the 2DEG once the Schottky barrier of around 1V is exceeded. "Due to the high bipolar on-set voltage of 3.4V of the anode junction at room temperature and the very low resistance offered by the 2DEG beneath the 2DHG region, the PiN diode does not turn on under normal conditions," the team adds.

Under 250 μ s pulsed operation of 160ms period, the forward current saturated at 76A at 25°C. The slope resistance was 125m Ω and the turn-on came at 0.9V. At 1.6V the current was 5A. The 5A forward voltage increased to 2.2V at 175°C. At the higher temperature the slope resistance also increased to 239m Ω .

The researchers comment: "Despite having a merged PiN and Schottky configuration, the GaN PSJ diode behaves like a pure Schottky diode without a bipolar mode of operation. This is entirely due to the low resistance of the 2DEG beneath the 2DHG region, ultra-short lifetime of holes and high bipolar on-set voltage."

The reverse recovery charge (Q_{rr}) in switching from forward to reverse bias was 45nC at 6A load. The softness factor was 0.6, the ratio of the restoration time to the overshoot time. Factors less than one are often described as "snappy". The peak reverse current was -4.35A. The total reverse recovery time was 20ns.

The surge handling capability was measured using 10ms half-sine forward current pulses (Figure 2). The device survived at currents up to 60A, nearly 8x the rating of the device, according to the researchers. The maximum deposited surge energy was calculated at 5.4J.

At 58.3A, a secondary peak appeared when the forward voltage dropped to around 25V, which the team attributes to activation of the bipolar operation mode. Thermal effects were seen with the forward voltage being higher for a given current in the return to zero part of the pulse.

The team explains: "The inrush of minority carriers (holes) from the p-GaN region due to activation of the bipolar mode leads to device degradation. The bipolar operation is only observed in the return/falling branch, which is due to the temperature dependency of the bipolar on-set voltage, which reduces due to self-heating."

After the 58.3A stress, the device was only capable of handling 54.8A before destruction. The team comments: "The rising branch shows a significant degradation in current due to the partial damage from the previous surge current pulse of 58.3A."

After 51A surge stress, the device showed a slight drop of forward current for given forward voltage, of order 2A at 20V. Meanwhile, the reverse current leakage

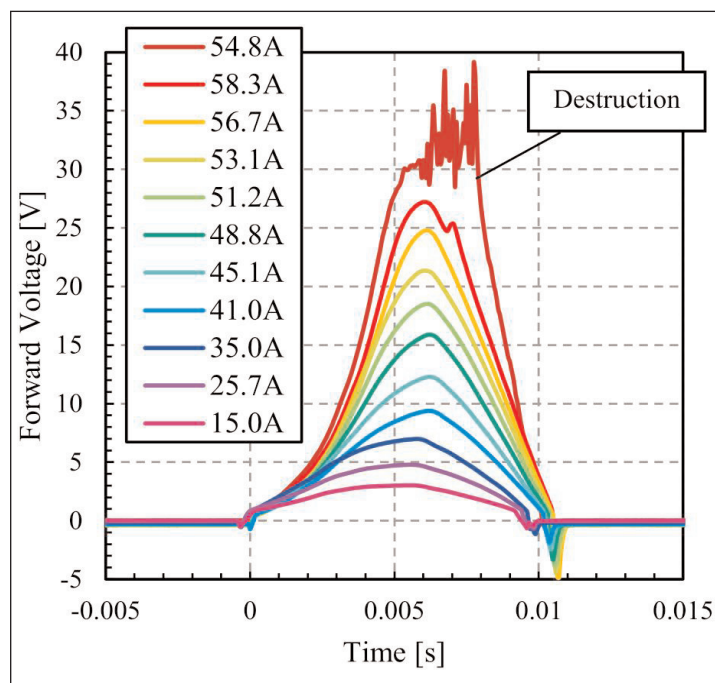


Figure 2. Voltage wave forms (V_{AC}) of GaN PSJ diode at different surge current conditions.

increased by about 10% at 1200V.

After 60A surge failure (Figure 3), the anode fingers showed black burnt out failure points uniformly across the device near the cathode terminal. The researchers comment: "The possible reason for this can be attributed to the triggering/activation of the p-GaN contact near the anode region where the damage can be seen. The activation of the p-GaN region results in a significant number of high-energy minority carriers to be injected into the device, which could result in lattice damage and device failure. ■

<http://powdec.co.jp/english/index.php>

<https://doi.org/10.35848/1347-4065/aca853>

Author: Mike Cooke

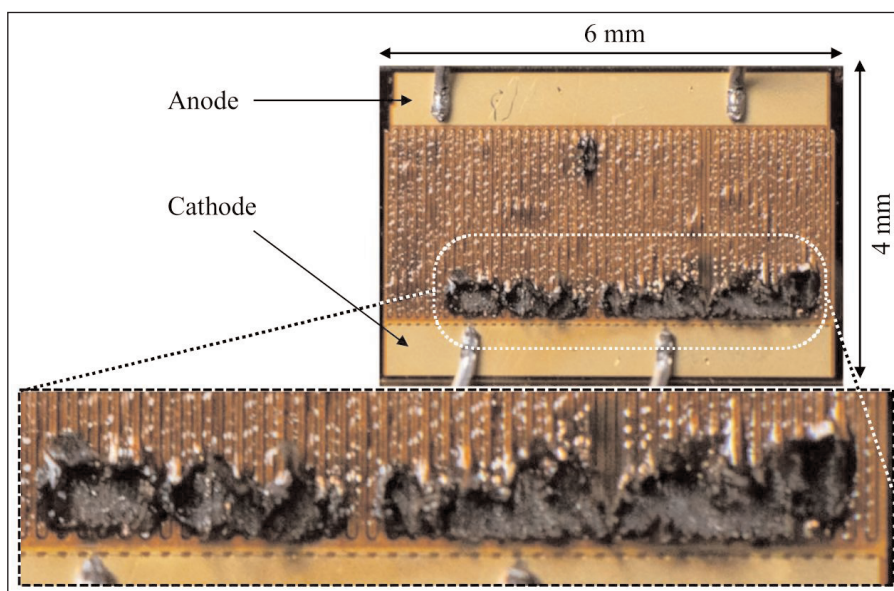


Figure 3. GaN PSJ diode after failure.

InGaAs QW HEMT for 6G communications

Researchers claim record balanced current/power gain cut-off performance.

Researchers based in South Korea and Japan have reported optimized indium gallium arsenide (InGaAs) quantum well (QW)-channel high-electron-mobility transistors (HEMTs) with what is claimed to be record balanced frequency performance (Figure 1) [Wan-Soo Park et al, IEEE Transactions on Electron Devices, published online 10 January 2023].

The team from Kyungpook National University and Quantum Semiconductor International Inc (QSI) in South Korea and NTT Corp in Japan, comment: "To the best of our knowledge, the $\text{In}_{0.8}\text{Ga}_{0.2}\text{As}$ QW HEMTs with $L_{\text{side}} = 150\text{nm}$ in this work exhibit the highest f_{avg} at all gate lengths in any III-V HEMT technology and the best balance of f_T and f_{max} in any transistor on any material system."

The various cut-off frequencies refer to different gain parameters. The T cut-off refers to current gain, while f_{max} refers to Mason's unilateral (power) gain (U_g). The researchers explain: " f_{max} is a more appropriate figure of merit for analog and mixed-signal applications for which the transistor provides a power gain." The f_{avg} value consists of the geometric mean of these two cut-off frequencies.

The team sees its achievements as contributing to meeting the demands of 'Edholm's law', a Moore's Law-like prescription for convergence of wired, wireless and nomadic capabilities as frequencies enter the sub-millimeter wavelength range for sixth-generation (6G) communications.

A key component of the work was optimizing L_{side} "as an effective remedy to mitigate the peak electric field intensity at the drain side of the gate, helping to reduce the intrinsic output conductance (g_{oi}) in aggressively scaled-down devices."

The material (Figure 2) for the QW HEMTs was grown on semi-insulating (100) indium phosphide (InP) substrates, using metal-organic chemical vapor deposition (MOCVD).

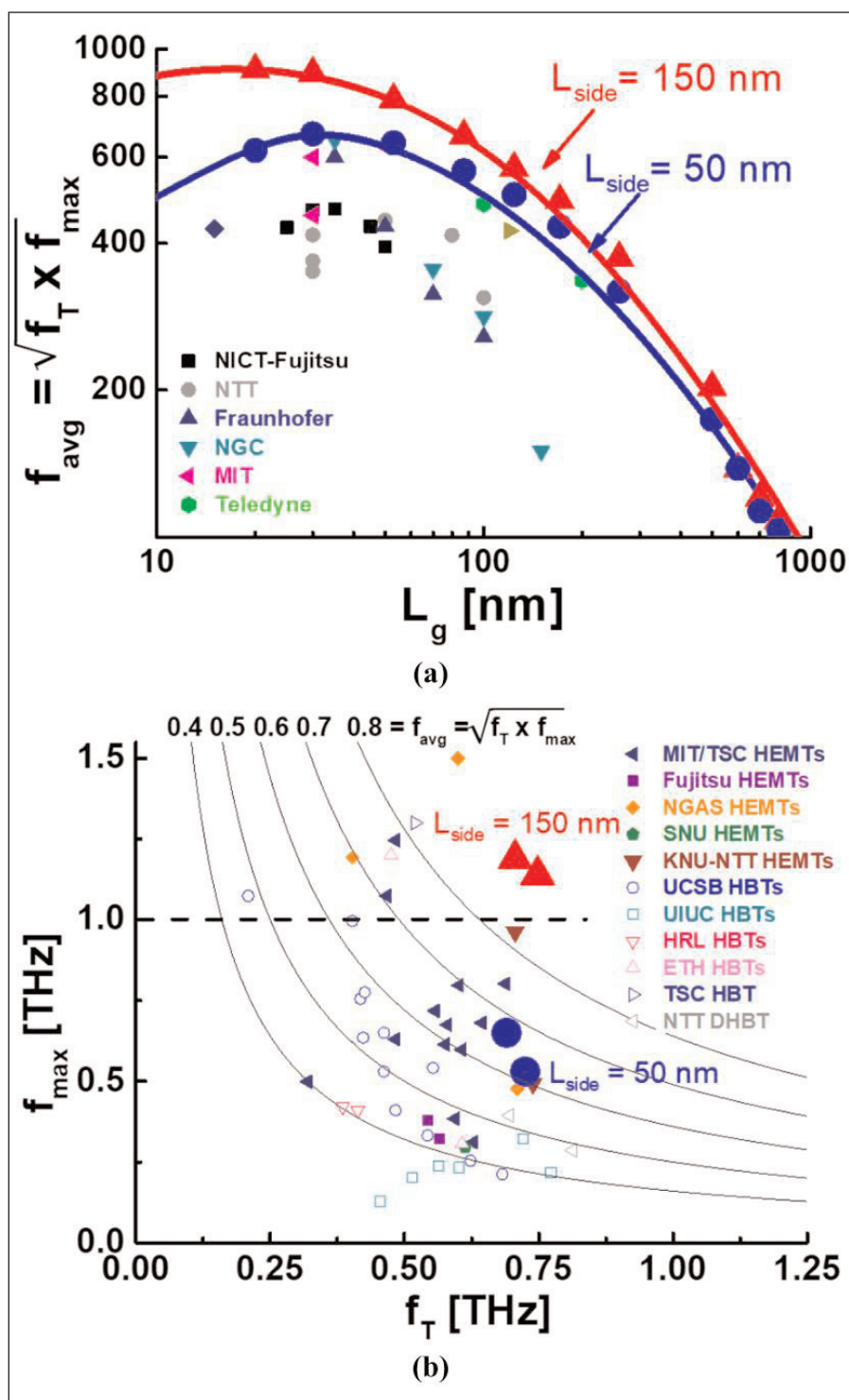


Figure 1. (a) Benchmark of f_{avg} versus gate length (L_g) for devices with different side-recess spacing (L_{side}) and those for other group reports on III-V HEMTs. (b) Benchmark of f_{max} as a function of f_T for various devices compared with the team's.

In the fabricated HEMTs (Figure 3), a gate-recess was implemented with InP used as an etch-stop layer. The recessing gave a gate-channel distance (tins) of about 5nm.

The doped cap had a two-layer structure to enhance tunneling efficiency between the QW channel and the source/drain contacts.

Without the capping layer the structure exhibited a two-dimensional electron gas (2DEG) of $1.78 \times 10^{12}/\text{cm}^2$ density and $13,500 \text{cm}^2/\text{V}\cdot\text{s}$ mobility, according to Hall measurements.

The source-drain distance was $1\mu\text{m}$. The ohmic source/drain electrodes consisted of titanium/molybdenum/titanium/platinum/gold (Ti/Mo/Ti/Pt/Au). The devices were isolated using mesa etching. The source/drain space was insulated with plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2). The T-gate was formed in the source-drain space, consisting of Pt/Ti/Pt/Au.

The researchers took particular care to control the side-recess spacing (L_{side}) by controlling the gate recess etch time. The gate length (L_g) varied between 300nm and 20nm . Some HEMTs were fabricated with longer gates between $10\mu\text{m}$ and $0.5\mu\text{m}$, using an i-line 365nm ultraviolet stepper rather than electron-beam lithography.

Devices with 20nm L_g and 150nm L_{side} demonstrated a cut-off frequency (f_T) of 0.75THz , extrapolated from $1\text{--}50\text{GHz}$ measurements. The 1.1THz maximum oscillation frequency (f_{max}) was derived from a small-signal model rather than measured directly from U_g , which was “challenging” to extrapolate. Reducing L_{side} to 50nm gave a similar f_T of 0.72THz , but there was a significant impact on f_{max} , which declined to 0.53THz .

The enhancement of the wider L_{side} on f_T was attributed to reduced delay times as a result of improvements in short-channel effects (SCEs). The researchers add: “Most importantly, the device with a wider L_{side} led to a far better f_{max} behavior due to the suppressed intrinsic output conductance (g_{oi}).”

Among the SCEs improved by the wider 150nm L_{side} was a drain-induced barrier lowering (DIBL) value to $60\text{mV}/\text{V}$, compared with $110\text{mV}/\text{V}$ for 50nm .

The team sees reducing the equivalent oxide thickness (EOT) between the gate and channel as key to accessing further improvements in frequency performance. However, the Schottky gate setup limits the ability to simply reduce the barrier thickness, which would at the same time increase gate leakage. The researchers comment: “In this regard, the use of an

Cap1	$n^{++}\text{-In}_{0.53}\text{Ga}_{0.47}\text{As}$	12nm
Cap2	$n^+\text{-In}_{0.52}\text{Al}_{0.48}\text{As}$	15nm
Spacer	$\text{In}_{0.52}\text{Al}_{0.48}\text{As}$	3nm
Stopper	InP	3nm
Barrier	$\text{In}_{0.52}\text{Al}_{0.48}\text{As}$	5nm
Spacer	$\text{In}_{0.52}\text{Al}_{0.48}\text{As}$	4nm
Sub-channel	$\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$	1nm
Channel	$\text{In}_{0.8}\text{Ga}_{0.2}\text{As}$	5nm
Sub-channel	$\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$	3nm
Buffer	$\text{In}_{0.52}\text{Al}_{0.48}\text{As}$	200nm
Substrate	InP	

Figure 2. Material for HEMTs. Red dashed line represents silicon δ -doped layer.

MIS [metal-insulator-semiconductor] scheme with high-k dielectric layers would help to not only scale down EOT but also effectively suppress the gate leakage current.” ■

<https://doi.org/10.1109/TED.2022.3231576>

www.qsilaser.com

Author: Mike Cooke

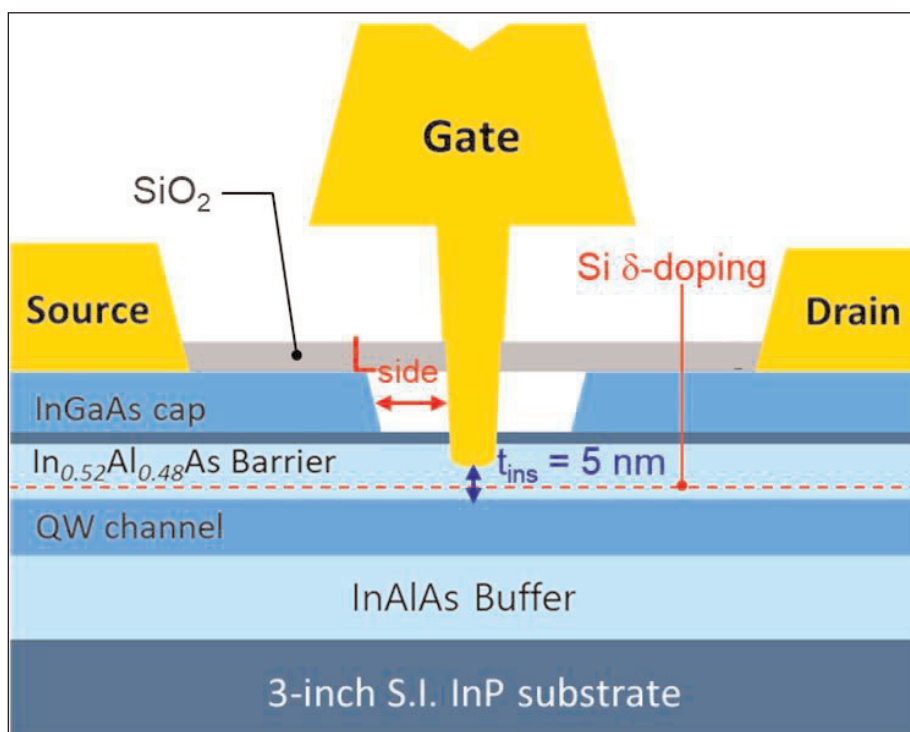


Figure 3. Schematic sketch of $\text{In}_{0.8}\text{Ga}_{0.2}\text{As}$ QW HEMT.

RF front-end market growing at 5.8% CAGR to \$26.9bn in 2028

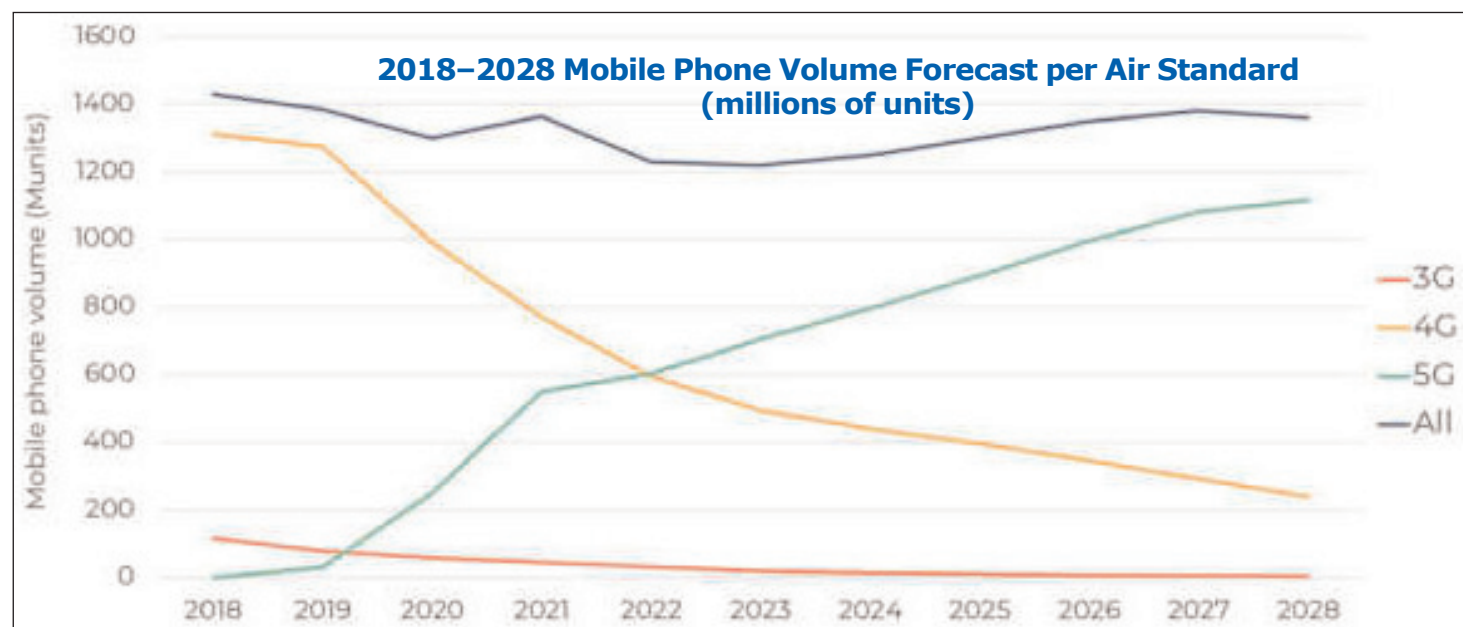
After post-COVID recovery in 2021, growth has been slowed by chip supply shortages, consumer hesitancy and limited 5G penetration, says Yole.

Following the dip caused by the COVID-19 pandemic in 2020, the cell-phone market recovered in 2021, but pre-COVID-19 levels have yet not been reached due to chip supply shortages. Furthermore, in 2022, the smartphone industry was seriously impacted following a global macroeconomic downturn: a market decline with high inflation caused by geopolitical tensions such as the Russia-Ukraine war and tensions between China and Taiwan. This downturn resulted in consumer hesitancy in purchasing new phones, pushing OEMs to enter an inventory correction phase. In addition, the zero-Covid policy in China further destabilized the smartphone manufacturing industry.

"Despite these challenging conditions, 5G phone production reached parity with 4G phone production in 2022, though the growth rate was significantly less than the industry's expectation," says Cédric Malaquin, team lead analyst of RF activity within the Power & Wireless Division at Yole Intelligence (part of Yole Group). "5G's hype has evaporated; however, at Yole Intelligence we expect further penetration in the smartphone market as original equipment manufacturers (OEMs) and mobile network operators (MNOs) further push deployment of this technology."

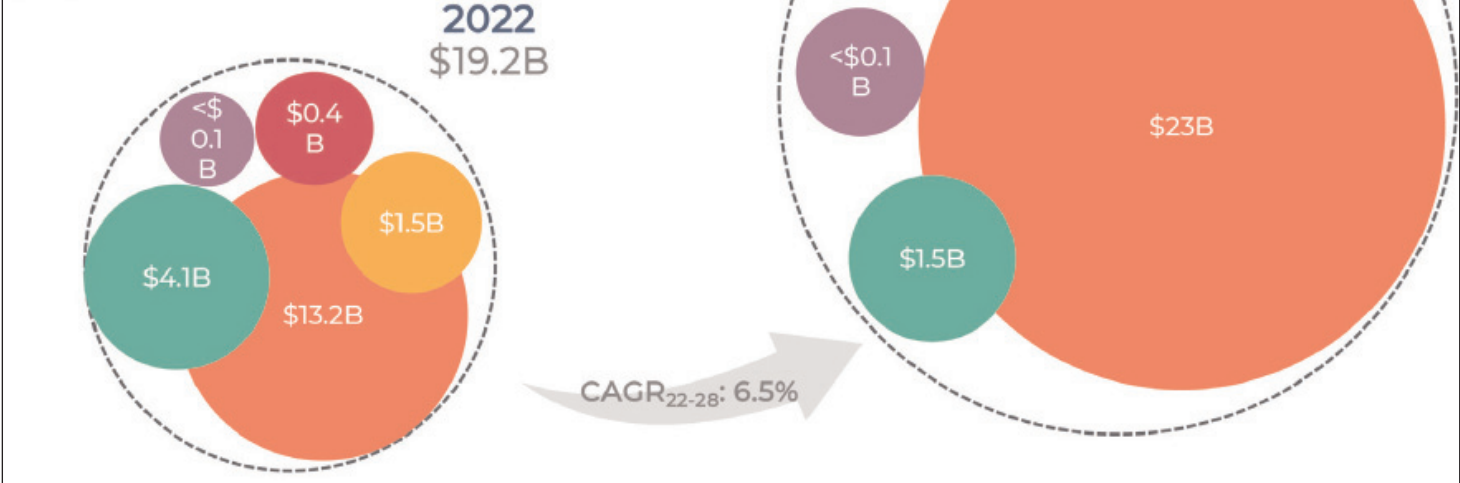
The RF front-end market leapt to more than \$19bn in 2021 as an effect of the post-COVID-19 recovery and 5G penetration, but 2022 ended flat following the smartphone market decline associated with lower-than-expected 5G penetration, according to Yole Intelligence's new RF Annual Report 'RF Front-End for Mobile 2023'. Consequently, the bill of materials (BOM) growth engine has been in low gear. As per the moderate smartphone growth expected toward 2028, along with the limited potential for 5G penetration, Yole Intelligence forecasts that the RF front-end market will rise at a mid-single-digit compound annual growth rate (CAGR) of 5.8% to \$26.9bn by 2028. Meanwhile, the market opportunity is huge, and new 5G technical features will keep driving RF front-end technology innovations. Mid to long term, there are developments in the pipeline, and investments are being made to prepare for the next growth wave, which will emerge from 5G advanced and the forthcoming 6G, says Yole.

"In 2021, Qualcomm led the market with its end-to-end approach, followed by Broadcom's custom power amplifier (PA) module offering," notes Malaquin. "Skyworks and Qorvo have similar company profiles with broad RF portfolios serving all market segments,



2021–2027 RF front-end market forecast

- TAM: Modules and RF front-end components
- 2G
- 3G
- 4G
- 5G
- 5G mmWave



although Skyworks has been more exposed to increased Chinese competition. Murata’s revenue was low, suffering from growing competition for its filters, and it is restructuring its module portfolio,” he adds. “In 2022, traditional players were impacted by the deterioration in the macroeconomic environment. Except for Broadcom, revenues generated by companies in RF front-end-related segments have decreased.”

The Chinese RF front-end ecosystem has been growing, with fabless companies mainly emerging, most taking a share of their local market. Maxscend, Vanchip and Smarter Micro are the most relevant examples, although Maxscend recently invested in upgrading to a fab-lite business model. In addition, there is a long list of companies with great ambitions and access to financial capital through public offerings on the STAR market. However, not all initiatives will succeed, and Yole expects consolidation to happen in the mid-term. In summary, Chinese RF front-end players are capturing a limited

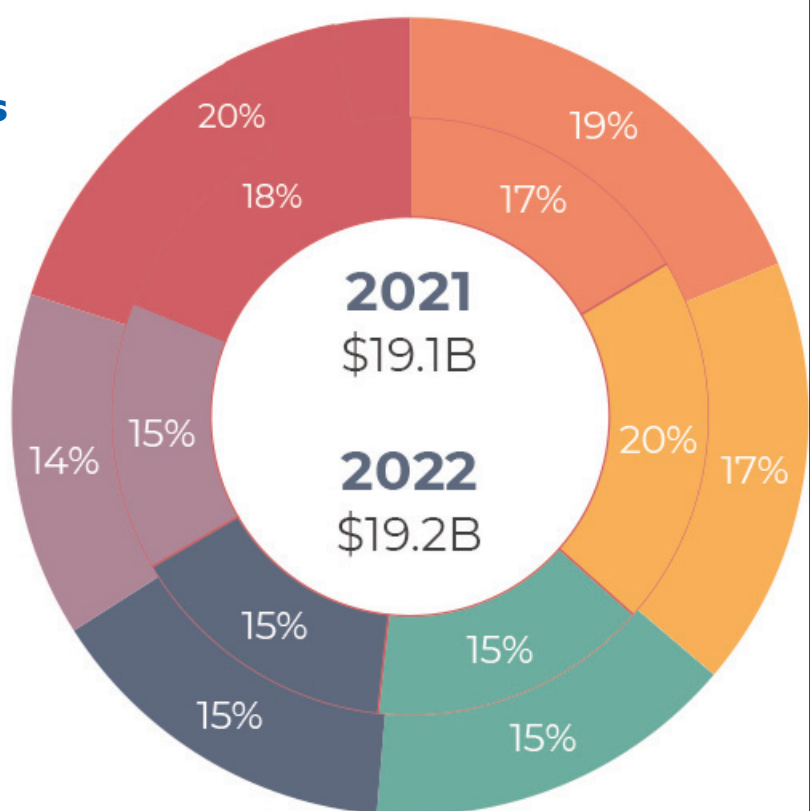
fraction of the market, as OEMs still rely on the leading players for their premium products, but the largest Chinese companies are on their way to catching up with the leaders.

Malaquin took part in an RF-dedicated event at the 8th Automotive Sensors and Electronics Summit 2023 in Munich, Germany (22–23 February). ■

www.yolegroup.com

2021–2022 RF front-end market shares

- Broadcom
- Qualcomm
- Qorvo
- Skyworks
- Murata
- Others



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Fax +41 21 694 35 01
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Veeco Instruments Inc

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9 Materials & metals

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Cardiff University, Cardiff, UK

E-mail: Future-CSHUb@cardiff.ac.uk

www.cardiff.ac.uk/conferences/sioe-conference

25–27 April 2023

26 Annual CMSE (Components for Military and Space Electronics) Conference and Exhibition (CMSE 2023)

Four Points by Sheraton (LAX), Los Angeles, CA, USA

E-mail: info@tjgreenllc.com

www.tjgreenllc.com/cmse

7–12 May 2023

2023 Conference on Lasers & Electro-Optics (CLEO)

San Jose Convention Center,

San Jose, CA, USA

E-mail: CLEO@compusystems.com

www.cleoconference.org

21–25 May 2023

LightFair 2023

Javits Center, New York, USA

E-mail: michellem@lightfair.com

www.lightfair.com

23–25 May 2023

SEMICON Southeast Asia (SEMICON SEA 2023)

Setia SPIICE Convention Centre & Arena, Penang, Malaysia

E-mail: semiconsea@semi.org

www.semiconsea.org

Microwave Week

11–13 June 2023

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San Diego Convention Center, San Diego, CA, USA

E-mail: support@mtt.org

www.rfic-ieee.org

11–16 June 2023

2023 IEEE/MTT-S International Microwave Symposium (IMS 2023)

San Diego Convention Center, San Diego, CA, USA

E-mail: exhibits@horizonhouse.com

www.ims-ieee.org/ims2023

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43rd Symposium on VLSI Technology & Circuits – ‘Rebooting Technology & Circuits for a Sustainable Future’

Rihga Royal Hotel, Kyoto, Japan

E-mail: vlsi@vlsisymposium.org

www.vlsisymposium.org

25–29 June 2023

World of PHOTONICS CONGRESS – International Congress on Photonics in Europe

ICM – Internationales Congress Center München, Munich, Germany

E-mail: info@photonics-congress.com

www.photonics-congress.com/en

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TaiNEX 1&2, Taipei, Taiwan

E-mail: semicontaiwan@semi.org**www.semicontaiwan.org**

17–22 September 2023**26th European Microwave Week (EuMW 2023)**

Berlin Messe, Germany

E-mail: eumwreg@itnint.com**www.eumweek.com**

1–5 October 2023**European Conference on Optical Communication (ECOC 2023)**

Glasgow, Scotland, UK

E-mail: postmaster@theiet.org**https://ecoc2023.theiet.org**

14–18 October 2023**2023 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)**

Monterey, CA, USA

E-mail: cs@cshawevent.com**www.bcicts.org**

14–17 November 2023**SEMICON Europa 2023**

Messe München,

Munich, Germany

E-mail: semiconeuropa@semi.org**www.semiconeuropa.org**

13–15 December 2023**SEMICON Japan 2023**

Tokyo Big Sight,

Tokyo, Japan

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18–22 February 2024**2024 IEEE International Solid- State Circuits Conference (ISSCC 2024)**

San Francisco, CA USA

E-mail: Issccinfo@yesevents.com**www.isscc.org**

12–23 June 2024**2024 IEEE Symposium on VLSI Technology and Circuits**

Hilton Hawaiian Village Waikiki Beach Resort,

Honolulu, HI, USA

E-mail: vlsi@vlsisymposium.org**www.vlsisymposium.org**

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Washington DC, USA

E-mail: exhibits@horizonhouse.com**www.ims-ieee.org/about-ims/past-and-future-ims**

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Frankfurt am Main, Germany

E-mail: michelle.dampier@nexusmediaevents.com**www.ecocexhibition.com/future-dates**

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