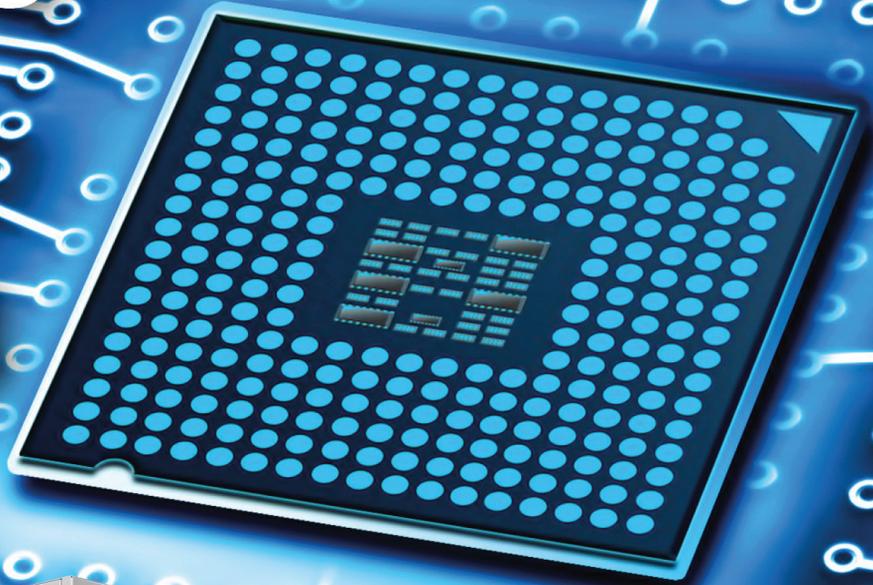


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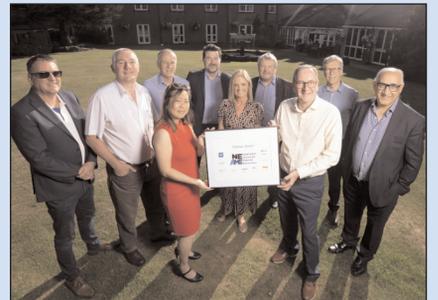


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p32 Eta Research of Shanghai, China is moving to its new HQ in Tongling, Anhui Province.



p37 The North East Advanced Material Electronics (NEAME) cluster group has been formally launched.



p41 The Translational Research Hub (TRH) — home to the Institute for Compound Semiconductors (ICS) and Cardiff Catalysis Institute (CCI) — is now open for business.



Cover: Germany's Bosch plans to invest another €3bn in its semiconductor division by 2026. A €400m expansion in Reutlingen will boost SiC chip production, while the firm will also explore GaN chips for electro-mobility applications. **p18**

Export bans extending to compound semis

Further to last issue's editorial, on 9 August US President Joe Biden signed into law the \$280bn 'Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) and Science Act', which allocates \$52.7bn of subsidies over five years for US semiconductor research, development, manufacturing and workforce development. The funding aims to boost domestic research and manufacturing of semiconductors in the USA (exemplified by a groundbreaking ceremony on 9 September for Intel's new \$20bn fab in Ohio, to be attended by Biden). This is not only to address the shortage of semiconductor supply but also to mitigate the risk of the dependency on offshore manufacturing in East Asia (particularly Taiwan) and to counter the corresponding threat to this from China, which also has allocated about \$50bn to its 'Integrated Circuit Industry Investment Fund'.

In particular, for the next 10 years the CHIPS Act prohibits subsidized firms from producing in China any chips that use sub-28nm process technology (possibly restricting investments in China by Taiwan Semiconductor Manufacturing Company (TSMC) and South Korea's Samsung Electronics, which are both investing in 5nm fabs in the USA). In terms of 12"-equivalent wafer processing, it is forecasted by TrendForce that, by 2025, China will account for 27% of global production capacity (versus 43% in Taiwan), but just 1% of 7nm-and-below capacity (versus Taiwan's 69%). China's largest IC foundry (and the world's fifth largest) Semiconductor Manufacturing International Corp (SMIC) has recently mass produced chips at 7nm (ahead of US and European chip makers, but behind TSMC and Samsung). However, apart from being low-complexity cryptocurrency-mining ASICs rather than more complex logic ICs, this used 193nm-wavelength deep-ultraviolet (DUV) lithography — at the limit of DUV's capability — rather than 13.5nm-wavelength extreme-ultraviolet (EUV) lithography (necessary for sub-7nm IC designs), for which sole lithography equipment maker Netherlands-based ASML was embargoed by Trump-era Export Administration Regulations in December 2020 from exporting to SMIC.

On 12 August, the US Commerce Department's Bureau of Industry and Security (BIS) announced further restrictions on exports from the USA of technologies considered to be key to advanced military systems, including not just electronic design automation (EDA) software for sub-7nm gate-all-around field-effect transistors (GAA-FETs) but also the ultrawide-bandgap semiconductors gallium oxide (Ga₂O₃) and diamond, limiting the development of high-power electronics for advanced power management, electric vehicles (EVs), and RF amplifiers. In the case of gallium oxide, for example, Ga₂O₃ metal-organic chemical vapor deposition (MOCVD) systems made by Aixtron and Agnitron, respectively, have been shipped to the University of Texas at Austin (see page 43) and to Cornell University (see page 34). The latter is working in collaboration with the US Air Force Research Laboratory (AFRL), highlighting the power electronics applications in not just EVs and renewable energy but also in reduced-size/weight cellular communications equipment with defense/national security implications.

While previous export bans have targeted leading-edge silicon, these are the first that apply explicitly to compound semiconductor materials.

However, while China states that the embargoes will drive it to accelerate development of its own technology for EDA etc, the example of 7nm suggests this could still take more time and expense, and lead to limited application.

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

(e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers and LEDs in wireless and optical communications, etc).

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- event calendar and event previews;
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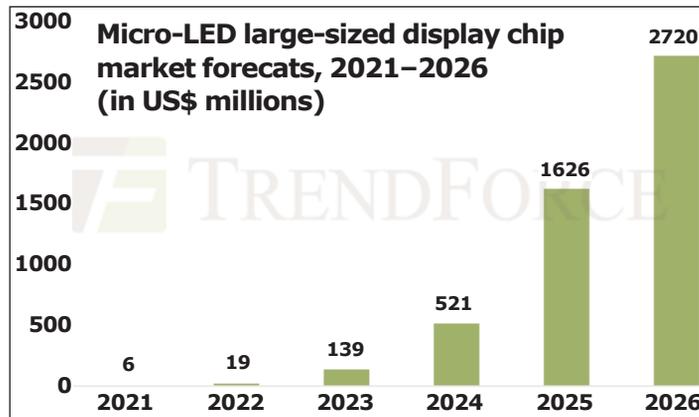
Micro-LED large-sized display chip market to reach \$2.7bn by 2026

4" wafers for micro-LED large-sized displays to reach 1.14 million units

According to the 'TrendForce 2022 Micro LED Self-Emitting Display Trends and Analysis on Supplier's Strategies', 4-inch wafers for micro-LED large-sized displays will reach about 1.14 million units by 2026, with the chip market rising at a compound annual growth rate of 241% from 2021 to \$2.7bn in 2026.

Large-sized displays are currently the most anticipated products among a number of micro-LED display applications, says TrendForce. However, the greater micro-LED market remains at an R&D and experimental stage as branded manufacturers have yet to launch mass-produced products. There are still technical and cost bottlenecks that need to be completely overcome before mass production and commercialization are feasible, including the improvement of wafer wavelength uniformity, increasing mass-transfer production capacity, and improving the glass backplane metallization yield rate. Therefore, future efforts to overcome technical bottlenecks will focus on wafers, mass transfer, and glass backplane metal processes. After the relevant technologies are mature, costs can be quickly reduced and mass production and commercialization accelerated, it is expected.

At its Micro LED Forum 2022 on 13 September, TrendForce will reveal the current progress of various manufacturers in developing large-sized displays from the perspectives of epitaxy, mass transfer, backplane technology, and equipment development. In terms of epitaxy equipment, the forum will discuss the methodology of manufacturing micro-LED epitaxial wafers with wavelength uniformity, low defect rates, and low cost as a key to reducing wafer costs. In the seminar, AIXTRON will introduce



the MOCVD solution for mass production of micro-LED wafers.

In terms of mass transfer, large-sized display mass transfer technology is primarily based on stamp and laser transfer. At this stage, stamp transfer technology is still mainstream but, due to the characteristics of red light wafer material, it is easy to cause wafer damage and stamping losses, resulting in a decrease in production yield. In addition, transfer cost depends on the size of the transfer head and the utilization rate of the wafer. Compared with stamp technology, laser transfer technology possesses the characteristics of speed, precision and high efficiency, which will help to greatly reduce mass-transfer cost in the future. However, intensive initial equipment investment has become one of the obstacles in micro-LED mass-transfer technology development. The Micro LED Forum 2022 features a large number of transfer equipment manufacturers including Contrel, K&S, and Ultra Display Technology. The forum also discusses future developments in micro-LED large-sized displays, starting from transfer technology.

In terms of driving backplanes, the active driving design scheme with seamless splicing technology has an opportunity to become the

mainstream design used in micro-LED large-sized displays in the future. Currently, side wire plating glass metallization technology has yet to become completely viable. After this technology is perfected, rapid cost reduction will fully unlock the advantages of an active drive backplane. The forum has also invited panel makers that are actively deploying glass-driven backplanes such as AUO, BOE and Luxnet to discuss development trends in related designs. In addition, PanelSemi will also share its experience and describe new opportunities for active flexible substrates. Macroblock, which is focused on driver ICs, is analyzing the role that micro-LED large-sized displays play in the metaverse.

TrendForce indicates that, as micro-LED large-sized display technology and cost continues to improve, coupled with aggressive planning on the part of international branded manufacturers, there will be opportunities to accelerate the realization of commercialized micro-LED large-sized display products. Future development trends will include commercial-grade cinema screens and indoor public display screens and consumer-grade TVs focused on home theaters. Although current product pricing remains high, as the development of technology, equipment and related components matures, micro-LED large-sized displays will be the first choice for the high-end display market in the future, reckons TrendForce.

www.ledinside.com

Micro-LED transparent AR smart glasses chip market to grow to \$38.3m by 2026

Concepts launched by over 10 branded manufacturers since 2021

Micro-LED light engine performance beats micro-OLEDs (organic light-emitting diodes) in terms of brightness, contrast ratio and responsiveness in transparent augmented-reality (AR) smart glasses micro-displays and is ideal for applications in outdoor environments, according to the report 'TrendForce 2022 Self-Emitting Micro LED Display Cost and Trend Analysis'.

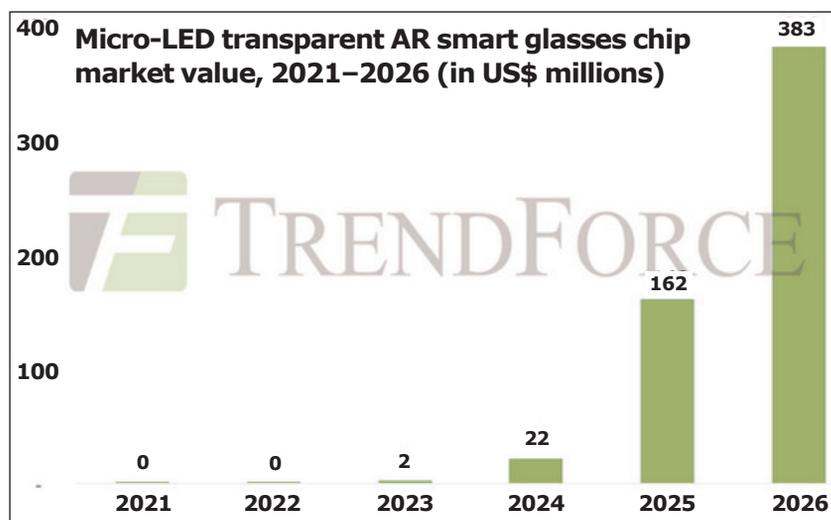
Since 2021, more than 10 branded manufacturers around the world have launched micro-LED transparent AR smart glasses concepts, and related suppliers have improved micro-LED technology and accelerated factory expansion in order to meet subsequent mass-production planning. Revenue for micro-LED transparent AR smart glasses chips is forecasted to rise at a compound annual growth rate (CAGR) of 704% from 2023 to about \$38.3m in 2026.

However, the current difficulties encountered in the development of micro-LED transparent AR smart glasses mainly arise from optical waveguide technology, light engine technology, battery storage capacity, and image transmission issues. Since transparent smart glasses require high-resolution and high-brightness specifications for outdoor use, micro-LEDs are the first choice for the light engine.

At present, micro-LED light engine technology is not yet mature and the external quantum efficiency of red chips is too low. Problems regarding the miniaturization of micro-displays have appeared one by one.

In addition, micro-display sizes are too small, resulting in a small field of view (FOV) so narrow as to affect viewing.

If the optical waveguide design method is employed, optical efficiency falls at less than 1%, and



developing light engines for micro-LED transparent AR smart glasses in recent years. JBD

incidental light must provide higher brightness to meet the specifications necessary for outdoor use of micro-displays. In addition, transparent smart glasses will need to be worn for a certain period of time. Therefore, battery lifespan and size directly affect product design. Furthermore, another major obstacle is finding a way to integrate the sensor to transmit and process image data.

At its Micro LED Forum 2022 on 13 September, TrendForce will reveal the current technological progress of various manufacturers in developing transparent AR smart glasses. Many technical fields are focused on the development of optics and light engines. In the field of optics, TrendForce invited Kura Technologies to share their 8K resolution and FOV 150 micro-LED transparent AR smart glasses, in a departure from products offered by other manufacturers that can only reach 1080P and FOV 50. In addition, ams OSRAM will analyze the market segmentation, application standards, and technical challenges of transparent AR smart glasses and discusses differences between micro-LED micro-projection displays and LBS laser beam scanning display technology.

In the field of light engines, JBD has been aggressively

announced a large-scale investment and construction plan in 2022 and established long-term strategic cooperation agreements with a number of optical waveguide manufacturers. The firm also achieved a major technological breakthrough, producing a micro-LED chip capable of emitting 500,000 nits of ultra-high-brightness red light, injecting fresh momentum into the transparent AR smart glasses field. Porotech, a UK-based micro-LED chip maker focusing on AR applications, developed a new porous GaN semiconductor material technology to complete the development of micro-LED red light chips that can improve external quantum efficiency (EQE) to resolve the full-color light source issue inherent in transparent AR smart glasses.

TrendForce indicates that, as micro-LED light engine and optical technology continues to progress and brands plan new products, there will be prospects to accelerate the advent of a commercial viable micro-LED transparent AR smart glasses product. When the technology and costs are in place, business opportunities will extend from military, medical, aviation and industrial fields to commercial and comprehensive consumer applications, concludes the report.

www.trendforce.com

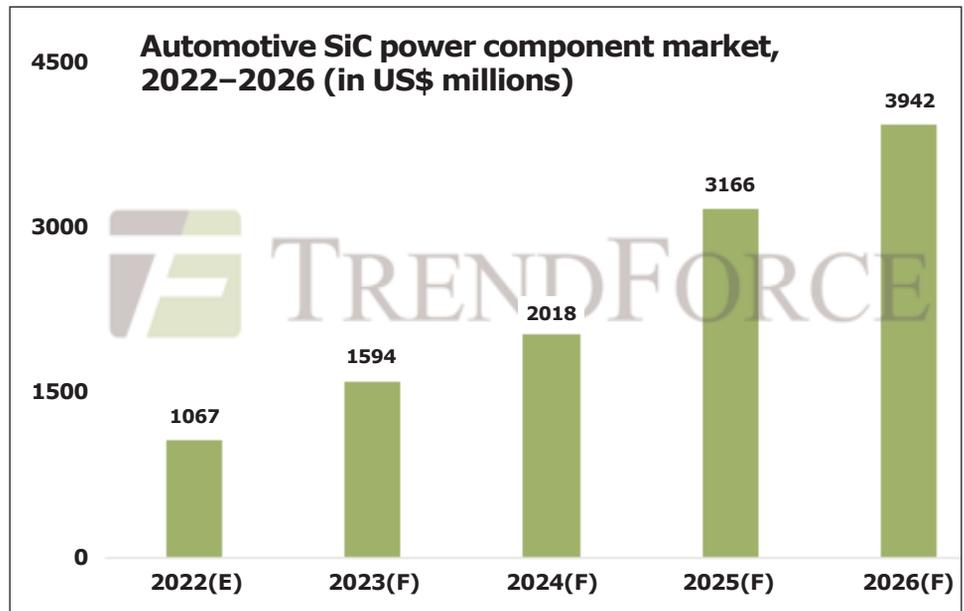
Automotive SiC power component market to grow to \$1bn in 2022 then \$3.94bn by 2026

Manufacturers moving up supply chain to secure substrate materials

To further improve the power performance of electric vehicles (EV), major global automakers have focused on a new generation of silicon carbide (SiC) power components and have successively launched a number of high-performance car models equipped with corresponding products. According to research by TrendForce, as more and more auto-makers begin to introduce SiC technology into electric drive systems, the market for vehicle SiC power components is forecast to grow to \$1.07bn in 2022 then \$3.94bn by 2026.

The automotive SiC power component market is currently dominated by major European and American IDMs, notes TrendForce. The key suppliers STM, onsemi, Wolfspeed, Infineon and ROHM have long been deeply involved in this field and have close interactions with major auto-makers and tier-1 manufacturers. The affluence of the automotive market has also impressed the importance of stable supply capacity onto major manufacturers. Therefore, in an effort to exert full control on the supply chain, they have moved successively into the upstream substrate materials field. For example, onsemi acquired GT Advanced Technologies last year.

Major auto-makers have high hopes for SiC and are simultaneously and vigorously participating in the construction of supply chains.



From the perspective of China (the world's largest EV market), auto-makers such as SAIC and GAC have begun to deploy an entire SiC industry chain, which has created invaluable development opportunities for domestic suppliers. At the same time, auto-makers such as BYD and Hyundai have launched their own chip R&D programs, which have injected new vitality into the market.

In addition, the cost-effectiveness of using SiC power components has always been a market concern and its key lies in upstream substrate materials. The industry is experimenting with various methods to further reduce costs, including new crystal growth approaches

(UJ-Crystal, Jing Ge Ling Yu), high-efficiency wafer processing technology (Soitec, Disco, Infineon, Lasic Semiconductor Technology), and following Wolfspeed in migrating from 6" to 8" wafer technology.

With continuing breakthroughs in SiC materials technology and the maturity of chip structure and module packaging processes, the penetration rate of SiC power components into the automotive market is expected to maintain an upward trajectory and will gradually extend from existing high-end vehicle applications to medium- and low-end vehicles in order to accelerate the process of vehicle electrification, concludes TrendForce.

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Smartphone shipments fall 7.3% year-on-year in Q2; Samsung on 21.5% marketshare and Apple at 16.3% Shipments to contract 7–8% for full-year 2022

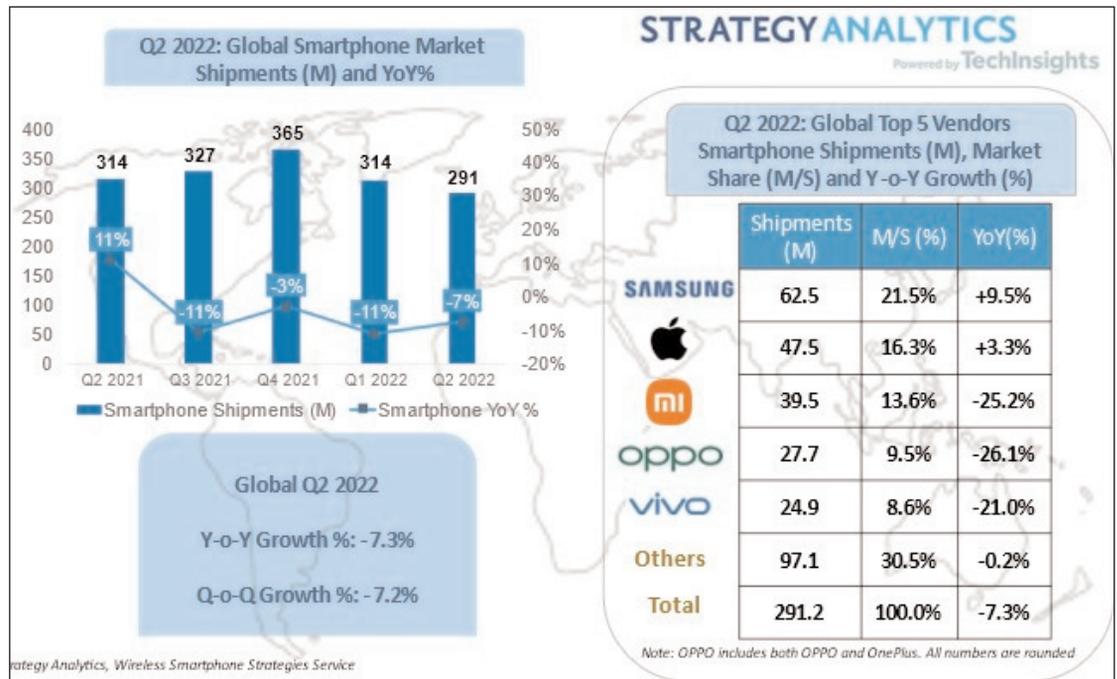
Global smartphone shipments fell by 7.3% year-on-year from 314 million units in second-quarter 2021 to 291 million units in second-quarter 2022 (the fourth consecutive quarter of year-on-year decline by smartphone volumes), according to Strategy Analytics.

"COVID disruption and geopolitical issues adversely impacted smartphone market in the second quarter," notes senior director Linda Sui. "Meanwhile, unfavorable economic conditions continued to weaken consumers' demand on smartphones and other non-essential products."

Samsung's smartphone shipments grew by 9.5% year-on-year to 62.5 million in Q2/2022, topping the global market with a 21.5% share. "It is the vendor's highest second-quarter performance by market share since 2020," notes director Woody Oh. "Demand continued to remain strong for the newly launched flagship Galaxy S22 series, especially the higher-priced S22 Ultra model."

Apple's iPhone shipments rose 3.3% year-on-year to 47.5 million (16.3% marketshare). "This is the highest second-quarter market share for Apple over the past ten years, at the expense of leading Chinese brands who are hampered by the sluggish performance in both home and overseas market," says Oh. "Apple had a good quarter, led by the iPhone 13 series, which continued to ramp up volumes in US, China and other key markets," he adds.

Chinese firms Xiaomi, OPPO (including OnePlus) and vivo remained among the top five smartphone makers.



Xiaomi shipped 39.5 million smartphones and took third place with 13.6% marketshare in Q2/2022, down from 17% a year ago.

"Xiaomi suffered from the geopolitical uncertainties in Europe," notes senior analyst Yiwen Wu. "China and India market also delivered a mixed bag for the Chinese brand."

OPPO (OnePlus) held fourth spot and captured 9.5% marketshare. Vivo stayed fifth, with 8.6%. "OPPO (OnePlus) and Vivo both lost ground in most markets, as 5G competition from Honor and other smartphone competitors intensified sharply in China and other markets," says Wu.

"Competition among other major smartphone brands, beyond the top five, was fierce during Q2/2022," says executive director Neil Mawston. "Transsion, Honor, Lenovo-Motorola and Huawei all outperformed the overall market but delivered different patterns. Transsion regained the leading position from Samsung in Africa region this quarter. Honor held firmly in China, being the largest vendor for the first time ever, and continued to ramp up in overseas markets. Lenovo-Motorola stabilized the performance in America region

and made progress in Europe and Asia Pacific. Realme stayed in the top-ten list but delivered a mixed performance and lost ground in China, Latin America, Central Eastern Europe and Africa Middle East region," he adds. "Among top-ten brands, there are eight Chinese brands. However, all these Chinese brands combined posted -13% annual decline, underperforming total market and the top two players."

Strategy Analytics forecasts that global smartphone shipments will contract by 7–8% year-on-year in full-year 2022. "Geopolitical issues, economy downturn, price inflation, exchange-rate volatility, and COVID disruption will continue to weigh on the smartphone market during the second half of 2022," says Sui. "All these headwinds would continue through the first half of next year, before the situation eases in the second half of 2023," she adds. "Samsung and Apple would continue to outperform and remain top two places. Chinese brands need to stabilize the performance in China market and explore new growth engine to terminate the falling track."

www.strategyanalytics.com

AmpliTech debuts MMIC designs & full product suite

New AmpliTech Group MMIC Design Center and acquisition Spectrum Semiconductor Materials join AmpliTech Inc and Specialty Microwave in RF system one-stop-shop

At the IEEE International Microwave Symposium (IMS) in Denver in June, AmpliTech Group Inc of Hauppauge, NY, USA — which designs and makes signal-processing radio frequency (RF) microwave components for satellite communications, telecoms (5G & IoT), space, defense and quantum computing markets — debuted its monolithic microwave integrated circuit chip designs.

The MMIC chips bring what is claimed to be AmpliTech's industry-leading lowest noise figures and power dissipation performance into a chip form factor. The low noise figures and low-power-dissipating MMIC chips are expected to enable up to 40% cost savings in systems by promoting higher link availability, increased data transmission bandwidth, and maintaining up to a 6x longer life than the next best-performing chips.

IMS marked the first public appearance of AmpliTech's full four division lineup including the newly formed AmpliTech Group MMIC Design Center (AGMDC), which was initiated last October,

and Spectrum Semiconductor Materials of San Jose, CA, USA, acquired in December. These two units are accretive to the group, as AGMDC enables the group to introduce AmpliTech's performance into a much more widespread form factor, while Spectrum Semiconductor Materials will package the MMICs and also serve as a global distributor of the chips. They join analog amplifier components manufacturer AmpliTech Inc and RF subsystem manufacturer Specialty Microwave to form a full RF product suite that will create a one-stop-shop for RF system needs and also enable AmpliTech Group to attract a broader range of sales representation, it is reckoned, due to its now increased horizontal integration.

"We were looking forward to serving as a [gold] sponsor for the event and welcoming our two new groups, AGMDC and Spectrum Semiconductor Materials, to their very first show," says founder & CEO Fawad Maqbool. "AGMDC, based in Plano, TX, impressed attendees with the unprecedented specs for their

MMIC designs, which are expected to enable AmpliTech Group to reach new markets given its use of a more flexible form factor that will allow for integration into a variety of systems that our analog amplifiers are not applicable to. Additionally, Spectrum Semiconductor Materials, our semiconductor packaging unit, was able to discuss its ability to deliver much-needed integrated circuit packaging and technical support to industries amid an ongoing shortage of semiconductor components with attendees," he adds.

"Both these groups will serve a crucial role in providing products that will support the future of wireless and broadband communication alongside AmpliTech Inc and Specialty Microwave," Maqbool continues. "The progress we have made over the past year has very well increased our ability to capture and fulfill larger orders from customers building solutions in 5G, IoT and quantum computing, among other innovative applications."

www.spectrum-semi.com

www.amplitechinc.com

Guerrilla RF common stock begins trading on OTCQX Best Market

Guerrilla RF Inc (GRF) of Greensboro, NC, USA says that its common stock began trading on the OTCQX Best Market on 28 July, under the ticker 'GUER'.

"This is an important milestone for Guerrilla RF as we seek to develop a liquid market for Guerrilla RF stock and welcome new investors to participate," says founder & CEO Ryan Pratt.

Founded in 2013, Guerrilla RF develops and manufactures high-performance monolithic microwave integrated circuits (MMICs) to

wireless and infrastructure OEMs in multiple market segments — including 5G/4G macro and small-cell base stations, cellular repeaters/DAS, automotive telematics such as SDARS/V2X/GPS/DAB, mission-critical military communications, navigation, and high-fidelity wireless audio. The firm has an extensive portfolio of over 100 high-performance radio frequency (RF) and microwave semiconductor devices. The existing product line includes ultra-low-noise amplifiers, gain blocks, driver amplifiers, mixers, RF switches,

and linear PAs (power amplifiers) — critical building blocks for mission-critical, performance-driven wireless applications, including 5G wireless infrastructure, cellular repeaters/boosters, and automotive telematics.

To date, the firm has shipped over 100 million devices and has repeatedly been included in Inc. Magazine's annual Inc. 5000 list. Guerrilla RF recently made the top Inc. 500 list for the second year in a row, coming in at No. 421 and 489 for the 2020 and 2021 rankings, respectively.

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II-VI closes \$100m contract to supply Tianyu with 150mm SiC substrates for power electronics

Contract to secure capacity to meet demand through 2023

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA has closed a contract worth over \$100m to supply 150mm silicon carbide (SiC) substrates to China's Dongguan Tianyu Semiconductor Technology Co Ltd (which specializes in the R&D, design and manufacturing of SiC epitaxial wafers), to be delivered beginning this quarter and through the end of 2023.

Tianyu, one of China's first and largest SiC epiwafer makers, has signed a long-term supply contract with II-VI, with upfront payments, to secure 150mm SiC substrate capacity that will meet its demand through calendar year 2023.

"In November 2021, we were pleased to announce that Tianyu had selected II-VI as its primary

strategic partner for the supply of 150mm SiC substrates for power electronics," notes Sohail Khan, executive VP, New Ventures & Wide-Bandgap Electronics Technologies business unit. "With the end-demand ramping up significantly, it became essential for Tianyu to secure its supply with this long-term, high-volume contract, which will be recurring and grow in value over time."

To meet the market demand in Asia, II-VI established in 2021 a backend processing line for SiC substrates, in over 50,000ft² of new cleanroom space, at II-VI's Asia Regional Headquarters in Fuzhou, China. Tianyu will benefit from II-VI's 150mm SiC global production capacity in both the USA and in China.

Tianyu and II-VI intend to provide the high-quality and reliable supply chain and future 200mm capability that will be critical to support the rapidly growing demand for SiC power electronics in the mega-markets of electric vehicles (EVs), renewable energy, smart grids, micro-grids, and power supplies for data networks. Tianyu is reckoned to be well positioned to serve the power electronics market for EVs in China (by far the world's largest).

Given their broad range of applications, power electronics based on SiC have a highly beneficial impact on the environment through enabling significant reductions in carbon dioxide emissions and energy consumption.

www.sicty.com
www.ii-vi.com

Infiniteon signs multi-year supply agreement for II-VI's 150mm silicon carbide wafers

Infiniteon expanding supplier base to increase supply chain resilience

Semiconductor chip manufacturer Infiniteon Technologies AG of Munich, Germany has signed a multi-year supply agreement for silicon carbide (SiC) wafers from II-VI Inc of Saxonburg, PA, USA.

Infiniteon's aim is to secure further access to silicon carbide to meet the strong increase in customer demand in this sector, and to support its multi-sourcing strategy and increase its supply chain resilience. The first deliveries have already taken place.

Infiniteon claims that its CoolSiC brand is already the industry's largest portfolio of devices for industrial power semiconductor applications. In addition to photovoltaic converters and industrial power supplies, SiC power semiconductors are also used particularly in e-mobility,

e.g. in the main inverters for e-vehicle drive trains, in onboard battery charging units and in charging infrastructures, as the material meets the highest quality standards for industrial and automotive applications. As strategic partners, II-VI and Infiniteon are also collaborating on the transition to 200mm-diameter SiC wafers.

"SiC compound semiconductors set new standards in power density and efficiency. We are leveraging them to deliver on our strategy of decarbonization and digitalization," says Infiniteon's chief procurement officer Angelique van der Burg. "Infiniteon is increasing investments in its SiC manufacturing capacity to meet the rapidly growing demand from our customers," she adds.

"Infiniteon, as a market leader in power semiconductors, is an important partner for us," says Sohail Khan, executive VP, New Ventures & Wide-Bandgap Electronics Technologies at II-VI. "Our highly specialized products are now helping Infiniteon provide innovative electronic components to key customers worldwide," he adds.

Infiniteon expects its SiC semiconductor sales to grow by more than 60% on average per year, reaching about \$1bn by mid-decade. For the second half of the decade, the firm expects on-going growth momentum, for which it is investing in its recently announced additional manufacturing block in Kulim, Malaysia.

www.ii-vi.com
www.infineon.com

onsemi expands silicon carbide production facility in New Hampshire

SiC boule production capacity to rise five-fold year-on-year

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA has held a ribbon-cutting ceremony to inaugurate its new silicon carbide (SiC) facility in Hudson, New Hampshire. Signifying the importance of semiconductor manufacturing in the USA was the attendance of multiple guests of honor led by the US Secretary of Commerce Gina Raimondo. Also present were US Senators Jeanne Shaheen and Maggie Hassan from New Hampshire, and Representatives Chris Pappas and Annie Kuster from the 1st and 2nd congressional districts of New Hampshire, respectively, as well as other local governmental dignitaries.

The site will increase the firm's SiC boule production capacity by five times year-over-year and almost quadruple the number of its staff in Hudson by the end of 2022. The expansion gives onsemi full control of its SiC manufacturing supply chain, starting with the sourcing of silicon carbide powder and graphite raw material to the delivery of fully packaged SiC devices. onsemi says that this allows it to provide customers with the assurance of supply required to meet rapidly growing demand for SiC-based solutions. SiC is critical for enabling efficiency in electric vehicles (EVs), EV charging and energy infrastructure and is an important contributor on the path to decarbonization. The SiC total addressable market (TAM) is projected to increase at a compound annual growth rate (CAGR) of 33% from \$2bn in 2021 to \$6.5bn in 2026.



Ribbon-cutting ceremony at onsemi's new SiC production facility in Hudson, NH. Attendees from left to right: Felicity Carson, senior VP & CMO, onsemi; US Senator Maggie Hassan (NH); Catherine Côté, VP & chief of staff to the CEO, onsemi; US Senator Jeanne Shaheen (NH); Tobin Cookman, senior VP of human resources, onsemi; Hassane El-Khoury, president, CEO & director, onsemi; US Secretary of Commerce Gina Raimondo; Joe Loiselle, VP of SiC operations & general manager of Hudson site, onsemi; US Representative Annie Kuster (NH-02); Simon Keeton, executive VP & general manager Power Solutions Group, onsemi; Thad Trent, executive VP & chief financial officer, onsemi; Rep. Chris Pappas (NH-01); Dr Wei-Chung Wang, executive VP of global manufacturing & operations, onsemi.

"In addition to market-leading efficiency of our products, our end-to-end vertically integrated solution in a supply-constrained environment is a compelling and differentiated competitive advantage," reckons Simon Keeton, executive VP & general manager Power Solutions Group at onsemi. "We have already expanded to a second building as we increased our substrate capacity and plan to continue ramping, allowing us to source our

We have already expanded to a second building as we increased our substrate capacity and plan to continue ramping, allowing us to source our own cutting-edge SiC wafers for customer products

own cutting-edge SiC wafers for customer products."

onsemi claims to be the only large-scale supplier of both SiC and insulated-gate bipolar transistors (IGBT) solutions with end-to-end supply capability. During its second-quarter earnings call in early August, the firm announced \$4bn of committed SiC revenue for the next three years through long-term supply agreements with a broad base of customers. It will triple last year's silicon carbide revenue in 2022 and exceed \$1bn in revenue in 2023, further emphasizing onsemi's progress in SiC.

The inauguration ceremony comes only days after US President Joe Biden signed into law the CHIPS and Science Act, which aims to strengthen supply chain resiliency and help to avoid disruptions for critical components affecting every sector of the economy.

www.onsemi.com

ROHM's fourth-generation SiC MOSFETs to be used in SEMIKRON's eMPack power modules for EVs

SEMIKRON wins billion-Euro contract to supply power modules to German car-maker from 2025

After collaborating for over ten years on implementing silicon carbide (SiC) inside power modules, the latest fourth generation of SiC MOSFETs of ROHM Semiconductor of Kyoto, Japan has recently been fully qualified for automotive use in the eMPack modules of SEMIKRON of Nuremberg, Germany.

SEMIKRON also says that it has secured a billion-Euro contract to supply its eMPack power modules to a major German car-maker, beginning in 2025. The firm developed a fully sintered assembly and connection technology 'Direct Pressed Die' (DPD), which enables extremely compact, scalable and reliable traction inverters.

The eMPack module technology has been specially designed for SiC-based converters of medium and high power in order to fully exploit the properties of silicon carbide. In addition, SEMIKRON provides evaluation boards for eMPack that incorporate ROHM's gate driver ICs, helping customers to shorten the time required for evaluation and adoption. In the future, SEMIKRON also plans to use ROHM's IGBTs in modules for industrial applications.

"Thanks to ROHM's SiC technology, SEMIKRON's innovative eMPack-family of power modules is ready to make a significant contribution to reducing emissions through e-mobility," says SEMIKRON's CEO & chief technology officer Karl-Heinz Gaubatz. "ROHM's SiC technology provides more efficiency, performance and reliability in automotive and also industrial applications," he comments.

ROHM says that it produces SiC components in-house in a vertically integrated manufacturing system, enabling a constant market supply. The firm's production subsidiary SiCrystal in Nuremberg, Germany, plans to strongly grow its SiC wafer



SEMIKRON's CEO & CTO Karl-Heinz Gaubatz (left), and CSO Peter Sontheimer (right), with ROHM Semiconductor GmbH's president Wolfram Harnack (center).

capacities and human resources, in order to produce several 100,000 substrates a year.

"SEMIKRON has selected ROHM as SiC supplier for the automotive-qualified eMPack. This partnership leads to a competitive solution for inverter application use inside electrical vehicles," says Isao Matsumoto, president & CEO of ROHM Co Ltd. "ROHM offers a broad portfolio of SiC devices — from chips to packages," he adds. "As the demand for SiC will continue to grow, ROHM will accelerate further investment and product development based on the technology we have cultivated as a leading SiC manufacturer. In addition, our



SEMIKRON's eMPack power module.

company will continue to propose solutions and deliver customer support."

ROHM was first to mass produce SiC MOSFETs. Its fourth generation of SiC MOSFETs provides low ON-resistance with improved short-circuit withstand time. These characteristics contribute significantly to extend the driving range and miniaturize the batteries of EVs when they are used in traction inverters. The firm

hence develops energy-saving SiC devices that reduce environmental impact.

Both companies aim to continue to contribute to automotive technology innovations by providing optimal power solutions that meet market needs through the fusion of ROHM's device/control technologies and SEMIKRON's module technologies that can optimally combine them.

SEMIKRON manufactures power modules and systems primarily in the medium output range (about 2kW up to 10MW). Products are at the heart of energy-efficient motor drives and industrial automation systems. Further application areas include power supplies, renewable energies (wind and solar power) and electric vehicles (private cars, vans, buses, lorries, forklift trucks, and more). SEMIKRON says that its power electronic products enable customers to develop smaller, more energy-efficient power electronic systems, which in turn reduce the global energy demand.

www.rohm.com/web/global/sic-mosfet

www.semikron.com

SEMIKRON and Danfoss Silicon Power become Semikron Danfoss

Danfoss Silicon Power's GM Claus A. Petersen becomes CEO

Less than five months after it was announced in late March, German firms SEMIKRON of Nuremberg and Danfoss Silicon Power GmbH of Flensburg have started doing business as Semikron Danfoss.

Semikron Danfoss is owned by the owner-families of SEMIKRON and the Danfoss Group, with Danfoss being the majority owner.

With an existing workforce of more than 3500, the merged power semiconductor module firm retains the two main locations in Germany. All global subsidiaries, production sites and distribution channels continue.

"The timing of the new company is perfect," believes Danfoss Silicon Power's general manager Claus A. Petersen, who becomes

CEO of Semikron Danfoss.

"With strong growth in our key markets — automotive, industry and renewables — the merger is a great opportunity for customers, partners, and our employees. Also, with the emerging technology transition from silicon to silicon carbide (SiC), we are set to become the strongest partner of our customers."

Karl-Heinz Gaubatz has stepped down from his position as CEO of SEMIKRON to focus on his role as chief technology officer and support the merger process until his planned retirement at the end of 2022.

"We have succeeded to position SEMIKRON as a market leader in industrial and renewable power module applications, with 2021 as one of the most successful years in

our history," notes Gaubatz. "It is only right that we now join forces with an equally driven and innovative company," he adds.

"Electrification is one of the main drivers in the green transition, and Semikron Danfoss technologies are key components within industry, renewable energy, and automotive traction," says Danfoss' president & CEO Kim Fausing, who becomes chairman of the board of Semikron Danfoss. "Combining more than 90 years of technology leadership in power module packaging, we have the passion, competences, technologies, and commitment to become the preferred decarbonizing partner for customers."

www.semikron.com

www.danfoss.com

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US Patent Office denies ST's petition to invalidate Purdue University silicon carbide patent

ST's challenge a response to Purdue's patent infringement lawsuit

Purdue University in West Lafayette, IN, USA says that the Patent Trial and Appeal Board at the US Patent and Trademark Office has denied STMicroelectronics' challenge to the patentability of its US patent 7,498,633 involving silicon carbide.

Purdue says that the patent covers technology invented by James Cooper and his graduate student/postdoc Asmita Saha. The denied petition was filed by STMicroelectronics in response to Purdue's patent infringement lawsuit and was an attempt to invalidate the patent and hence stop the litigation.

"It means that the patent office has examined the prior art cited by STMicro and has ruled that it does not even raise a legitimate question of patentability," says Ken Waite, chief patent counsel & director of intellectual property at the Purdue Research Foundation Office of Technology Commercialization. "This is an excellent result, as the majority of such requests are granted by the patent office, resulting in a proceeding that can, and often does, invalidate a granted US patent," he adds.

The Office of Technology Commercialization serves as a great steward for intellectual property

created by researchers at all Purdue University campuses, comments Brooke Beier, senior VP of commercialization at the Purdue Research Foundation. "We take managing and protecting Purdue IP very seriously throughout the process from the initial invention disclosure by Purdue researchers through vetting, marketing, licensing it to established companies and startups and beyond," she adds. "We follow the letter of the law through each step, holding ourselves and others accountable."

www.prf.org/otc
www.purdue.edu

Marelli unveils 800V SiC inverter platform at Dritev

Higher efficiency and reduced size and weight allow increased electric vehicle driving range

At the 22nd International VDI Congress 'Dritev' (Drivetrain Transmission Electrification in Vehicles) in Baden Baden, Germany (6-7 July), automotive supplier Marelli unveiled a new, complete platform of 800V silicon carbide (SiC) inverters, ensuring improvements in terms of inverters' size, weight and especially efficiency (a critical parameter in electric vehicles).

Due to its excellent performance at high temperature and high voltage (enabling smaller, lighter and more efficient solutions), silicon carbide is recognized as a technology of choice for power electronics, notes the firm. It is hence particularly suitable for inverters, which convert direct current (DC) power derived from batteries to alternating current (AC) electric power used in the motors of electric vehicles (EVs). In addition, Marelli's new 800V inverter platform also features an optimized thermal structure, due to innovative structural and cooling channel designs that drastically reduce the thermal resistance

between the SiC components themselves and the cooling liquid (a critical aspect in high-power applications, where the heat rejection of the power module is significant).

Among the main advantages, the new inverter platform can extract more energy from the battery at a higher efficiency and ensure a significant increase in the driving range of a vehicle, says Marelli. It also ensures faster charging times and better acceleration, it adds. Finally, a smaller and more efficient inverter allows a reduction in battery size, which delivers cost, weight and sustainability benefits.

"The new inverter platform based on our 800V silicon carbide power module technology allows to serve applications where energy use is optimized, the performance is maximized and efficiency is dramatically improved," says Dr Razvan Panati, head of Power Electronics Technology of Marelli's Vehicle Electrification Division.

"With a complete range of modular solutions, we are able to offer to

our customers more flexibility in terms of packaging, cooling system design and energy storage," he adds.

The software for all the inverters in Marelli's range is developed in-house by the company and is hosted by an electric control unit located in the same inverter case. The software is compliant with AUTOSAR (AUTomotive Open System ARchitecture) standards and specifically customized for the diagnostic standards required by car makers. Functional safety requirements are compliant to ASIL D (Automotive Safety Integrity Level D) standard.

The new 800V SiC platform completes the inverters range offered by Marelli, resulting from over ten years of experience that also includes 400V solutions based on both insulated-gate bipolar transistor (IGBT) and silicon carbide, with gallium nitride (GaN)-based converters in development.

www.vdiconference.com/dritev
www.marelli.com

Catania and ST launch Advanced Master's Program in Power Electronics Devices and Technologies

Applications for 30 places to be submitted by 19 September

Wide-bandgap semiconductor-based technologies guarantee more efficient power electronics performance in line with sustainable development. Looking to educate and expand the pool of professionals in the key power technologies for industrial sectors such as automotive, renewable energy, energy conversion and storage, the University of Catania Department of Electrical, Electronic & Information Engineering (DIEEI) and integrated device manufacturer STMicroelectronics of Geneva, Switzerland are launching an advanced master's degree program in Power Electronics Devices and Technologies.

"Training highly skilled professionals in power electronics is strongly demanded by the market to meet the needs identified by macro-trends in energy efficiency and sustainable development," says professor Mario Cacciato, coordinator of the Master's course. "This program offers master's graduates in various scientific disciplines (STEM) the opportunity to direct their education and training towards topics of great interest for research and industry. In addition, this new Advanced Master's degree represents a model of synergy between academia and industry aimed at the professional develop-

ment and future employment of young talents," he adds.

"Developments in power electronics play a key role in energy-efficiency processes and make it possible for modern society to meet the challenge of sustainable development. Rapid changes in power electronics require training specialists with multi-disciplinary skills," says Giuseppe Arena, program management office director, Power Transistor Sub-Group, STMicroelectronics. "Combining theoretical lectures with experimental activities performed with experts from ST adds major value to the training and development of the next generation of highly skilled professionals."

The new advanced master's degree offers both theoretical and practical training. Coursework is divided into seven teaching modules, conducted in English. Lectures will be presented by university professors and professionals from ST, who will also act as mentors in the final internships inside the company's departments and research laboratories. Moreover, some lectures will be held at ST's Catania site. Trainees will also participate in seminars led by experts from several major international companies in the sector.

The advanced program is open to

graduates holding a master's degree obtained in the last five years in Electrical Engineering, Electronic Engineering, Automation Engineering, Chemistry, Computer Engineering, Telecommunications Engineering, Mechanical Engineering, Chemical Engineering, Materials Science and Engineering, and Chemical Industry Science and Technology. Mastery of English is also required.

The advanced master's degree program will admit a maximum of 30 participants. It awards 60 university credits (CFU) upon completion. Moreover, the program will award a scholarship to ten participants, while another ten students will receive a contribution to cover tuition fees. Applications must be submitted by 19 September.

The Scientific Committee is composed of University of Catania professors Mario Cacciato (coordinator), Giuseppe Compagnini, Guglielmo Guido Condorelli, Salvatore Mirabella, Salvatore Pennisi and Antonio Terrasi, along with Giuseppe Arena, Michele Calabretta, Mario Saggio, Rosario Scollo, Filippo Scrimizzi, and Vincenzo Randazzo of STMicroelectronics.

www.dieei.unict.it/en

www.st.com/

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Bosch investing €3bn in semiconductor business by 2026

€400m Reutlingen expansion to boost SiC chip production, while exploring GaN chips for electro-mobility applications

As part of the 'Important Project of Common European Interest (IPCEI)' funding program on Microelectronics and Communications Technology, Robert Bosch GmbH of Reutlingen, Germany plans to invest another €3bn in its semiconductor division by 2026. "Microelectronics is the future and is vital to the success of all areas of Bosch business," said Dr Stefan Hartung, chairman of the Bosch board of management, at the Bosch Tech Day 2022 in Dresden.

One of the projects Bosch plans to fund is the construction of two new development centers — in Reutlingen and Dresden — at a combined cost of over €170m. In addition, the firm will spend €250m over the coming year on the creation of an extra 3000m² of cleanroom space at its wafer fab in Dresden. "We're gearing up for continued growth in demand for semiconductors," Hartung says.

Promoting microelectronics to increase Europe's competitiveness

Within the framework of the European Chips Act, the European Union (EU) and German federal government are providing additional funding to develop a robust ecosystem for the European microelectronics industry. The objective is to double Europe's slice of global semiconductor production from 10% to 20% by the end of the decade. The newly launched IPCEI on Microelectronics and Communication Technology is intended primarily to promote research and innovation. "Europe can and must capitalize on its own strengths in the semiconductor industry," Hartung says. "More than ever, the goal must be to produce chips for the specific needs of European industry. And that means not only chips at the bottom end of the nanoscale." Electronic components used in the electro-mobility industry, for example, require process sizes of



40–200nm. This is exactly what the Bosch wafer fabs are designed for.

Expansion of 300mm chip production in Dresden

The new investment in microelectronics also opens up new areas of innovation for Bosch. New fields of innovation at Bosch include systems-on-a-chip, such as the radar sensors a vehicle uses to perform 360° scans of its surroundings during automated driving. Bosch will now be looking to enhance such components, making them smaller, smarter, and also cheaper to produce. The firm is also working to further modify its own micro-electro-mechanical systems (MEMS) specifically for the consumer goods industry. One of the things company researchers are currently using this technology to develop is a new projection module that is so small it can be built into the temple of a pair of smartglasses. "We also plan to manufacture our MEMS sensors on 300mm wafers," Hartung says. "Production is scheduled to start in 2026. Our new wafer fab gives us the opportunity to scale production." **Big demand for SiC chips from Reutlingen**

A further focal point, at Bosch's Reutlingen plant since the end of 2021, has been mass-producing silicon carbide (SiC) chips, as used in the power electronics required for electric and hybrid vehicles (HEVs), where they have already helped to boost operating ranges by up to 6%.

On the back of annual market growth rates of 30% or more, demand for SiC chips remains high, meaning full order books for Bosch.

In a bid to make these power electronics more affordable and more efficient, Bosch is also exploring the use of other types of chips. "We're also look-

ing into the development of chips based on gallium nitride for electro-mobility applications," Hartung says. "These chips are already found in laptop and smartphone chargers."

Before they can be used in vehicles, they will have to become more robust and able to withstand substantially higher voltages of up to 1200V. "Challenges like these are all part of the job for Bosch engineers," says Hartung. "Our strength is that we've been familiar with microelectronics for a long time — and we know our way around cars just as well."

Bosch expanding semiconductor manufacturing capacity

Bosch has made several investments in its semiconductor business over the past few years. The best example of this is the wafer fab in Dresden, which opened in June 2021. At €1bn, it is the single biggest investment in the company's history.

The semiconductor center in Reutlingen is also being systematically expanded. Between now and 2025, Bosch is investing about €400m in expanding manufacturing capacity and converting existing factory space into new cleanroom space. This includes the construction of a new extension in Reutlingen, which will create an additional 3600m² of cleanroom space. In total, cleanroom space in Reutlingen is set to grow from around 35,000m² at present to over 44,000m² by the end of 2025.

www.bosch.com

Siemens establishes power electronics innovation hub in UK with CSA Catapult

Germany's Siemens has entered into a strategic innovation partnership with the UK's Compound Semiconductor Applications (CSA) Catapult to accelerate the development of leading-edge power electronics capability. The partnership model, a first for both companies in the UK, aims to focus on the development of disruptive power electronics and building advanced skills in the UK.

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 (based in Newport, South Wales) focused on accelerating the adoption of compound semiconductors and on bringing applications to life in four technology areas: power electronics, RF & microwave, advanced packaging and photonics. It works across the UK in a range of industry sectors from automotive to medical, and from digital communications to aerospace.

The partnership between Siemens and CSA Catapult aims to deliver a series of joint projects and potential future collaborative supply chain programs with other UK companies. CSA Catapult notes that it has a track record in bringing together end-to-end UK supply chains in power electronics.

To facilitate engagement with the UK power electronics ecosystem such as universities, Catapults, RTOs (research and technology organizations), industrial partners, start-ups and grant-funding organizations, there will be a dedicated Siemens power electronics innovation hub at CSA Catapult in Newport, Wales.

Siemens employees will be based on site at the Catapult, hosting Siemens colleagues from new recruits to sponsored students and PhDs. Siemens and CSA Catapult will jointly work on initiatives with other UK partners to address the skills gaps in power electronics.

For Siemens, power electronics is one of 11 Company Core Technologies, innovation areas which are most critical for the long-term success of the firm and its customers. Led by Digital Industries Motion Control (DI MC), the hub is a joint initiative between Technology Power Electronics (T PEL) and the Research and Innovation Ecosystem (T RIE), delivering disruptive technological solutions for a more sustainable world.

CSA Catapult's role is to deliver long-term benefit to the UK economy and accelerate UK economic growth in industries where applying compound semiconductors creates a competitive advantage and enables new products or end markets.

CSA Catapult is delivering three projects: ESCAPE, @FutureBEV and Driving the Electric Revolution Industrialisation Centres (DER-IC), to create new UK supply chains and accelerate electrification and Net Zero. CSA Catapult is one of the four regional centers for DER-IC, a UK-wide investment program. It develops supply chain capability and competence for the underpinning of power electronics components and materials, towards UK net-zero goals.

"We are looking forward to expanding our Research and Innovation Ecosystem of world-leading universities and research institutes working with CSA Catapult," says professor Rolf Hellinger, VP of Power Electronics at Siemens AG. "This collaboration will bring radical and disruptive technologies to market — fast, risk mitigated and economical," he adds.

"Siemens being an innovation leader in power electronics is creating a high-value UK collaboration ecosystem with CSA Catapult, enabling us to accelerate commercialization of next-generation disruptive technologies underpinned by advanced PEMD skills," comments Imran Agha, innovation manager, Innovation Centre for Power Electronics at Siemens plc. "This will help with building more sustainable, cleaner

supply chains, and create more jobs for the future," he adds.

"We are a global leader in compound semiconductor technology, with made in Wales products powering devices in every corner of the world," says the Welsh Government's Economy Minister, Vaughan Gething. "It's great to see such a major company choosing to co-locate their first UK innovation hub alongside the Catapult in Newport. This will help with developing the skills of our existing and future workforce, and foster the ongoing development of the compound semiconductor cluster."

"Catapults are supported by Innovate UK to drive innovation through a unique combination of facilities and expertise, and have a great track record of attracting inward investment and accelerating clusters," notes Simon Edmonds, chief business officer at UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation). "The Compound Semiconductor Applications Catapult is continuing this through the valuable partnership with Siemens, which will make a significant contribution to the CS cluster in South Wales, to the UK economy, and to the UK's capability in compound semiconductors."

"It will help us accelerate power electronics projects across UK industry, to solve complex innovation problems," comments CSA Catapult's CEO Martin McHugh. "We are hoping this is the first partnership of many," he adds. "Working with Siemens, we will accelerate our internal research program and demonstrators and provide opportunities for our people. Working alongside Siemens will provide opportunities to attract more talent and skills to the region. Working across our industry, we will continue to build on our track record in bringing power electronic supply chains together, to support UK growth."

www.siemens.com

<https://csa.catapult.org.uk>

Infineon lays foundation of third wafer fab module in Kulim, Malaysia

Construction to be completed by third-quarter 2024 for SiC and GaN power semiconductor manufacturing

The foundation stone has been laid for construction of a new wafer fab module at Infineon Technologies (Kulim) Sdn Bhd in Kulim Hi-Tech Park (KHTP), Malaysia. With more than RM8bn worth of investment, the third module will add significant manufacturing capacity in power semiconductors, particularly wide-bandgap technology based on silicon carbide (SiC) and gallium nitride (GaN). Construction is expected to be completed by third-quarter 2024.

The foundation stone ceremony was officiated by guest of honour YAB Dato' Seri Haji Muhammad Sanusi Bin Haji Mohd Nor, chief minister of Kedah, accompanied by Ng Kok Tiong, senior VP & managing director of Infineon Technologies Kulim, Ms Lim Bee Vian, deputy CEO (investment development) of the Malaysian Investment Development Authority (MIDA), Ms Kam Ai Mei, chief financial officer, Infineon Technologies (Kulim) Sdn Bhd, and Dr Raj Kumar, VP of technology, Infineon Technologies (Kulim) Sdn Bhd.

"I am pleased that Infineon, who has a long-term presence in Kedah, continues to expand in the Kulim Hi-Tech Park (KHTP)," said YAB Dato' Seri Haji Muhammad Sanusi Md Nor. "Since KHTP's establishment in 1996, the number of capital-intensive high-tech manufacturing companies have steadily grown, bringing advanced technologies and R&D activities as well as high-tech jobs to Kedah state, and creating a vibrant economy for the local community," he added.

"We are fortunate to have long-term and committed industry partners including Infineon, which have been instrumental to bringing growth in Malaysia's semiconductor industry," commented Ms Lim Bee Vian. "As we revel in the announce-



Ms Kam Ai Mei (Infineon), Ms Lim Bee Vian (MIDA), YAB Dato' Seri Muhammad Sanusi Md Nor (Menteri Besar Kedah), Ng Kok Tiong (Infineon) and Dr Raj Kumar (Infineon) joining hands to launch the Foundation Stone Ceremony for Infineon Kulim's third wafer fab module.

ment for the third facility today to increase the wafer fabrication of wide-bandgap semiconductors, I am pleased to note that Infineon Kulim's third module will be instrumental in increasing Malaysia's position in the global semiconductor supply chain," she added. "Our collective aim is to establish Malaysia as one of the key partners in global semiconductor supply chains. Having like-minded global partners like Infineon will strengthen our position in global value chains and our goal to be an advanced manufacturing base in the region driven by innovation. We are committed to supporting industry leaders like Infineon," she continued.

"Malaysia is an important hub for Infineon due to economies of scale already present in our front-end wafer fab manufacturing in Kulim, and back-end chip manufacturing in Melaka. When fully equipped, products from the new module will generate additional €2bn in annual revenue," said Infineon Technologies' chief operations officer Dr Rutger Wijburg.

"As decarbonization efforts gain

momentum globally, demand from electric vehicles, charging and storage infrastructures, and renewable energy for wide-bandgap power semiconductors is growing, and we are prepared to support the demand," he added.

"Malaysia

offers a bright and highly motivated talent pool that we can further invest in and grow via on-the-job training and competency development," said Ng Kok Tiong, senior VP & managing director of Infineon Technologies Kulim, as he expressed his gratitude to the Kedah State, MIDA and Malaysia government for its support. "Bringing new technology to Malaysia requires skills to manage complexity and experience to master the technology. The new module will create 900 high-value job opportunities adding to the existing employees at Infineon Kulim."

The electrical and electronics (E&E) industry contributes significantly to Malaysia's GDP growth, export earnings, investment and employment and plays a vital role in the country's industrial development, it is reckoned. In first-quarter 2022, Malaysia attracted RM18.6bn (US\$4.4bn) in approved investments for the E&E industry (among the top performing industries for the manufacturing sector).

www.infineon.com

www.mida.gov.my

Infineon and Delta strengthen collaboration on WBG-based server and gaming PC power solutions

CoolSiC MOSFET and CoolGaN technologies maximize efficiency in end-applications

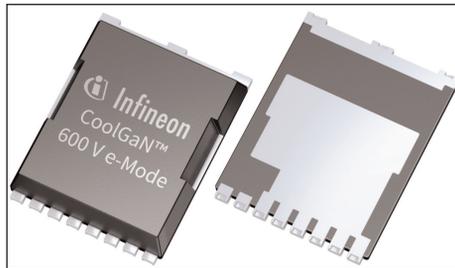
Global megatrends, such as digitalization, and decarbonization, call for wide-bandgap (WBG) devices (SiC/GaN). Due to their unique characteristics, they enable the highest performance and energy efficiency at the same time. Targeting both of these domains, Infineon Technologies AG of Munich, Germany and power supply maker Delta Electronics Inc have deepened their collaboration.

The latest examples of their cooperation include Delta's 1.4kW server power supply and a 1.6kW Titanium gaming power platform. The 1.4kW server power supply leverages Infineon's CoolSiC MOSFET technology and Delta's multi-decade core competence in power electronics to achieve beyond 96% efficiency. Another case for highest efficiency is the 1.6kW gaming power platform powered by Infineon's CoolGaN technology complemented with EiceDRIVER gate driver ICs. The efficiency of this design reaches 96% at wide-range input and multi-output and meets the Titanium standard in the industrial domain. This is enabled by Infineon's CoolGaN gate-injected transistor (GIT) 600V enhancement-mode high-electron-mobility transistor (e-mode HEMT), adapted in an interleaving totem-pole power factor correction (PFC) topology.

Both design examples demonstrate how Infineon's broad, performance-driven portfolio of WBG devices, together with Delta's system innovation potential, can enable new efficiency levels to meet and exceed modern application requirements, the firms say. By deepening their collaboration, both companies target a leading position in WBG-based platforms through cost-effective, robust solutions backed up by what is claimed to be the highest supply stability.



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The 1.6kW gaming power platform is powered by Infineon's CoolGaN technology complemented with EiceDRIVER gate driver ICs.



Johannes Schoiswohl, business line head, Efficient Power Supplies, Isolation & Connectivity of Infineon's Power & Sensor Systems Division.

"Given our commitment to investing over 8% of our annual revenues in R&D-based innovation, Delta's power supply solutions for servers and gaming PCs provide the high-quality and high-efficiency components needed to build customized, reliable and energy-efficient infrastructure which satisfies our customers' expectations," claims Jimmy Yiin, VP & general manager of Delta's Power and System Business Group. "Being successful in such an extremely competitive environment requires collaborating with highly trustworthy, top-tier component suppliers with extensive system understanding and offering fully customized solutions for application-specific requirements. Infineon's inclusive portfolio of WBG products made it possible to achieve industry-leading energy efficiency for many of our customer's applications," he adds.

"Our manufacturing scale and technology excellence, combined with a focus on quality and reliability at each step of the value chain, are the key to success factors for our wide-bandgap semiconductor business and are well recognized by our customers," reckons Johannes Schoiswohl, business line head, Efficient Power Supplies, Isolation & Connectivity of Infineon's Power & Sensor Systems Division. "By applying rigorous qualification and reliability test procedures to our devices, above and beyond standard JEDEC qualification, we can predict the long-term behavior of our WBG devices and ensure reliability in the field over the entire product lifecycle. We are excited about the opportunities our collaboration with Delta holds for us in the server and gaming market."

www.deltaww.com

www.infineon.com/wbg

www.infineon.com/green-energy

Navitas acquires GeneSiC, accelerating entry into EV, solar and energy storage markets by 2–3 years

For second-quarter 2022, gallium nitride (GaN) power IC firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has reported net revenue of \$8.6m, up on \$6.74m last quarter and 58% on \$5.45m a year ago.

However, gross margin (on a non-GAAP basis) has fallen further, from 46% a year ago and 44% last quarter to 41.6%. Operating expenses were \$12.5m, level with last quarter but up from \$8.3m a year ago. Net loss was \$9.1m (\$0.07 per share), up from \$5.8m (\$0.28 per share) a year ago but nevertheless cut from \$9.6m (\$0.08 per share) last quarter.

“While we see significant softness in the China smartphone market, our leadership in the GaN mobile charger market has never been stronger,” says CEO & co-founder Gene Sheridan.

“In the second quarter, we added over 20 new customer launches, set new industry benchmarks in ultra-fast charging, and achieved significant progress in our expansion markets of data center, solar and EV,” he adds.

New GaN smartphone chargers include Motorola edge+ (in-box 68W), vivo X-Fold (in-box 80W), OnePlus Ace/10R and 10T 5G (in-box 150W), plus the vivo iQOO 10 and 10 Pro smartphones with 120W and record-setting 200W in-box chargers (achieving what is claimed to be a new industry-benchmark, with 0–100% charging in less than 10 minutes). Aftermarket GaN chargers include Anker’s GaNPrime series (120–150W), and Belkin’s 108W 4-port GaN charger (now available in the Apple Store). New laptop GaN chargers include Xiaomi Redmi (in-box 100W), Lenovo Legion (135W) and Dell XPS 13 Pro (in-box 60W).

Key platform and customer developments in the firm’s expansion into higher-power markets include:

- four new Titanium Plus efficiency-grade data-center platforms in

development supporting eight major customer projects;

- two industry-leading residential solar customers in development that are committed to a broad transitions from silicon to GaN;
- three new electric vehicle OBC/DC–DC platforms in development supporting five major customer programs.

Also, Navitas has acquired silicon carbide (SiC) power semiconductor device designer and manufacturer GeneSiC Semiconductor Inc of Dulles, VA, USA for about \$100m in cash, 24.9 million shares of Navitas stock and possible earn-out payments of up to \$25m (conditional on the achievement of substantial revenue targets for the GeneSiC business over the four fiscal quarters to end-September 2023). The acquisition is expected to be immediately accretive to Navitas’ earnings per share.

GeneSiC is highly profitable, with EBITDA margins of more than 25%, expected full-year 2022 revenue of about \$25m, and demonstrated annual growth rates of over 60%.

Founded in 2014, Navitas launched what it claimed to be the first commercial GaN power integrated circuits. Its proprietary GaNFast power ICs integrate GaN power and drive with sensing, control and protection circuits to enable faster charging, higher power density and greater energy savings for mobile, consumer, enterprise, eMobility and new energy markets. Complementary GeneSiC power devices are optimized high-power, high-voltage and high-reliability silicon carbide solutions. Targeted markets include mobile, consumer, data center, EV, solar, wind, smart grid, and industrial.

The combined company creates what is said to be a comprehensive technology portfolio in ‘next-generation’ power semiconductors — both GaN and SiC — with an aggregate market opportunity forecasted

to exceed \$20bn per year by 2026.

“With the acquisition of GeneSiC, Navitas has become the industry’s only pure-play, next-generation power semiconductor company,” reckons Sheridan. “GeneSiC is an ideal SiC partner for Navitas with its industry-leading performance, world-class robustness, and the broadest product portfolio in SiC, from 650V to 6500V,” he comments. “They have focused on core SiC technology, while Navitas has invested significantly in global sales, operations and technical support teams, along with system design centers in EV and data centers — all of which can be immediately leveraged to accelerate GeneSiC’s already fast-growing business. With GeneSiC’s 500 diverse and synergistic customers, we now have immediate revenue in solar, EV, energy storage and many other diversified industrial markets.”

Navitas’ recent acquisition of VDD Tech of Mont-Saint-Guibert, Belgium and its digital-isolator technology is reckoned to be a great combination for both GaN and SiC higher-power applications, adding up to \$4 of system content and opening up an additional \$1bn annual market opportunity for Navitas.

Navitas expects that the GeneSiC acquisition will accelerate its expansion into higher-power markets by 2–3 years, with immediate Q3 revenue in synergistic solar, energy storage and EV markets, among other industrial markets.

Including a partial quarter of GeneSiC revenue, net revenues for third-quarter 2022 are expected to be \$9–11m, reflecting short-term softness in the China smartphone market. Gross margin should be 40% (plus or minus 2%). Operating expenses (including a partial quarter of expenses for GeneSiC) are expected to be about \$14m (plus or minus 3%), excluding stock-based compensation and amortization of intangible assets.

www.genesicsemi.com

Navitas acquires VDD Tech to expand high-power, next-generation semiconductor capabilities

Proprietary new isolation technology enables smaller, faster, lighter power conversion for consumer, motor drive, solar, data center, and electric vehicle markets

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has acquired VDD Tech of Mont-Saint-Guibert, Belgium, a creator of digital-isolators for next-generation power conversion.

Advanced digital-isolation techniques are essential to deliver size, weight and system-cost improvements in high-power markets such as consumer, motor drive, solar, data center and electric vehicles (EVs). VDD Tech's proprietary modulation-technique is said to enable stable, reliable, efficient power conversion at MHz+ switching speeds.

Proprietary dV/dt sensing, blanking and refresh technologies enable a combination of very-high-voltage isolation capability with the highest frequency of operation requiring 5–10x higher dV/dt immunity than

legacy silicon. Low isolation-capacitance (<0.5pF) and innovative, robust modulation deliver low-jitter digital-communication for isolated-driver control and analog-sensing feedback. A minimum 200V/ns common-mode transient immunity (CMTI) is uniquely guaranteed across all temperature and operating conditions.

VDD Tech was founded by Vincent Dessard, quickly joined by Aimad Saib, each of them holding a doctorate and 15+ years' experience in analog/mixed-mode IC research and development. Dessard and Saib have taken leading roles in Navitas' advanced R&D teams.

"It's exciting to see two breakthrough technologies – optimized digital-isolators and GaN power ICs – combine to deliver such leading-edge, high-power solutions," says

Dessard. "High-speed and high-reliability are the critical factors to accelerate wide-bandgap semiconductor adoption over legacy silicon chips, and we're very excited to be a catalyst in this once-in-a-generation revolution, with new, high-power products launching in 2023," he adds.

"VDD Tech's isolation technology is a key part of our growing power-and-control integration strategy, creating an additional \$1bn/year market opportunity," notes Navitas' CEO & co-founder Gene Sheridan. "We continue to research and review new technologies that we could add to Navitas' core strengths, and deliver significant CO₂ emission-reduction benefits."

www.vddtech.com

www.navitassemi.com

Navitas highlights fast charging at Asia Charging Expo

Expansion of applications to consumer, data-center, solar and EV

Navitas participated (as a sponsor) in the 2022 Asia Charging Expo and Global Third Generation Semiconductor Industry Summit at the Futian Convention & Exhibition Center in Shenzhen, China (18–20 July).

Since GaN is reckoned to run up to 20x faster than silicon, GaNFast power ICs are said to deliver up to 3x faster charging or 3x more power with up to 40% energy savings in half the size and weight for mobile, consumer, enterprise, eMobility and new energy markets. GaNFast power ICs with GaNSense technology integrates power, drive, control, with additional autonomous-protection and loss-less current-sensing to deliver what is claimed to be the simplest, smallest, fastest and now even higher-power

performance. New 'ultra-fast' charging enables smartphone charging from 0–100% in less than 10 minutes using a small, light, ultra-portable 150W GaN charger.

As part of the 2022 Asia Charging Expo's 'Global Third Generation Semiconductor Industry Summit', Reyn (Renxiong) Zhan, Navitas' senior technical marketing manager delivered a keynote presentation 'Navitas: kick-starting the GaN revolution' highlighting how GaN makes a significant contribution to 'Net-Zero' climate goals, as each GaNFast IC shipped saves 4kg of CO₂. Navitas claims to have been the first company to publish a sustainability report that comprehensively quantifies the positive impact of GaN power semiconduc-

tors on climate change based on global standards, and recently announced that it is the first semiconductor company worldwide to be certified as CarbonNeutral.

Navitas has shipped over 50 million units with zero reported GaN field failures, and with nine of the top ten mobile OEMs in mass production now using Navitas ICs – including Samsung, Xiaomi, Dell, Lenovo and OPPO. The firm detailed how the latest GaNFast ICs improve charging speed, size, weight and system-cost across a broad range of charger power from 20W to 240W, and highlight consumer, data-center, solar and electric vehicle (EV) solutions up to 22kW.

www.huodongxing.com/event/9651871672200

Anker partners with Infineon, Navitas, Innoscience and Southchip to develop all-GaN fast chargers

Sub-100W chargers developed with Innoscience and Southchip; >100W chargers combine Infineon's Hybrid Flyback and CoolGaN switch with Navitas' GaNFast power ICs with GaNSense

Mobile charging and consumer electronics products company Anker Innovations of Changsha, Hunan, China has partnered with gallium nitride (GaN) technology firms to develop a new generation of charging solutions for both home and on-the-go.

"GaN is allowing us to completely change the way we charge our electronics by delivering better power transfer efficiency, faster-charging speeds, and smaller, more portable chargers," says CEO Steven Yang. "Our partners provided exclusive access to cutting-edge GaN technology that empowered us to create chargers that last longer and are more sustainable."

To develop its new, higher-watt GaN chargers (with power output of over 100W), Anker partnered with semiconductor manufacturer Infineon Technologies AG of Munich, Germany as well as GaN power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland. By applying their technology, Anker was able to increase the efficiency of its new GaN chargers, reducing both the electricity lost by the charger while in use as well as the chargers' carbon footprint.

"By combining Infineon's Hybrid Flyback and CoolGaN switch in Anker's new charging lineup, we achieved a system efficiency of 95%, amongst the highest level in industry, reducing energy losses by about 20% in comparison with other charging solutions," reckons Adam White, Infineon division president of Power & Sensor Systems. "This is the first time Infineon's HFB architecture and the CoolGaN switch have been applied together to any commercially available consumer electronics," he adds.

"Navitas' next-generation GaNFast power ICs with GaNSense technology are used in the latest lineup of Anker GaN chargers, replacing slow and inefficient legacy silicon materials, reaching 97% peak efficiency and with up to 25% energy savings," says Navitas' CEO Gene Sheridan. "By adopting our latest technology, Anker can reduce the CO2 footprint of the whole charger by up to 30% versus legacy solutions."

For its new, lower-watt GaN chargers (with power output of under 100W), Anker partnered with GaN power device manufacturer Innoscience Technology of Suzhou, China and Shanghai-based high-performance semiconductor design firm Southchip Semiconductor Technology Co Ltd.

"By using all GaN FET technology, each charger in Anker's new series is powered by two Innoscience GaN power chips on both the AC side and DC side (an all-GaN solution)," notes

Innoscience's founder Wei Wei Luo. "The new Anker chargers take full advantage of GaN, bringing its system's efficiency and power density to a new level," he adds.

"Southchip's proprietary GaN differential drive technology is used in Anker's new chargers, which highly integrates the GaN power devices and controllers to ensure the reliability of the system," says Southchip's CEO Stefan Ruan. "The lab test data shows that, with 100% GaN, the energy loss of the AC-to-DC circuit is reduced by 7.2%, and the circuit efficiency is greatly improved."

Anker's new generation of GaN chargers will feature the latest version of PowerIQ, the company's proprietary technology that allows chargers to intelligently detect the power needs of each connected device. Anker partnered with digital-analog (mixed-signal) hybrid system-on-chip (SoC) design firm Zhuhai iSmartware Technology Co Ltd to develop the latest PowerIQ.

"iSmarWare's new SoC single-chip solution for high-current and high-voltage DC-DC PD fast charging greatly simplifies the hardware circuit design and, together with Anker's own PowerIQ, greatly reduces the energy consumed by the chargers by 40%," says iSmartWare's CEO Eric Li.

Anker's new lineup of GaN chargers was unveiled at a virtual launch event on 25 July. The event was streamed on Anker.com as well as Anker's Youtube, Facebook and Twitter accounts.

www.navitassemi.com
www.infineon.com
www.innoscience.com
www.southchip.com
www.ismartware.com
www.anker.com

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GaN-on-Si device maker Innoscience opens Korean sales and design center

Innoscience Korea to design new solutions tailored to Korean market

Innoscience Technology of Suzhou, China has opened a new office in Gwangmyeong, near Seoul, South Korea, to provide technical and marketing services to the country's consumer and automotive market. Innoscience Korea will also design new solutions tailored to the Korean market's needs and based on InnoGaN technology.

Founded in December 2015 with main investment from CMBI, ARM, SK and CATL, Innoscience first established a mass-production 8-inch wafer line for gallium nitride-on-silicon (GaN-on-Si) devices in Zhuhai National Hi-Tech District in November 2017, then inaugurated a new facility in Suzhou in September 2020. With 1400+ staff and over 300 R&D specialists, the firm now claims to be the largest

integrated device manufacturer (IDM) fully focused on GaN technology, with two wafer fabs including what is claimed to be the world's largest dedicated 8-inch GaN-on-Si site. Innoscience is now delivering GaN power devices that can be used in applications including cloud computing, electric vehicles (EV) and automotive, portable devices, mobile phones, chargers and adapters.

VP & general manager of Innoscience Korea is Ke Hong, responsible for business development in Korea. Hong has 27 years' experience in the power semiconductor industry, holding key roles at other international and Korean companies.

"As we expand Innoscience's global presence, it is vital to have a direct presence in Korea, which

is a very strategic market for Innoscience," says Innoscience's CEO Jay Son.

The team in Korea is already formed by nine engineers and is quickly expanding with the addition of designers, sales and product marketing experts.

"Innoscience has shaken up the GaN market by making products readily available at competitive prices," comments Hong. "Innoscience is perfectly positioned to provide GaN power devices in mass volume, which is what we think the Korean market was waiting for," he adds. "Korea is a significant opportunity for Innoscience. We are working hard to support all our customers here and to showcase the benefit of using InnoGaN in relevant applications."

www.innoscience.com

Navitas' GaNFast power ICs powering Anker's 100W fast charger

Engineering teams from both firms co-located at Anker offices

Navitas Semiconductor Corp of El Segundo, CA, USA and Dublin, Ireland says its GaNFast power ICs with GaNSense technology are powering the new 100W fast charger of consumer electronics firm Anker Innovations of Changsha, Hunan, China.

Both the GaNFast ICs and the Anker 736 Charger (Nano II 100W) multi-port (2x USB-C, 1x USB-A) charger are Consumer Electronics Show (CES 2022) Innovation Award honorees, with the Anker 736 officially launched to the market in May.

Compatible with USB 3.0 PD PPS and Qualcomm Quick Charge 3.0, and measuring only 67mm x 31.5mm x 56.97mm (120cc) the charger achieves a power density of 0.83W/cc and can deliver a 50% charge to an Apple MacBook Pro 16 2021 in just 40 minutes.

Since GaN runs up to 20x faster than legacy silicon, gallium nitride chargers can achieve 3x the power or 3x faster charging with up to 40% energy savings in just half the size and weight.

Navitas' GaNSense technology integrates real-time, accurate and fast sensing of system parameters (including current and temperature) and achieves patent-pending, loss-less current sensing to deliver an extra 10% energy saving. GaNSense enables a 'detect-to-protect' time of only 30ns — 6x faster than discrete GaN power chips for increased system reliability. The Nano II 100W uses two NV6136A ICs, one in the boost PFC (power factor correction) stage, the other in a high-frequency quasi-resonant (HFQR) flyback converter, using loss-less current sensing for high-efficiency, cool operation and fast charging.

"By using Navitas GaNFast ICs instead of silicon, we are able to deliver more power from a smaller, lighter charger, achieving a power efficiency of over 93%," says Anker Innovations' CEO Steven Yang.

"The result is an ultra-compact, high-performance charging solution that provides the convenience of fast and simultaneous multi-device charging with maximum portability," he adds.

"Anker and Navitas have an established relationship that goes back to 2017," says Charles Zha, VP & general manager of Navitas China. "Since we announced our strategic partnership, engineering teams from both Navitas and Anker have been co-located at Anker offices, which accelerates the time-to-market of innovative products such as the Nano II 100W charger."

www.anker.com

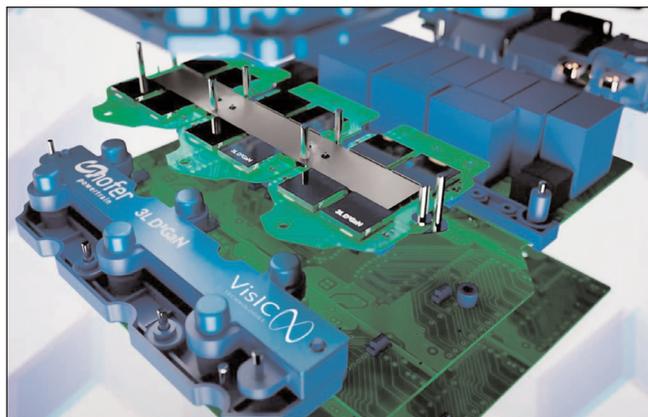
VisIC's D³GaN chip technology used in hofer's new 3Level traction inverter

Minimal Viable Product to prove capability of using 650V GaN in 800V 3L NPC inverter

VisIC Technologies Ltd of Ness Ziona, Israel – a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors — says that its D³GaN (Direct Drive D-Mode) chip technology has been used by automotive technology company hofer powertrain of Nürtingen, Germany to develop new multi-level power electronics. Tests prove that the new solution's efficiency and power density exceed the capabilities of silicon-based technology, the firm adds. The new 3Level GaN Inverter is said to have proven its capabilities on the test bench, confirming significantly better switching speed and smaller and lighter package size, reducing total system cost.

hofer and VisIC aim to develop GaN-based power inverters for electric vehicles (EVs), achieving the breakthrough of GaN technology for 800V battery systems in the automotive industry.

"We are proud to achieve the next step in developing efficient GaN-based, high-frequency inverters for 800V automotive applications," says Lukasz Roslaniec, electronics expert at hofer powertrain.



hofer powertrain has developed a Minimal Viable Product (MVP) to investigate and prove the capability of using 650V GaN in an 800V 3L NPC inverter application, specifically its behavior in terms of switching speed, EMC, and the limits. The main goal is to prove the capability for feeding a sinusoidal current of 100A_{rms} through an inductive load and performing a double pulse test. Measurements have shown the possibilities for an excellent performance increase.

"hofer powertrain's development paves the way for a breakthrough in GaN inverter performance, which is superior to silicon and silicon carbide (SiC)-based designs for high

efficiency," says Iliia Bunin, senior product manager & technical expert at VisIC.

The system is said to provide valuable insight and in-depth understanding of the short-circuit protection, switching properties of the implemented GaN transistors, the impact on dv/dt, oscillations

during switching, voltage overshoots, and much more. In addition, the firm has identified the most important electrical and thermal properties for rapid further development.

The upcoming sample stage (A1) has already started and is expected to perform well in real test conditions with a permanent synchronous motor. The team aims to validate and benchmark existing systems using test cycles like the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) and prove its outstanding potential for the entire automotive powertrain.

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Finwave raises \$12.2m in Series A financing round to bring 3D GaN to volume production

Funds to be used to expand team, product development activities and lab facilities

Finwave Semiconductor Inc of Waltham, MA, USA has raised \$12.2m in a Series A round of funding led by Fine Structure Ventures with additional participation from Citta Capital, Soitec, Safar Partners and Alumni Ventures. This follows an award of \$4.3m in federal funding from the US Department of Energy Advanced Research Projects Agency – Energy (ARPA-E) SCALEUP (Seeding Critical Advances for Leading Energy technologies with Untapped Potential) grant, to help bring the company's three-dimensional gallium nitride (3D GaN) technology to volume production. The funds will be used to expand the firm's team, product development activities and lab facilities.

Founded in 2012 by researchers at Massachusetts Institute of Technology (MIT) as Cambridge Electronics before being rebranded this June as Finwave Semiconductor (with offices in San Diego, CA and the Bay Area), the firm aims to revolutionize 5G communications with its 3D GaN technology, which features a 3D fin transistor (GaN FinFET) structure.

"3D GaN FinFET technology is a result of over 10 years of research and development, initially developed at MIT and recognized with the coveted 2012 IEEE Electron Device Society George Smith Award," notes Finwave's CEO & co-founder Dr Bin Lu. "The enormous potential of GaN FinFETs has since been demonstrated by a growing number of researchers around the world," he adds.

"The company combines best-in-class power amplification efficiency with high-volume manufacturing to overcome the performance and cost limitations that have together stymied widespread adoption of mmWave," comments said Jennifer

Uhrig, senior managing director at Fine Structure Ventures, a venture capital fund affiliated with FMR LLC, the parent company of Fidelity Investments.

Millimeter-wave (mmWave) is critical to the future of all wireless technology, but the realization of its potential faces severe roadblocks, says Finwave. Weak uplink, high deployment costs, low 5G radio efficiency and soaring operating costs are all combining to thwart the promise of mmWave. Currently, 5G networks are being held back from realizing their true potential due to a critical missing component: high-performance mmWave power amplifier technology, the firm adds.

High-performance GaN-on-silicon (GaN-on-Si) could make 5G millimeter-wave more practical. At mmWave frequencies, GaN-on-Si amplifiers excel versus alternative solutions such as radio-frequency silicon-on-insulator (RF SOI) MOSFETs, gallium arsenide (GaAs) pseudomorphic high-electron-mobility transistors (pHEMTs) or

3D GaN technology significantly improves linearity, output power and efficiency in 5G mmWave systems — while greatly reducing costs for carriers.

By leveraging high-volume 8" silicon CMOS fabs for producing 3D GaN chips, the firm's devices benefit from both the cost model and scalability of silicon technology

silicon germanium (SiGe) devices, says Finwave. The firm claims that its 3D GaN technology significantly improves linearity, output power and efficiency in 5G mmWave systems — while greatly reducing costs for carriers. In 2020, Finwave demonstrated the first GaN insulating-gate FinFETs fabricated with 8" silicon CMOS tools. By leveraging high-volume 8" silicon CMOS fabs for producing 3D GaN chips, the firm's devices benefit from both the cost model and scalability of silicon technology.

"Finwave was founded with the mission to scale the technology from lab to high-volume products that benefit society, and 5G presents the perfect market opportunity for the scale, performance gains and cost advantages this technology brings," says Bin Lu. "Having solved numerous manufacturing challenges and successfully created a fabrication process using standard 8" Si CMOS tools, Finwave is leading the way in commercializing the 3D GaN technology for 5G," he adds.

"After spending 30 years working in silicon-on-insulator technology and being an early pioneer in getting this technology into every cell phone on the planet, the opportunities for Finwave's 3D GaN GaN-on-silicon technology are enormous," comments Finwave's chief strategy officer & executive chairman Dr Jim Cable. "I personally understand the challenges of ramping up a new technology into high-volume markets, and we are very focused on all aspects of enabling this. Closing this Series A round is a major step forward for us."

Beyond 5G, Finwave aims to also bring its technology to artificial intelligence (AI), cloud computing, and electric vehicles (EVs) and autonomous vehicles (AVs).

www.finwavesemi.com

Micross to distribute EPC Space's rad-hard GaN power devices for space, aerospace and high-rel applications

EPC Space LLC of Haverhill, MA, USA says that Micross Components Inc of Orlando, FL, USA (a global provider of bare die and a mission-critical microelectronic components and services for high-reliability aerospace & defense, space, medical and industrial applications) has agreed to become an authorized distributor for its line of packaged radiation-hardened gallium nitride on silicon (GaN-on-Si) transistors and ICs, which are designed and qualified for satellite and other high-reliability applications.

Spanning a range of 40–300V, EPC Space offers a family of rad-hard enhancement-mode power transistors that are said to demonstrate significant performance advantages over competing silicon-based rad-hard power MOSFETs. The firm's technology produces GaN devices that are smaller, lighter and better performing, meaning that the devices have many times superior switching performance compared with silicon solutions.

To complement the EPC Space discrete products, Micross will also distribute EPC Space's family of rad-hard enhancement-mode GaN drivers and power stages. These rad-hard GaN drivers are optimized to drive the rad-hard GaN transistors in critical space-borne systems and applications. The rad-hard power stages integrate a high-speed gate drive circuit with power switches to provide a complete monolithic power stage in a tiny footprint for a smaller, lighter solution.

The agreement combines the performance and reliability of EPC Space's rad-hard GaN technology with Micross' portfolio of high-reliability product lines along with their extensive relationship-driven network within the high-reliability community.

Critical space-borne applications that benefit from the performance improvements that EPC Space devices offer include power supplies for satellites and mission equipment, light detection and ranging (LiDAR) for robotics, autonomous

navigation and rendezvous docking, motor drives for robotics and instrumentation, and ion thrusters for satellite orientation and positioning as well as interplanetary propulsion of low-mass robotic vehicles.

"The addition of EPC Space's rad-hard gallium nitride-based power management products complements Micross' expansive hi-rel product solutions portfolio and global expertise in providing mission-critical components and services for hi-reliability applications," says Mark Zack, Micross Components' senior VP of Die & Wafer Services.

"We are excited to bring our leading-edge high performance rad-hard GaN technology together with the expertise of Micross to reach wider and deeper into the space marketplace where these customers' power applications require 'state-of-the-art' performance along with greater-power-density solutions," says EPC Space's CEO Bel Lazar.

www.micross.com/epc-space
www.epc.space

EPC Space expands rad-hard GaN transistor family for critical space-borne and other high-rel environments

EPC Space has introduced two new radiation-hardened (rad-hard) gallium nitride (GaN) transistors with ultra-low on-resistance and extremely low gate charge for high-power-density solutions that are claimed to be lower cost and more efficient than the nearest comparable rad-hard silicon MOSFET. With drain-to-source voltages (V_{DS}) of 100V and 200V respectively, the EPC7018G and EPC7007B are supplied in hermetic packages in very small footprints (of 8.0mm x 5.6mm and 5.7mm x 3.9mm, respectively).

Chip-scale versions are available from Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA.

With higher breakdown strength, lower gate charge, lower switching losses, better thermal conductivity and lower on-resistance, power devices based on GaN significantly outperform silicon-based devices and enable higher switching frequencies resulting in higher power densities, higher efficiencies, and more compact and lighter-weight circuitry for critical space-borne missions. Drain-to-source on-resistances ($R_{DS(on)}$) of the EPC7018G and EPC7007B are 6m Ω and 28m Ω , respectively. The single-pulse drain current (I_{DM}) is 345A and 80A, respectively.

Applications benefiting from the performance of these products include DC–DC power supplies for

satellites and space mission equipment, motor drives for robotics, instrumentation and reaction wheels, deep space probes, and ion thrusters.

"These two new additions to our rad-hard product line offer designers high-power, ultra-low on-resistance solutions enabling a generation of power conversion and motor drives in space operating at higher efficiencies, and greater power densities than what is achievable with traditional silicon-based rad-hard solutions," says EPC Space's CEO Bel Lazar.

For the EPC7018G and EPC7007B, 500-unit pricing is \$212.80/ea for engineering models and \$315.84/ea for space-level grade.

Odyssey's foundry revenue recovery in Q3/2022 to offset cash used during product development

Large-scale device fabrication process validated; device packaging planned for Q4/2022

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA, which is developing high-voltage vertical power switching components based on proprietary gallium nitride (GaN) processing technology, has reported revenue of just \$20,581 for second-quarter 2022 (following just \$29,938 in Q1), down from \$287,153 a year previously, with net loss remaining about \$1.3m (\$0.10 per diluted share).

"We expect a significant sequential revenue improvement in Q3/2022. Our foundry revenue will be approximately \$195,000 in the third quarter," says CEO Mark Davidson. "This revenue is generated from our foundry services, which helps to offset our cash use while our products are being developed. We're focused on re-building our foundry services revenue to approximately \$300,000 per quarter

or better. Our opportunity pipeline for foundry services has recently increased to approximately the \$2m level," he adds.

"Odyssey completed important technology development milestones in Q2," notes Davidson. "The team has made substantive progress in fabricating vertical GaN power transistors for high-performance and high-power conversion in key applications such as industrial motors, electric vehicles, and renewable energy," he adds.

Technology development and business milestones accomplished recently include the following:

- Odyssey has now validated its approach to a vertical 1000+ volt transistor, while the firm is extending the architecture to the next milestone of a 1200V rating. The existing devices will provide what is claimed to be industry-leading effi-

ciency with low on-resistance at high switching frequencies for reduced solution size.

- Validated process for large-scale device fabrication.

- Secured commitments from three customers to evaluate Gen1 engineering product samples.

- Secured and received \$1.25m bridge loan financing, and completed filing of Form S-1.

- Positioning the firm to receive funding through the USA's CHIPS and Science Act Of 2022.

"Our 1000+ volt milestone further validates our approach to deliver industry-leading efficiency with remarkably high switching frequencies at lower price points than more expensive alternatives, including silicon carbide," says Davidson. "Odyssey is on-track to build Gen1 engineering product samples in Q4/2022."

Odyssey receives bridge loan from chairman

Funding to yield Gen1 engineering product samples in Q4/2022

Odyssey has received a \$1.25m bridge loan from John Edmunds, chairman of its board.

"This capital allows us to build Gen1 engineering product samples in fourth-quarter 2022," says CEO Mark Davidson. "Our 1000+ volt GaN power device milestone completed in second-quarter 2022 further validates our approach to deliver industry-leading efficiency with remarkably high switching frequencies at lower price points than more expensive alternatives, including silicon carbide," he adds.

"They have been working in earnest and making progress toward delivering revolutionary vertical GaN power transistors which could enable the company — now with Mark Davidson aboard — to capture meaningful opportunities

and achieve sustainable growth in the long term," comments Edmunds.

The firm anticipates that this \$1.25m convertible bridge loan will provide adequate cash for growth and working capital through the end of 2022. The note bears 10% interest per annum and is payable in kind at conversion or at maturity in one year. The note may be

convertible anytime at the holder's discretion into shares of common stock at a price equal to the average of the last 20 trading days' closing

Our 1000+ volt GaN power device milestone completed in second-quarter 2022 further validates our approach

price, or automatically converted upon the closing of a public offering of the common stock with aggregate proceeds of at least \$5m at a 15% discount to the per share public offering price. The note will not be and has not been registered under the Securities Act of 1933, as amended, and may not be offered or sold in the USA absent registration or an applicable exemption from registration requirements.

The \$1.25m bridge loan is part of a \$3.75m offering of convertible promissory notes approved by the board of directors. The firm has also recently filed a registration statement on Form S-1, paving the way for a potential future equity financing.

www.odysseysemi.com

GaN Systems and PowerSphyr co-developing 30W, 100W and 500W industrial and automotive wireless charging solutions

Enhanced customer service and support to accelerate time-to-market

GaN Systems Inc of Ottawa, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) and wireless energy technology developer PowerSphyr Inc of Danville, CA, USA are collaborating to deliver a portfolio of end-to-end wireless power solutions (30W, 100W and 500W) for industrial and automotive applications worldwide. Combined with new and enhanced levels of customer service and support, the new portfolio provides what is said to be an easy path to obtain the most compact, wireless power solutions with industry-leading performance and cost.

The development builds on a multi-year strategic partnership to develop GaN-based wireless power systems. The partnership combines PowerSphyr's years of power technology expertise and GaN Systems' gallium nitride semiconductors. For example, PowerSphyr is now implementing GaN Systems'

power semiconductors on the receiver of the wireless charging solution in addition to the transmitter. The combination delivers easy-to-use, high-performance and completely wireless charging solutions — the ongoing collaboration results in continuous innovation of hardware and firmware solutions that adhere to wireless charging standards.

"Our combined efforts will bring cutting-edge solutions, as well as comprehensive service and support, to our industrial and automotive clients," says PowerSphyr's CEO Will Wright. "GaN Systems and PowerSphyr are aligned around our strategic vision to pioneer new and advanced wireless charging solutions," he adds. "By partnering with GaN Systems, with their proven ability to rapidly deliver a comprehensive portfolio of best-in-class GaN power semiconductors, and PowerSphyr's expertise in wireless power system design, we will enter a new stage of wireless power."

GaN-based wireless power solutions enable higher device placement, spatial freedom, and more extensive air gaps between transmitter and receiver. GaN transistors are optimal for maximizing efficiency in applications from 30W up to several kilowatts — far more significant than what is possible with traditional silicon solutions.

"Our expertise in GaN power semiconductors, combined with PowerSphyr's proven portfolio of wireless power technologies, is changing the game in wireless power charging," reckons GaN Systems' CEO Jim Witham. "Today's announcement is pivotal as industrial and automotive customers can get high-performance wireless charging technologies powered by GaN and a full suite of service and support offerings. This will accelerate our customers' momentum, ease of use, and time-to-market."

www.PowerSphyr.com
www.gansystems.com

GaN Systems' transistors powering HARMAN's 100W 4-port USB InstantCharger

Samsung Electronics subsidiary's fast-charger allocates power according to which devices are plugged in

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) says that its GS-065-011-1-L power transistor is being used in Samsung Electronics subsidiary HARMAN's new InfinityLab InstantCharger 100W, 4 USB GaN charger.

Made from 90% recycled plastics, the charger features two USB-A ports plus two USB-C ports, safely charging up to four devices simul-



taneously (phones, tablets, laptops, speakers, headphones, gaming consoles, drones, cameras, power banks etc). Power Delivery 3.0 ensures fast charging, and the charger is smart enough to know how to allocate power, depending on which devices are plugged in.

"HARMAN's GaN-powered charger addresses the needs of today's consumer while putting sustainability front and center," comments GaN Systems' CEO Jim Witham. "The ability for GaN-based chargers to power multiple devices means that consumers need fewer chargers and can keep them longer," he adds. "This has significant sustainability implications when considering the more than 30,000 tons of landfills generated by discarded cell phone and laptop chargers each year."

HG places new shares and announces subscription of shares and warrants by GCL's founder

Hong Kong-based HG Semiconductor Ltd has announced placement of 30 million new shares at the placing price of HK\$3.20 per share to no less than six places. In addition, the group has entered into an investment agreement with Profit Act Ltd, an entity indirectly wholly owned by GCL Technology Holdings Ltd's founder, chairman & executive director Zhu Gongshan, pursuant to which the group had conditionally agreed to allot and issue, and the strategic investor had conditionally agreed to subscribe for 60 million subscription shares and 60 million warrants.

As at 5 August, the group has 563,591,000 shares in issue. Pursuant to the placing agreement, the placing shares represent about 5.32% of the existing issued share capital of the group. After deducting the placing commission and other relevant expenses, the maximum net proceeds will amount to about HK\$93.6m. The group intends to use about HK\$78m of the proceeds for strengthening its R&D capabilities of semiconductor business including light-emitting diode (LED), mini-LED, fast charging, gallium nitride (GaN) devices and related products, which includes set-up of R&D centres, recruitment of R&D professionals, and the procurement of equipment and materials with an aim to develop and/or capture patent and technology. The remains of the net proceeds will be used for provision of general working capital and improving the financial position of the group.

Regarding the investment agreement with strategic investor, the shares subscription price is HK\$3 per subscription share, while the subscription price of each warrant share upon exercise of the warrants will be HK\$3.68. After deduction of relevant costs and expenses, the gross and net proceeds from the shares subscription and full exercising of the subscription rights attaching to the warrants will be

about HK\$180m and HK\$220.8m, respectively.

The group proposes to use the proceeds from the shares subscription and warrants subscription for the development of GaN business.

The subscription shares and warrants shares cannot be sold or transferred for 18 months, commencing on the date of issuance. Meanwhile, the strategic investor will conduct due diligence examinations on the group regarding its business, financial, and legal aspects etc. If the results of the due diligence examinations are to the satisfaction of Zhu Gongshan, the strategic investor will participate in the shares subscription and the warrants subscription. The subscription shares and warrant shares will be allotted and issued under the shares specific mandate to be sought from the shareholders at an extraordinary general meeting (EGM).

Zhu is the founder, chairman & executive director of GCL Technology Holdings Ltd. He was a member of the 12th National Committee of the Chinese People's Political Consultative Conference (CPPCC) and is currently a member of the 12th Jiangsu Province Committee of the CPPCC, chairman of the Global Green Energy Industry Council, the vice chairman of Global Innovation Centre, chairman of the Asian Photovoltaic Industry Association, deputy director of the Green and Low Carbon Development Promotion Committee of the China Enterprise Confederation, executive VP of the Energy Storage and Electric Vehicle Branch of China Electricity Council. Over the years, Zhu has been deeply involved in the fields of electric power, photovoltaic, natural gas, new energy vehicle (NEV) operation and semiconductors. HG says that the investment agreement between the group and the strategic investor signifies the trust and support of Zhu Gongshan, giving the group a strong vote of confidence in further

solidifying the business strategies and development of GaN.

The new investors follow the personal investment in HG Semiconductor by Dr Justin Chiu, executive director of CK Asset Holdings Ltd. HG reckons that the shares subscription and warrants subscription represent an opportunity to raise additional capital for expanding its GaN business, expediting the group's development. In view of the steady development of new energy vehicles (coupled with global geopolitical risks and other factors), various countries fully support the development of the semiconductor industry (particularly third-generation semiconductors), so HG reckons that its GaN business has bright prospects. Leveraging the background of Zhu Gongshan as a strategic shareholder, the group expects

- further coordination of resources in the new energy industry with the strategic investor alongside strategic synergy with the group's third-generation semiconductors (especially power chips) to form complementary industrial resources;
- use of the strategic investor's financial resources and business network in the financial system to assist in the rapid development of production capacity and products;
- facilitating working closely with local governments to improve the policies and support for the third-generation semiconductor industry;
- that the strategic investor will share experience in operation and management to assist the group in building up its talent, operations, technology and R&D.

Looking ahead, HG will continue to proactively pursue technological innovation, refine its business strategies to capture market opportunities and accelerate growth in its GaN semiconductor business, striving to generate continuous and stable returns for its shareholders in the long run.

www.hg-semiconductor.com

Transphorm adds 50mΩ 650V SuperGaN FET in TO-263, extending SMDs to high-power applications

D2PAK simplifies and speeds development of GaN-based higher-power systems for data-center and broad industrial applications

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 expanded its surface-mount package offerings with the addition of the TP65H050G4BS. The latest higher-power surface-mount device (SMD) is a 650V SuperGaN FET in a TO-263 (D2PAK) offering a typical on-resistance of 50mΩ. It marks Transphorm's seventh SMD, adding to a wide range of currently available PQFN devices for lower-to mid-power applications.

The JEDEC-qualified TP65H050G4BS offers several advantages to designers and manufacturers developing high-power (single-to-multi-kilowatt) systems typically used in data-center and broad industrial applications. It delivers Transphorm's best-in-class

reliability, gate robustness ($\pm 20V_{max}$) and silicon noise immunity threshold (4V) along with the ease of design and drivability synonymous with its GaN technology. Engineers use the larger D2PAK where both higher power and surface-mount packaging is needed, enabling better thermal performance versus PQFN-type packages while increasing the efficiency of PCB assembly through the use of a single manufacturing flow.

Available as a discrete device, the D2PAK is also provided on a vertical daughter card to increase the power density of Transphorm's TDTP2500B066B-KIT — a 2.5kW AC-to-DC bridgeless totem-pole power-factor correction (PFC) evaluation board. The new device can also be swapped into the 1.2kW synchronous half-bridge TDHBG1200DC100-KIT evaluation board to drive multi-kilowatt power.

"The D2PAK is an important addition to our portfolio. It expands the usability of our SMDs to high-power applications, where before we supported these with through-hole devices," says Philip Zuk, senior VP of worldwide marketing, applications and business development. "It's another step in helping customers leverage our GaN platform's advantages with familiar TO-XXX packages that eliminate design challenges, simplify system development, and quicken go-to-market ramps."

Transphorm claims to be the only GaN supplier currently offering high-voltage GaN devices in standard TO-XXX packages. Notably, these packages cannot be used with alternative e-mode GaN technology, given its inherent gate sensitivity to damage.

The new device and evaluation boards are available from distributors Digi-Key and Mouser.

www.transphormusa.com

Shanghai-based Eta moving HQ to Tongling in September

17,000m² factory's capacity to exceed several thousand wafers per month

Eta Research of Shanghai, China is moving in September to its new headquarters in Tongling, Anhui Province, after beginning construction on the new factory in 2017.

Founded in 2015, the firm first offered 2" and 4" gallium nitride (GaN) wafers to customers in 2020 and is currently focused on the development and production of free-standing GaN wafers. The GaN wafer production process includes self-developed hydride vapor phase epitaxy (HVPE) growth equipment, wafer separation method, and GaN wafer polishing. The firm offers n-type GaN wafers for LEDs, laser diodes, and power devices. Semi-insulating GaN wafers are available for lateral GaN RF devices.



Housing the entire production process (including HVPE for GaN growth and polishing equipment for GaN wafers), the new 17,000m² Tongling factory will be the site for

both GaN wafer production and R&D. The fully built-out production capacity will exceed several thousand wafers per month.

www.eta-research.com

Transphorm's SuperGaN Gen IV technology powering Phihong's new 65W 2C1A USB PD adapter

High-reliability device for low-power applications simplifies power system development and reduces component count

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 — says that its GaN technology is powering the new 65W 2C1A USB PD adapter by Phihong, a global supplier of power products and electric vehicle (EV) charging stations. The adapters leverage Transphorm's SuperGaN Gen IV technology, a GaN FET platform that is said to offer benefits ranging from easy system design-in with lower system component count to higher performance with world-class reliability.

Capable of charging three devices simultaneously, Phihong's 65W adapter includes two USB-C ports and one USB-A port (2C1A) in a small form factor (51mm x 55.3mm x 29mm). The charger leverages a single 650V SuperGaN device, the TP65H300G4LSG, for an approximate 17% reduction in power loss over a silicon solution using a quasi-resonant flyback (QRF) topology. The adapter also offers USB PD and PPS functionality up to 65W.

The TP65H300G4LSG is a 240mΩ, JEDEC-qualified PQFN88 surface-

mount device with a ±18V gate safety margin. The FET is optimal for lower-power applications at 150W or below built on QRF, active-clamp flyback (ACF) or LLC resonant topologies.

Transphorm's TP65H300G4LSG offers silicon-like threshold levels and high gate breakdown voltage (±18V maximum). It can pair with off-the-shelf controllers (including those with integrated drivers) without the need for a negative-bias voltage. This simplifies the power system's design; eliminates the need for additional peripheral circuitry (thereby reducing component count), and increases overall system reliability — all key reasons behind Phihong's decision to use the Transphorm FET.

Facts and Factors recently released a report projecting that the global AC-to-DC adapter market will rise at a compound annual growth rate (CAGR) of 12.7% to \$1.854m by 2026. Transphorm also reported in May that its 240mΩ device is gaining traction, with it securing pre-production orders from ODMs for large Asia mobile phone (65W) and leading WW e-retailer (140W) projects. Additionally, the firm's increase in market share is being driven by another laptop

adapter design-win from a tier-1 Fortune 100 company, which includes an initial purchase order of 50,000 units of the SuperGaN 240mΩ FETs. These FETs provide higher efficiency for 65W fast-charging adapter applications versus competing e-mode GaN FETs that require a larger 150mΩ device for similar applications (so the SuperGaN FETs allow customers to do more with less).

"Our SuperGaN platform is built from the ground up with four key tenets in mind: reliability, designability, drivability and reproducibility. Our 240mΩ device is no exception," says Kenny Yim, Transphorm's VP of Asia Pacific sales. "We enable adapter manufacturers to design small, light and cool-running products that can offer the latest in advanced USB charging features. It is that type of innovation that is driving GaN adoption in the global adapter market, positioning us to strengthen our foothold in the market with a high-performing solution backed by high-volume production capabilities," he adds.

The TP65H300G4LSG is currently available through distributors Digi-Key and Mouser.

www.transphormusa.com/en/product/tp65h300g4lsg

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Agnitron installs Agilis 100 gallium oxide MOCVD system at Cornell University

Collaboration with AFRL–Cornell Center for Epitaxial Solutions to optimize MOCVD for Ga₂O₃

Agnitron Technology Inc of Chanhassen, MN, USA says that a Agilis 100 metal-organic chemical vapor deposition (MOCVD) system installed in the Duffield Hall laboratory of Dr Hari Nair, assistant research professor of materials science & engineering, at Cornell University began operation on 30 June.

The firm says that the Agilis 100 delivers what are claimed to be multiple, best-in-class capabilities that support R&D of oxide semiconductors. The system can reach substrate temperatures exceeding 1500°C (2700°F) and keep it within ±1.0°C, and it has the ability to grow epitaxial semiconductor layers at unmatched purities and rates.

Nair has partnered with Agnitron to customize a system to enable the exploration of ultrawide-bandgap semiconductor materials. Specifically calibrated to create thin films of gallium oxide (Ga₂O₃), the system has since demonstrated high-quality growth.

“A key advantage of gallium oxide is the ability to grow single crystals of this material from its molten form, which will be key for scaling up the substrate size,” Nair says.

“This capability to scaling up is very important for industry adoption of electronic devices made using new semiconductor materials,” he adds.

“With this system, we can grow thin films on up to 2-inch-diameter substrates under widely tunable oxidation chemical potentials,” says Nair. “It also has a very high substrate temperature capability and we can heat the substrate up to 1500°C. High substrate temperatures yield better quality films which is key for pushing the performance of electronic devices,” he adds.

“The wide bandgap offered by gallium oxide is great, but if you cannot grow this on large-area sub-



The reactor of Agnitron Agilis 100 MOCVD system can heat substrates up to 1500°C.

strates, then it’s a showstopper from a practical point of view,” Nair says. “There’s a big promise gallium oxide has to offer, but we’re not there yet.”

Nair’s partnership with Agnitron will continue. He plans to collaborate with researchers from the AFRL–Cornell Center for Epitaxial Solutions and elsewhere on campus to optimize MOCVD for gallium oxide, which would make the material more economically attractive to manufacturers looking for high-precision, high-volume production.

The materials developed at Duffield Hall will enable the next-generation technologies needed for high-power electronic systems, it is reckoned. Potential uses include electric vehicles, renewable energy solutions, and next-generation cellular communications.

“There is a need to make power electronics more compact and more efficient,” Nair says.

“One of the dreams is to take a power substation, which is about the size of a small house, and shrink it down to the size of a suitcase. Such innovations will be key for creating a smart power grid, and gallium oxide semiconductor-based power electronics is a stepping stone in making this possible.”

www.agnitron.com



Doctoral student Cameron Gorsak opens the reactor to an MOCVD system used to create thin films of gallium oxide.



Hari Nair, assistant research professor of materials science and engineering (left), and doctoral student Cameron Gorsak in front of an MOCVD system.



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UKRI awards National Epitaxy Facility £12m to support UK semiconductor R&D

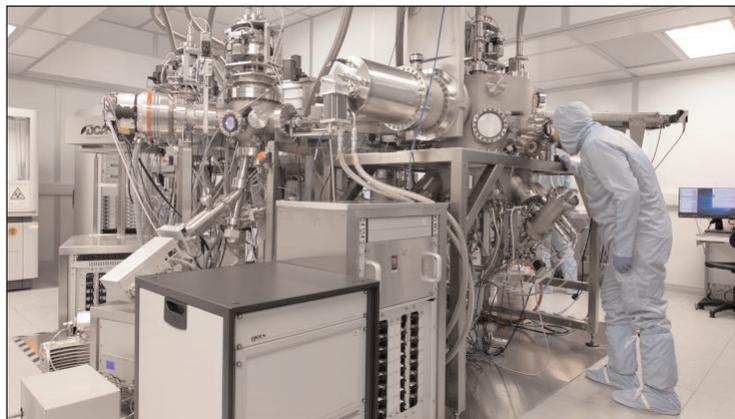
Collaboration between universities of Sheffield, Cambridge and UCL to be critical element of UK's strategy in semiconductors

The UK's National Epitaxy Facility, a collaboration between the Universities of Sheffield, Cambridge and University College London (UCL), has been awarded £12m in funding from UK Research and Innovation (UKRI) and will be a critical element of the UK's scientific and industrial strategy in semiconductor technologies.

Led by the University of Sheffield, the National Epitaxy Facility is built on more than 40 years semiconductor and epitaxy research in the Department of Electronic and Electrical Engineering. Its role is to deliver bespoke semiconductor wafers to research projects in universities and industry across the UK and to provide access to the expertise and resources needed to progress from basic discovery to mass manufacture for major economic/societal impact for the UK.

Since 2017, the facility has supported £122m of research in 25 universities. The new funding means that the facility can continue to support R&D in the UK for the next 5-10 years.

"UKRI has continued to fund and support the National Epitaxy Facility at this critical time for the UK to increase its technological innovation in semiconductors," notes National Epitaxy Facility director Jon Heffernan, professor in Electrical Engineering at the University of Sheffield. "Semiconductors have been the backbone of modern technological society for more than 60 years and the semiconductor industry has had an estimated overall economic value of around \$8tn. Practically every aspect of our modern world is dependent on semiconductor devices, from silicon microchips that control computers, mobile phones, aircraft and even washing machines, to the internet, electric vehicles and LED lighting



A molecular beam epitaxy system for quantum technologies — a key piece of equipment in the National Epitaxy Facility.

that has revolutionized global energy efficiency," he adds.

"The pace of innovation and the demand for more and more advanced technology means that semiconductors will continue to be one of the most important and critical technologies of the 21st century, including in emerging areas of great importance, such as quantum computing and artificial intelligence (AI)," continues Heffernan. "Both the economic and strategic value of semiconductors is being recognized by all technologically advanced countries. Here in the UK, semiconductor innovation is key to addressing areas of critical importance to our economy, such as net zero, electrification, telecommunications, healthcare, security and quantum technologies.

The National Epitaxy Facility we're leading from Sheffield will support the UK's research community in pioneering new types of semiconductor devices that will be the

The National Epitaxy Facility is built on more than 40 years semiconductor and epitaxy research in the Department of Electronic and Electrical Engineering

basis for future technologies."

The UK's electronics industry, of which semiconductors play a fundamental role, contributes £16bn annually to the country's economic output, employing 300,000 people in 12,000 companies. The

UK's photonics industry, which also relies on semiconductors, has a £13bn annual economic output, employing 69,000 people across 1500 companies. The global market for compound semiconductor components is expected to reach \$43bn by 2025.

The UK has a strong industrial base in semiconductor manufacturing with leading companies such as IQE, Lumentum, Plessey and II-VI all manufacturing semiconductor-based products for global markets.

"Cambridge will have the opportunity to continue to support the UK semiconductor community via the National Epitaxy Facility," comments professor Rachel Oliver, who leads the University of Cambridge's work in the facility. "The UK semiconductor ecosystem is extraordinarily innovative, on both the industrial and academic sides, and is underpinned by the availability of state-of-the-art epitaxial materials," she adds. "Through the new facility, such materials will be at the heart of future collaborations between world-class researchers, driving real-world economic and societal impact."

www.nationalepitaxyfacility.co.uk
www.sheffield.ac.uk

North East Advanced Material Electronics cluster launched in UK

North East England region promoted as centre of excellence for compound semiconductor technology expertise

The North East Advanced Material Electronics (NEAME) cluster group has been formally launched, with a mission to highlight and promote the region as a centre of excellence for advanced compound semiconductor technology design and manufacture.

NEAME is a cluster led by CEOs and other senior decision makers in the North East electronics industry, with the intention of providing a central voice both to raise the profile of the region and to help its members to address their main challenges and opportunities profitably.

The sector makes a significant contribution to the regional economy and is projected to contribute £447m gross value-added by 2026, with the potential to create and support around 4500 jobs.

International factors mean that all companies in the sector face significant supply chain challenges. Led by chief executives and other senior decision makers, NEAME will act as a single voice to raise the profile of the region's competencies and address the main challenges and opportunities for advanced material electronics.

Since electronic components based on compound semiconductor materials (like gallium nitride) can outperform silicon devices in speed, size and energy efficiency, they can power transformational applications including electric and autonomous vehicles, satellite and 5G/6G communications, energy decarbonization, IoT (Internet of Things) sensors and computer imaging technologies, it is noted.

"NEAME is an opportunity to showcase this region's strength within advanced material electronics," says Richard Gibbs, CEO of Filtronic.



"The North East of England is a powerhouse for innovation and quality in advanced material electronics," reckons Ken Williamson, chief operating officer of Pragmatic. "At Pragmatic we have demonstrated our commitment with our investment in PragmatIC Park; we believe this represents the future of UK semiconductor manufacturing"

High-tech companies within a 25-mile radius of Sedgefield include Kromek — the world's largest cadmium zinc telluride (CZT) facility — at NETPark, where it is developing and manufacturing radiation detection devices. Filtronic (which, like Kromek, is a recent winner of a UK Queens Award for Enterprise – International Trade) designs and manufactures high-frequency electronic modules that connect telecommunications systems in space and for terrestrial 5G mobile networks.

In addition, after last year raising \$90m in its Series C funding round, PragmatIC is the first large-scale semiconductor manufacturing facility to be announced in the UK

for several decades and will house the first 300mm fab in the country. Evince Technology is developing an innovative process to manufacture electronic devices on synthetic diamond substrates.

"The North East continues to pioneer and develop

new technologies that can have a huge impact on a global scale," stated Paul Howell, MP for Sedgefield, who officially launched NEAME. "The formation of the NEAME highlights the strength of the region's growing advanced material electronics sector and presents an opportunity to develop the skills and the jobs of the future, establishing the North East as a global hub for this technology," he added.

"NMI are delighted to be continuing our support of the UK semiconductor industry by hosting the announcement of the NEAME during our annual conference," commented Jillian Hughes, director of the National Microelectronics Institute (the industry trade body for electronic systems in the UK & Ireland), who hosted the launch. "During the last 25 years we have supported the semiconductor design, manufacturing and supplier communities adding value through collaboration, networking and knowledge sharing."

www.neame.org.uk
<https://nmi.org.uk>

AXT's Q2 revenue up 17% year-on-year

InP supply constraints to continue into 2023 despite doubling capacity

For second-quarter 2022, AXT Inc of Fremont, CA, USA — which manufactures gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials at its plants in China — has reported revenue of \$39.5m, down slightly on \$39.7m last quarter but up 17% on \$33.7m a year ago. Also, this was despite COVID playing a role in the last week or two of the quarter, thwarting about \$1.5m of deliveries.

Of total revenue, the proportion from the Asia Pacific region was 74%, Europe was 13%, and North America was 13%. The top five customers generated about 35% of total revenue (up from 29% last quarter), with just one over 10%. "We continue to believe that revenue diversity demonstrates our growth is not overly dependent on any particular customer or application," says CEO Dr Morris Young. "This is another factor contributing to our confidence that we have reached a point of sustainability and can outpace market growth in 2022."

Total substrate revenue was \$31.7m, level with last quarter but up 27.3% on \$24.9m a year ago.

By product category, germanium substrate revenue was \$3.9m, down on \$4.2m last quarter (following two of AXT's highest ever revenue quarters for germanium in Q4/2021 and Q1/2022). "The satellite solar cell market, which is the primary driver for germanium, tends to be lumpy," notes Young.

GaAs revenue was \$12.2m, up slightly on \$12m last quarter (and the highest since Q3/2012). "Our traditional high-end LED market demand remains strong in applications such as automotive display and high-end signage and lighting. We also continue to see strength in high-power industrial laser applications where we have gained significant market share," says Young. "Wi-Fi applications for IoT also helped to drive a modest increase in revenue over the prior quarter."

InP revenue was again a record \$15.7m, up on \$15.5m last quarter. This "puts us well on track to achieve indium phosphide revenue growth of 30% or more this year," says Young. "Demand for our product for 5G telecommunications, data-center and LiDAR applications continue to grow, overcoming a downstate in the PONs [passive optical networks] market in Q2. We also saw healthy growth in our new customer applications with its continued ramp in Q2," says Young.

Revenue was \$7.8m from AXT's two consolidated raw material joint venture companies BoYu (which makes high-temperature pyrolytic boron nitride crucibles and pBN-based tools for organic light-emitting diodes) and JinMei (which supplies high-purity materials including gallium and germanium, as well as InP poly and other materials). This is down on \$8.8m a year ago but roughly level with \$7.9m in Q1/2022, after very strong growth throughout 2021.

"We continue to achieve strong growth in highly strategic applications and are currently ramping several tier-1 customers," says Young.

"This strong execution has driven first-half revenue growth of 22% over the previous year and continues to enable us to outperform our market, with emerging opportunities that will layer on over the coming quarters," Young adds.

On a non-GAAP basis, gross margin was a better-than-expected 39.4%, up from 33.8% last quarter and 36.4% a year ago.

"While there were many factors that contributed, improved yields (partic-

ularly in crystal growth) was one of the most significant ones," notes chief financial officer Gary Fischer. "Morris conducted regular meetings on yields during his four months in Beijing [at AXT's manufacturing facilities, from which he returned recently] and part of our margin improvement has come as a result of this focus."

Both BoYu and JinMei improved their gross margins. "The contribution from the equity-method raw material companies is higher than usual and reflects higher average selling prices (ASPs) for the raw materials and more units sold," says Fischer. "A third factor is that we developed a process technology that enables us to recycle remnants of indium phosphide processing material. In addition to the gross margin benefit, this program is another step forward for us in our ESG [environmental, social and governance] commitment," he adds. "A fourth factor is product mix - by comparison to the first quarter, the mix looks pretty similar. However within each substrate product, the diameter mix can impact gross margin. So product mix was more favorable in Q2."

Operating expenses were \$9.1m, up from \$8.6m last quarter and \$7.4m a year ago.

Net income was \$6.7m (\$0.16 per share, exceeding the expected \$0.08–0.10), up from \$4.3m (\$0.10 per share) last quarter and \$5.4m (\$0.12 per share) a year ago.

Depreciation and amortization was \$2m. Capital investments were \$16.8m, of which about \$14.8m was facilities construction (mostly related to adding equipment to expand InP growth capacity).

During the quarter, cash, cash equivalents and investments rose by \$12.9m, from \$44.3m to \$57.2m. However, excluding a \$13.8m bank loan received in China, cash reserves are basically unchanged.

Net inventory rose further, by \$8.5m from \$68.8m to \$77.3m, despite

Demand for our product for 5G telecoms, data-center and LiDAR applications continue to grow, overcoming a downstate in the PONs market in Q2

the current supply-constrained environment, as AXT bought ahead in preparation for when demand accelerates. However, 50% of the inventory is raw materials and work-in-progress (WiP) is 46%. Finished goods actually declined to only 4% of inventory.

"Our strong execution on a number of fronts has set the stage for great opportunities in the coming quarters," believes Young.

For Q3/2022, AXT expects revenue of \$39–41m, with continued strong gross margin and net income of \$0.15–0.17.

Germanium revenue is expected to fall further to \$2–1.9m, as a result of a customer-specific payment issue that is expected to be resolved before the end of 2022. "Demand is still there. It's been improving in the last couple of quarters. It's all tied to satellites," says Fischer. "Industry forecasts for new satellite launches show continued strength," adds Young.

"Demand across our portfolio continues to be strong and we are working hard to keep up with customer orders. In particular, we're expecting indium phosphide to have healthy growth in Q3, with multiple tier-1 customers and the breadth of applications driving this, including data-center, telecom, consumer, driverless cars and others," says Fischer.

"This year, we doubled our indium phosphide capacity, demonstrating our unique ability to scale quickly and cost effectively to meet customer demand," says Young. "Even with the additional capacity, we expect that there will continue

to be supply constraints into next year. We continue to work closely with our customers to meet their requirements," he adds.

"We are now qualifying into a second consumer application for which we delivered pre-production quantities of indium phosphide wafers in May and June. AXT answered the call on a very tough product specification, surpassing the best efforts of our competition," says Young.

"We are now in a position to build meaningful revenue in a brand-new market for AXT and we are also engaging with other tier-1 customers for opportunities that were previously not available to us."

"We are achieving notable success in the development of larger-diameter substrates that we believe will enable the next generation of technology innovation across a number of end-markets," says Young. "We have achieved an important milestone in the development of 6-inch InP. We are now producing and beginning to sell prime device-quality wafers of 6-inch InP," he adds.

"The material quality of our large-diameter substrates demonstrate our commitment to excellence and the differentiation of our VGF [vertical gradient freeze] crystal growth process. We're pleased to be able to offer our customers meaningful advantages in scalability, low stress and low defect rates as new high-volume application comes to market."

Gallium arsenide for lasers and LEDs is also growing well. "In RF devices, demand is expected to come down a bit in Q3 but we continue to focus on strengthening

our position for future opportunities. We made good use of the tighter environment to renew our relationship with key customers and believe we have laid important groundwork for future market share growth," says Young. "Our new manufacturing facility, coupled with our achievement of several tier-1 customers, have demonstrated our ability to support customers in this space with high-volume, high-quality substrates," he adds.

"On our 8-inch gallium arsenide development program, we now have two major customers for this product and we are working with them on design specifications, giving us increasing confidence that there is a real market developing for large diameter in gallium arsenide," says Young. "We believe that 8-inch substrate will be an important enabler for new high-volume applications over the next several years," he adds.

Revenue from the two consolidated joint ventures should remain solid in Q3. "In particular, JinMei has been contributing well. It has continued to diversify its product offering beyond high-purity gallium," says Young. "Since relocating to our Kazuo location, JinMei has more capacity and state-of-the-art facilities. Today, it also offers purified indium and indium phosphide poly for sale. In addition, JinMei successfully developed the gallium recycling program, which is helping us drive the efficiency in our cost structure. Both indium and BoYu have a strong R&D culture that is contributing to innovation to new offerings that enhance their value."

www.axt.com

Update on STAR Market listing of subsidiary Tongmei

In late December, AXT's China-based wafer manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd submitted its application to list its shares in an initial public offering on the Sci-Tech innovation board (STAR Market) of the Shanghai Stock Exchange (SSE). On 10 January, the SSE formally

accepted the application for review. Subsequently, Tongmei responded to several rounds of questions received from the SSE. On 12 July, the SSE approved the listing.

The IPO remains subject to review and approval by the China Securities Regulatory Commission (CSRC) and other authorities. AXT

notes that the process of going public on the STAR Market includes several periods of review and is therefore a lengthy process. Subject to review and approval by the CSRC and other authorities, Tongmei expects to accomplish this goal in second-half 2022, probably in Q4/2022.

IQE expects revenue growth of 7% for first-half 2022 Full-year growth to be weighted towards second-half 2022

In an unaudited pre-close update for first-half 2022, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that trading was in line with management expectations. Revenue is expected to be at least £85m (>7% growth) on a reported basis. With a foreign exchange tailwind, this is in line with £79.5m a year ago on a constant-currency basis.

"I am pleased we have met our expectations and commitments for first-half 2022," says CEO Americo Lemos. IQE will report full (unaudited) interim results on 6 September.

The firm's view of the full year remains unchanged with previously issued guidance of low-single-digit % revenue growth in 2022 (at constant currency), with growth weighted towards second-half 2022.

IQE says it is focussing on executing the strategy of pursuing long-term sustained growth through diversification and value creation. Milestones achieved in first-half 2022 include the signing of a multi-year supply agreement with Lumentum, a strategic partnership agreement with Porotech, the announcement of the world's first

commercially available 200mm VCSEL, and a commitment to Net Zero and Carbon Neutrality. Further milestones are anticipated for second-half 2022 as the business is positioned for growth.

"This year is about laying foundations for the healthy growth of the business, with a focus on a market approach while developing relationships with strategic customers to deliver long-term growth and value to shareholders," says Lemos. "We look forward to continuing with this momentum throughout the rest of the year."

www.iqep.com

IQE sues Tower over porous silicon technology Epi foundry alleges misappropriation of trade secrets

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has filed a lawsuit against specialty analog foundry Tower Semiconductor Ltd of Migdal Haemek, Israel.

IQE claims that it has significant evidence that Tower misappropriated IQE's trade secrets to unlawfully obtain patents on IQE's technology. These claims relate to IQE's proprietary porous silicon technology, underpinning devices used in 5G and advanced sensing applications.

IQE filed its complaint in the US Federal Court in California (case number 8:22-cv-00867) under Federal and California state law in relation to the misappropriation of trade secrets, correction of inventorship, breach of contract, unfair competition, and intentional interference with prospective economic advantage.

"We have significant reason to believe that Tower has misappropriated IQE's proprietary trade

secrets for its own benefit," says IQE's general counsel & company secretary Tom Dale. "Our technology, processes and intellectual property are vital in underpinning IQE's products and solutions and in maintaining our market-leading position in advanced semiconductor materials," he adds. "We will vigorously protect them and will provide further updates as material developments occur."

www.towersemi.com

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Cardiff University-based Translational Research Hub opens for business

Innovation hub TRH includes Institute for Compound Semiconductors, aiming to foster collaboration between industry and academia

The Translational Research Hub (TRH) — home to the Institute for Compound Semiconductors (ICS) and Cardiff Catalysis Institute (CCI) — is now open for business, with the aim of fostering collaboration.

Funded by UK and Welsh governments, TRH brings together industrial partners alongside researchers to design, develop and test new cleaner, greener products and processes using its bespoke laboratories, offices, shared collaborative spaces, bespoke European Regional Development Fund (ERDF)-funded cleanroom and microscopy suite.

The 129,000ft² research hub is the largest of its kind in Wales and exemplifies UK and Wales commitments to new collaborative scientific solutions to Net Zero.

TRH has been supported by UK and Wales funders, including £17.3m through UK Research Partnership Investment Fund (UKRPIF), £12m from Welsh Government, £13.1m in European funding administered by the Welsh European Funding Office (WEFO), and £2.7m from the Higher Education Funding Council for Wales (HEFCW).

"South Wales is home to the world's first compound semiconductor cluster based on the prowess and prestige of Cardiff's chemical science research," notes Science & Innovation Minister George Freeman. "This Translational Research Hub will bring together business and academia to help generate new technological solutions to tackle some of the world's greatest challenges, from healthcare to energy... The government's investment will help drive forward our Net Zero ambitions while boosting our efforts to establish the UK as a science and technology superpower," he adds.

"The significant investment we've made in the center will help bring some of the most brilliant minds in



Welsh academia together to find and develop made-in-Wales solutions to the major problems facing Wales and the rest of the world," says Wales Economy Minister Vaughan Gething. "Developing 'next generation' practices and technologies that will both shape our lives today and improve our experiences tomorrow will be crucial if we are to meet the climate emergency head on and build a greener, more sustainable economy."

The TRH forms part of Cardiff University's biggest campus upgrade for a generation — a £600m investment that includes sbarc|spark, the Centre for Student Life and the Abacws building.

"TRH is a magnet for innovation. Built with industry to support cutting-edge research and to strengthen the university's interaction with industry, it will support the UK and Wales economy by building partnerships that create new products and processes," says professor Rudolf Allemann, pro vice-chancellor, International and Student Recruitment and head of the College of Physical Sciences and Engineering. "Cardiff's leading researchers will use these fantastic bespoke facilities to work with partners across exciting sectors including energy, advanced materials, transport, communication and healthcare, creating pioneering

new technologies, charting innovative research directions that lead to future funding proposals," he adds.

"As a founder member of the CSconnected cluster in South Wales, we play a pivotal role in developing new energy-effi-

cient technology and effective techniques for the mass production of compound semiconductors," states professor Peter Smowton, director, Institute for Compound Semiconductors (ICS). "CS technologies are at the heart of green transport — electric vehicles, energy-efficient communications and so-called 'smart' technologies," he adds.

Two new buildings sit alongside the TRH to help industry turn ideas into transformative industrial applications. A first-in-class ICS ERDF-funded cleanroom features the capability to trial, establish and scale new and innovative compound semiconductor devices to an industrial standard on wafers up to 200mm in diameter. Also, CCI's bespoke Electron Microscopy Facility will deliver expertise and capability in nanomaterial imaging, analysis and characterization, facilitating new approaches to catalyst design and synthesis.

TRH sits next door to Cardiff's newly opened sbarc|spark building, home to the Social Science Research Park (SPARK) and Cardiff Innovations@sbarc|spark — the University's creative base for spinouts and startups.

www.cardiff.ac.uk/campus-developments/projects/translational-research-hub
<http://csconnected.com>

LPE and A*STAR's IME to develop high-quality 200mm SiC and specialty epitaxy processes

Aim is to enhance growth rate and uniformities, and reduce killer defect densities

LPE SpA of Milan, Italy, which designs and makes epitaxial reactors for power electronics applications, and the Institute of Microelectronics (IME) at the Agency for Science, Technology and Research (A*STAR) have announced a research collaboration to develop high-quality 200mm silicon carbide (SiC) and specialty epitaxy processes including enhanced growth rates with improved uniformity. This will be done through experimental activities supported by simulation studies.

The parties will leverage LPE's knowledge in SiC chemical vapor deposition (CVD) reactor technology and SiC epitaxial growth, plus IME's research capabilities and facilities, 200mm SiC pilot process integration line, and material characterization equipment. The aim is to create 200mm epitaxy processes with enhanced growth rate and uniformities, and reduced killer defect densities.

The 200mm SiC pilot line is being established by A*STAR's IME to validate 200mm manufacturing processes and tools on a pilot scale



before transitioning to 200mm high-volume manufacturing. This collaboration will be part of IME's plans for establishing a 200mm SiC innovation program.

SiC epitaxy is one of the essential process steps for 200mm device processing of the upcoming 200mm SiC pilot line. The manufacturing industry is projected to move towards using a unique single-wafer chamber SiC epitaxy tool. LPE, which contributes its tools into the innovation program, is geared towards quicker industrial adoption.

For this collaboration, both parties will work on the development of high-quality 200mm SiC and specialty epitaxy processes, includ-

ing the following areas:

- validation of the LPE PE108 SiC epitaxy reactor for 150mm/200mm wafers;
- enhancement of 200mm SiC epilayer uniformity;
- development of 200mm SiC epitaxy processes with increased growth rates;
- development of specialty SiC epitaxy processes on 200mm SiC wafers.

The collaboration will result in "extraordinary market expansion of 200mm SiC-based devices, believes LPE's CEO Franco Preti. "As SiC power modules become pervasive, a more efficient use of electrical power will make a sustainable growth possible," he adds.

"The success of this collaboration will benefit the SiC manufacturing ecosystem and accelerate the adoption of high-performance SiC power modules across various applications such as electric vehicles and charging points," says IME's executive director Terence Gan.

www.a-star.edu.sg/ime/Research/power-electronics
www.lpe-epi.com

5N Plus adds chief commercial officer role

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Canada has appointed Roland Dubois to the newly created position of chief commercial officer, leading the firm's commercial excellence program and go-to-market strategy with a segmented approach to commercial partnering.

The new role is "highly strategic for the company at this stage of our growth," says CEO Gervais Jacques. "Bringing deep commercial expertise, relevant industry experience and a proven track record of success,

Roland is the ideal candidate to lead our commercial activities. He will not only ensure the continued execution of our commercial excellence program but will also be able to bring our go-to-market strategies for our value-added products to the next level in support of our growth objectives," he adds.

Dubois has over 30 years of experience in B2B sales, marketing, commercial and strategy. He has implemented go-to market strategies on multiple continents in the metals, engineering plastics and electricity industries.

Dubois joins 5N Plus from ABB where for the last three years he was VP, group head of sustainability, based in Zurich, Switzerland. Prior to that, he spent 16 years with Rio Tinto, in leadership roles including sales & marketing product director, general manager of strategic marketing & development, and general manager of global strategy, overseeing group commercial excellence.

Dubois is a graduate of Grenoble École de Management, in addition to having completed an Executive MBA from HEC Paris.

www.5nplus.com

Aixtron to ship CCS MOCVD system to University of Texas at Austin for gallium oxide power devices

Microelectronics Research Center to develop Ga₂O₃ and GaN-based epilayers for photodiodes and power switches

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany is to ship a new Close Coupled Showerhead (CCS) metal-organic chemical vapor deposition (MOCVD) system to The University of Texas at Austin, Microelectronics Research Center (MRC), Department of Electrical and Computer Engineering.

The MOCVD deposition tool is specially configured to provide dual material capability, namely gallium oxide (Ga₂O₃) as well as gallium nitride (GaN)-based materials. Both materials qualify as wide- and ultrawide-bandgap materials – gallium oxide and its alloys can operate at higher voltages, frequencies and temperatures than incumbent semiconductor materials – opening up new applications in the areas of photodiodes and

power switches.

“We had great experience with Aixtron CCS reactors in the past for GaAs and InP materials. We look forward to partner with Aixtron as we develop novel epitaxy layers and devices using this flexible system for dual materials, Ga₂O₃ and GaN,” says professor Xiuling Li, Endowed Professor in the Department of Electrical and Computer Engineering at The University of Texas at Austin, and also an IEEE fellow. “This unique MOCVD reactor for growing gallium oxide and III-nitrides will put The University of Texas at the forefront of research in this area,” believes MRC director professor Sanjay Banerjee.

The MOCVD system can easily be switched from gallium oxide to gallium nitride modes, enabling

safe, flawless operation of the system, says Aixtron. At the heart of the MOCVD tool is a triple-plenum showerhead, allowing the oxidizing materials to be kept completely separate from the metal-organic and gas precursors until injection into the process chamber. The system assures a high degree of thermal uniformity through the ARGUS full temperature mapping across the susceptor, and it is sized for high-end R&D – in academic institutions as well as in innovative private enterprises, the firm adds.

“Our CCS MOCVD tools have an excellent track record supporting academic work and scaling later to tier-1 industrial players,” says Aixtron’s CEO & president Dr Felix Grawert.

www.mrc.utexas.edu
www.aixtron.com

Unitemp supplies ESPEC fast-rate environmental test chamber to Warwick University

Power Electronics Applications and Technology in Energy Research team commissions chamber for R&D on wide-bandgap semiconductors

Led by professor Phil Mawby, the Power Electronics Applications and Technology in Energy Research (PEATER) team in the School of Engineering at the UK’s Warwick University has installed and commissioned a new ARS060680 fast rate environmental test chamber of Japan-based ESPEC, supplied by specialist environmental engineering company Unitemp Ltd.

As part of a suite of equipment funded through Driving the Electric Revolution (DER) as part of its main centers of expertise initiative, the new chamber will support research and development on wide-bandgap semiconductor technologies in power electronics machines and

drives (PEMD). This tranche of equipment augments a well-established cleanroom for die processing as well as an epitaxy capability for silicon carbide (SiC).

The new ARS 060680 ultra-fast-rate environmental stress chamber has a temperature and humidity range of +10°C to +95°C/10% to 98%rh with a refresh rate of 15K/min. It will be used to stress the semiconductors and invertors specifically for automotive applications.

“We wanted a chamber that provided us with maximum flexibility, allowing us to undertake a multitude of tests including high- and low-temperature storage,

thermal cycling and temperature and humidity stress testing,” says Mawby.

The emphasis at PEATER is to develop a facility for reliability and testing of assembled power devices, modules and assemblies. Industry already has access to these facilities and PEATER is providing both the expertise and facilities to evaluate new ideas, assemblies and integrations for use in the fast-growing automotive sector.

www.warwick.ac.uk/fac/sci/eng/research/grouplist/electricalpower/peater
www.unitemp.co.uk
www.espec.co.jp

Aixtron's Q2 revenue up 51% year-on-year, driven by demand from SiC and GaN power electronics

Highest order intake since 2011 includes first volume production order for micro-LEDs

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported 63% growth in revenue (equipment & after-sales), from €117.2m in first-half 2021 to €191.1m in first-half 2022.

Of total revenue, 78% came from equipment sales (€148.6m, up 62% on €91.6m in first-half 2021), while 22% came from after-sales service & spare parts (€42.4m, up 65% on €25.7m in first-half 2021).

Second-quarter 2022 revenue was €102.5m, up 16% on \$88.6m in Q1/2022 and up 51% on €67.7m in Q2/2021.

Of the equipment revenue, metal-organic chemical vapor deposition (MOCVD)/chemical vapor deposition (CVD) equipment for making gallium nitride (GaN)- and silicon carbide (SiC)-based power electronics devices comprised 29% (with SiC growing strongly); MOCVD equipment for making optoelectronics devices (telecoms/datacoms and 3D sensing

lasers for consumer electronics, solar, and wireless/RF communications) comprised 24% (with optical data transmission and 5G applications growing strongly); and MOCVD equipment for making LEDs comprised 43% (mainly traditional red LEDs, but also micro-LED applications).

On a regional basis for first-half 2022 revenue, 70% came from Asia (up from 62% in first-half 2021), 16% from Europe (down from 32%) and 14% from the Americas (up from just 6%).

Net profit more than doubles year-on-year

First-half 2022 gross margin was level year-on-year at 39%. However, Q2/2022 gross margin of 37% is down from Q2/2021's 41%, driven by a comparatively low-margin product mix (from the delivery of equipment for producing traditional red LEDs) as well as one-off costs incurred from projects to optimize production and supply chain processes.

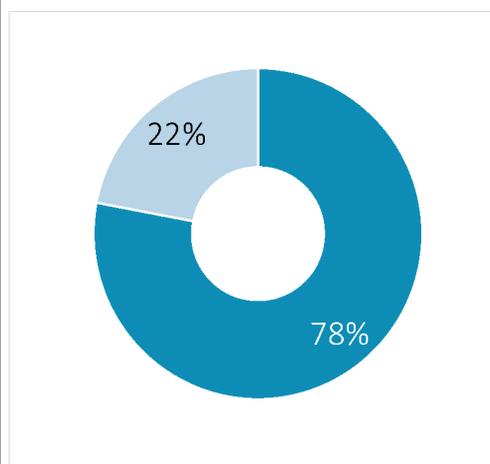
Operating expenses rose from €40.2m in first-half 2021 to €42.3m in first-half 2022, due to increased R&D expenses and higher variable-compensation components. However, quarterly operating expenses have been cut from €21.7m in Q1/2022 to €20.6m in Q2/2022, due to €1.1m lower R&D expenses.

The operating result (EBIT, earnings before interest and taxes) increased year-on-year from €4.9m (EBIT margin of 4%) in first-half 2021 to €31.4m (16% margin) in first-half 2022. Quarterly EBIT has more than tripled year-on-year from €5.6m (8% margin) in Q2/2021 and €14.2m (16% margin) in Q1/2022 to €17.2m (17% margin) in Q2/2022.

Net profit rose from €11.5m in first-half 2021 (10% of revenue) to €31.1m (16% of revenue) in first-half 2022. Quarterly net profit has more than doubled, from €7.7m (11% of revenue) in Q2/2021 then €13.8m (16% of revenue) in

H1/2022:

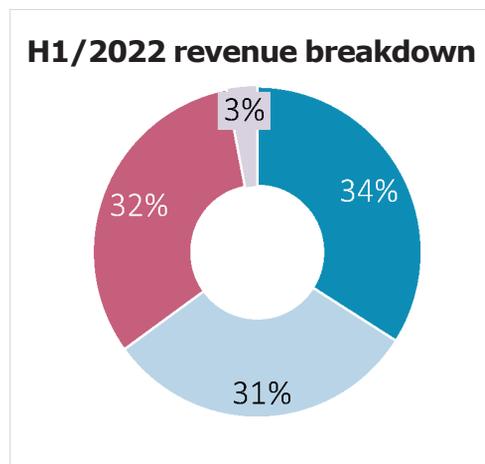
by equipment & after sales



■ Equipment ■ After Sales

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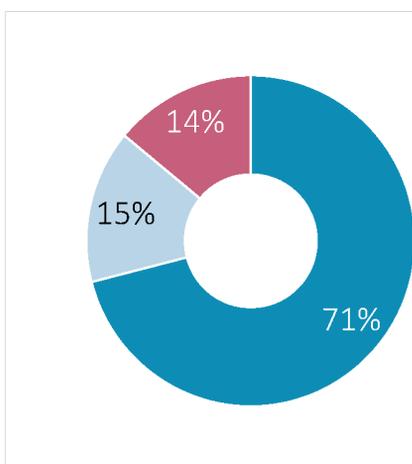
by end application (equipment only)



■ LED incl. Micro LED
 ■ Power Electronics
 ■ Optoelectronics & Communications2
 ■ Other incl. R&D

H1/2022:

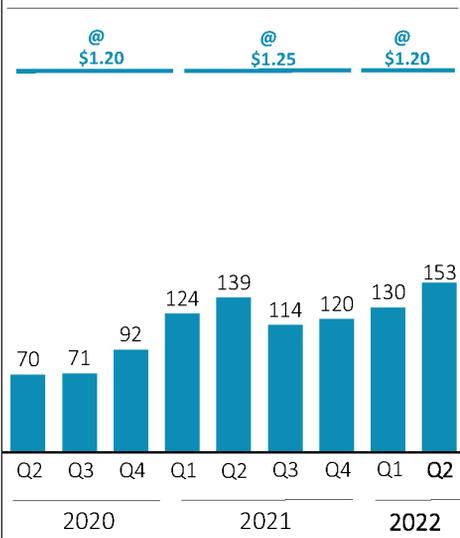
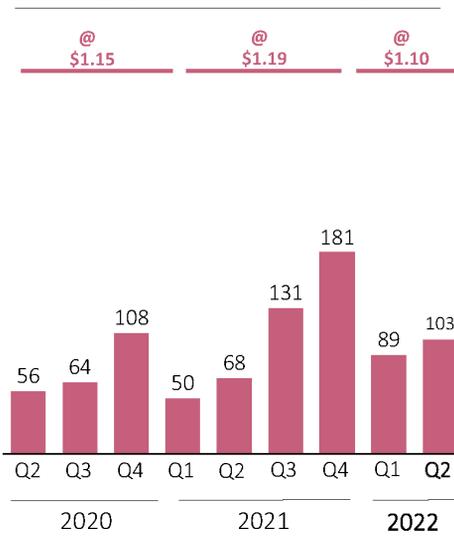
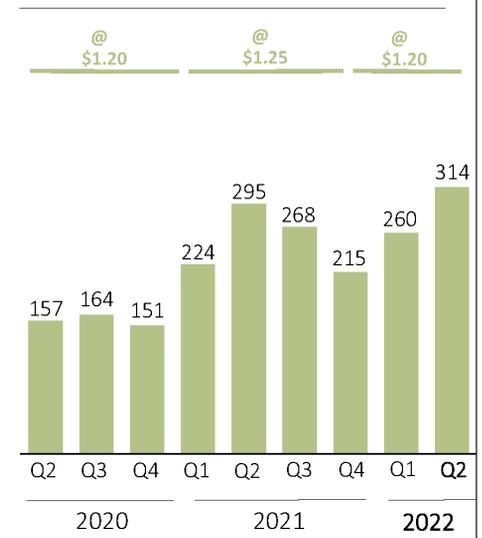
by region



■ Asia ■ Europe ■ Americas

1 Rounded figures; may not add up

2 Includes applications in Consumer Optoelectronics, Solar and Telecom/Datacom

Order Intake(incl. equipment & after sales)¹**Revenues**(incl. equipment & after sales)²**Order Backlog**(equipment only)¹

Q1/2022) to €17.3m (17% of revenue) in Q2/2022.

Inventories boosted to prepare for higher business volume

Despite quarterly operating cash flow of -€27.6m in Q2/2022, first-half 2022 operating cash flow was €35.4m.

Capital expenditure (CapEx) was €8.9m in first-half 2022, including €4.2m in Q2/2022.

Free cash flow was hence €26.4m in first-half 2022 (almost halving from €46.1m in first-half 2021) — including just €4m in Q2/2022 — as the increase in advance payments received for customer orders was outweighed by the corresponding increase in inventories (from €120.6m to €161.6m during first-half 2022) in preparation for the higher business volume in the coming quarters.

At the annual general meeting (AGM) of shareholders on 25 May Aixtron proposed a dividend payment of €0.30 per share (up from €0.11 per share in 2021), totalling €33.7m (a payout ratio of 35% of the firm's net income).

Cash and cash equivalents including financial assets hence fell from €352.5m at end-December 2021 to €346.2m at end-June.

Aixtron says that its financial strength is underlined by its high equity ratio of 78% at the end of June (up from 73% at end-June 2021). Meanwhile, staffing has

risen by 8% from 718 to 772. So, structural strengthening of the organization for further growth is reckoned to be well on track.

"We were able to grow as planned despite the challenging market environment with supply chains remaining constrained," says chief financial officer Dr Christian Danningner. "In addition, we are driving process improvements along the entire organization in order to prepare Aixtron SE for the expected future growth."

Highest quarterly order intake since Q2/2011

Order intake (including equipment and after-sales) has grown by 7% year-on-year from €263.3m in first-half 2021 to €282.8m in first-half 2022.

In particular, Q2/2022 order intake was €152.6m, up 17.2% on even last quarter's strong €130.2m and up 10% on €139m a year ago (and Aixtron's highest quarterly order intake since Q2/2011).

"Many years of research work are now paying off," says Aixtron's CEO Dr Felix Grawert. "This quarter marks another milestone as we are not only showing continued strong growth on a broad basis in our addressed markets [particularly SiC- and GaN-based power electronics], but especially with the first order for our equipment for the volume production of micro-LEDs," he adds.

Equipment order backlog at the end of June was €314.4m, up 20.7% on €260.4m at the end of March. Most of the order backlog is due for delivery in 2022.

Full-year 2022 growth guidance confirmed

Based on a budget rate of \$1.20/€ (versus \$1.25/€ in 2021), due to the good business development in first-half 2022 and in view of the expectation of a positive development of demand for the remainder of 2022, Aixtron expects double-digit growth in full-year order intake to €520–580m for 2022.

Based on the first-half 2022 revenue of €191.1m plus a forecasted €40m in after-sales revenue, joined by equipment order backlog of €150m (as of end-June) plus a forecasted €70–120m in new order intake (convertible into revenue during 2022), Aixtron still expects double-digit growth in full-year revenue to €450–500m in 2022.

Full-year gross margin should be about 41% and EBIT margin should be 21–23% for 2022 (again reiterating the guidance given in February).

"Overall, the current global crisis situations and market developments continue to only have a minor impact on our business," notes Aixtron. "Logistics and supply chains are still challenging, but in our view continue to be manageable."

www.aixtron.com

Veeco grows revenue 4.9% in Q2/2022, despite supply chain constraints

Full-year guidance maintained, as San Jose operations to be fully transferred to new building by end-Q3

For second-quarter 2022, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has reported revenue of \$164m (above the midpoint of its \$150-170m guidance). This is up 4.9% on \$156.4m last quarter and 12% on \$146.3m a year ago, despite revenue being impacted by some demand not being able to be fulfilled due to supply chain constraints.

Growth was driven by the Semiconductor sector (Front-End and Back-End, as well as EUV Mask Blank systems and Advanced Packaging) reaching another record of \$97.5m (59.5% of total revenue). This is up 25.6% on \$77.6m last quarter and 81.6% on \$53.7m a year ago, due to significant contributions from laser annealing and advanced packaging lithography systems. "Demand is stemming predominantly from advanced- and trailing-node logic applications

[artificial intelligence (AI) and high-performance computing (HPC), as well as mature automotive and consumer applications], where Veeco's semiconductor exposure is greatest," notes CEO Bill Miller.

The Compound Semiconductor sector (Power Electronics, RF Filter & Device applications, and Photonics including specialty, mini- and micro-LEDs, VCSELs, laser diodes) contributed \$31.1m (19% of total revenue). This is down 16.2% from \$37.1m last quarter (due to a slowdown in 5G RF-related activity) but up 28.5% on \$24.2m a year ago (driven by systems shipments for photonics applications). "We shipped multiple deposition systems to support laser diodes for optical communication and specialty LED production," notes Miller.

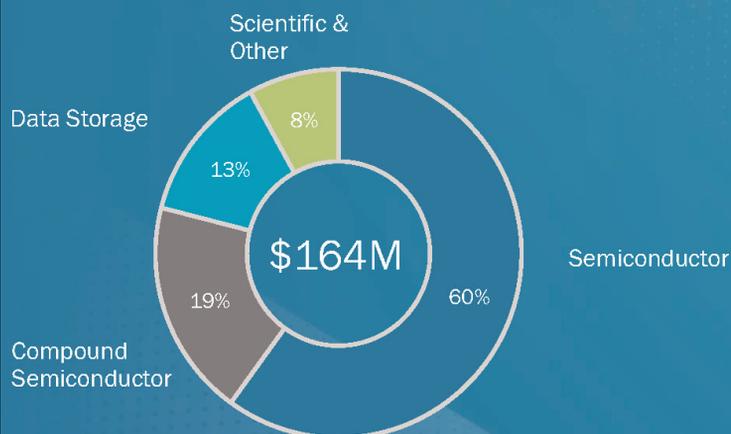
Data Storage contributed \$21.5m (13.1% of total revenue), more than halving from \$52m a year ago but roughly level with \$21.6m last quarter.

The Scientific & Other sector contributed \$13.8m (8.4% of revenue), down 31.3% on \$20.1m last quarter and 15.9% on \$16.4m a year ago.

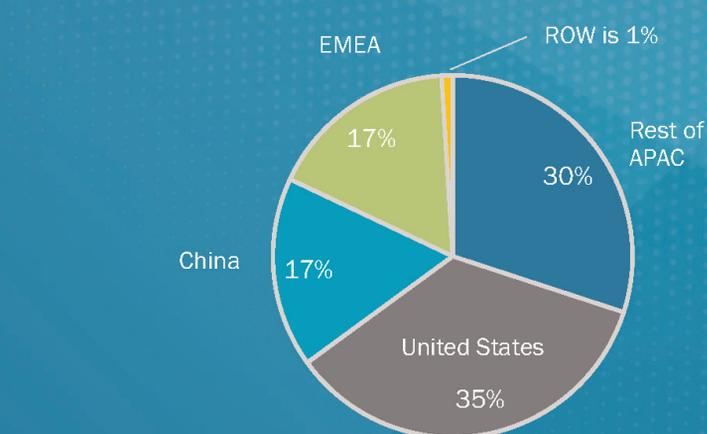
By region, the USA comprised 35% of total revenue (driven primarily by sales of laser annealing and advanced packaging lithography systems). The Asia-Pacific region (excluding China) comprised 30% (driven mainly by Semiconductor system sales). Europe, Middle-East & Africa (EMEA) comprised 17% of total revenue. China comprised 17% of total revenue (primarily for photonics applications).

On a non-GAAP basis, gross margin was 40.3%, down from 43.1% last quarter and 41.6% a year ago. This was due to an unfavorable product mix (since two of the three evaluation tools that were signed during the quarter were offered with especially low pricing). "We expect gross margins to improve in the second half compared to Q2," notes chief financial officer John Kiernan.

Revenue by Market



Revenue by Region



Revenue Trend (\$M)	Q2 21	Q1 22	Q2 22
Semiconductor	54	78	98
Compound Semi	24	37	31
Data Storage	52	22	22
Scientific & Other	16	20	14
Total	146	156	164

Operating expenses have risen further, from \$39.6m a year ago and \$42.8m last quarter to \$43.2m, although this is below the expected \$44–46m.

Operating income was \$23m, down from \$24.7m last quarter but up on \$21.3m a year ago (and exceeding the guidance of \$15–22m).

Net income was \$20m (\$0.35 per diluted share), down from \$21.7m (\$0.38 per diluted share) last quarter but up from \$17.9m (\$0.35 per diluted share) a year ago, and exceeding the guidance of \$12–19m (\$0.22–0.34 per diluted share).

Operating cash flow was \$3.4m. Capital expenditure (CapEx) was \$4.5m. During the quarter, cash and short-term investments hence fell only slightly, from \$232m to \$231m. Long-term debt, including the current portion of \$20m, was recorded at \$274m on the balance sheet and represents the carrying value about \$278m in convertible notes.

“We’re experiencing success with the investments we’ve made in our evaluation program, as demonstrated by the continued adoption of our technologies by leading customers,” says Miller.

“We’re working to penetrate the compound semiconductor market with our MOCVD solutions by targeting micro-LED and power electronics applications. Our gallium nitride and arsenide–phosphide systems are in the field under evaluation with leading customers,” he adds.

“In the power electronics case, we’re working with a foundry customer who is evaluating our Propel single-wafer gallium nitride system for 8-inch power applications. We believe there are opportunities in the consumer, automotive and data-center power markets to enable improved cost of ownership.”

“In micro-LED, we’re engaged in two applications working with a number of leaders in the industry for five-plus years. The first approach is more traditional, where red, green and blue micro-LEDs are produced independently and transferred to a display. We have

our aluminium arsenide phosphide system under evaluation for red micro-LED opportunities. We expect this evaluation to close in the second half of this year. For the second approach, we have 200 and 300mm gallium nitride systems that we’re deploying for an innovative micro-LED application where the blue, green and red pixels are produced on the same silicon wafer. Both approaches can potentially be a good long-term opportunity for the company going forward,” believes Miller.

“While our demand is quite strong, we’ve not seen a meaningful improvement in inbound material lead times,” notes Kiernan. In this constrained supply chain environment, for third-quarter 2022 Veeco expects revenue of \$160–180m. Due to a more favorable product mix than in Q2, gross margin should improve to 41–43%. With operating

We’re working to penetrate the compound semiconductor market with our MOCVD solutions by targeting micro-LED and power electronics applications. Our gallium nitride and arsenide–phosphide systems are in the field under evaluation with leading customers

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expenses of \$45–47m, operating income should be \$21–30m and net income \$18–28m (\$0.32–0.48 per diluted share).

With healthy order activity (especially in the Semiconductor and Data Storage markets), demand for Veeco’s products continues to outpace supply, leading to growing order backlog, notes Veeco.

“Our San Jose facility ramp is on schedule, and our operations will be fully transferred to the new building by the end of Q3,” says Miller. “The increased manufacturing footprint is enabling the ramp of our laser annealing output to meet our customers demand. Demand for laser annealing remains healthy as we see customers adopt our technology and add capacity, because our laser annealing platform is a production tool of record at the world’s leading logic players,” he adds.

“Beyond Q3/2022, although supply-chain challenges persist, we continue to experience strong demand for our products,” says Kiernan. “We’re reiterating our previously guided full-year revenue range of \$640–680m and diluted non-GAAP EPS range of \$1.50–1.70 per share.”

By market segment, Veeco expects year-on-year revenue growth of 50% in Semiconductors (to about \$370m), of 20–25% in Compound Semiconductors (to \$130m), and of 10% in Scientific & Other (to \$70m, or just over 10% of total revenue). Data storage is expected to fall by about 45% (to \$90m).

“We are excited to introduce laser annealing to the memory market,” states Miller. “In fact, a leading DRAM manufacturer recently signed-off their evaluation system for a future node. We anticipate follow-on orders in the late 2023 or early 2024 timeframe to support our customers manufacturing plans. Overall, our laser annealing business is growing as we win process steps and new customers,” he concludes.

www.veeco.com

Penn State orders another Veeco GENxplor R&D MBE system for opto materials research

Applications include lasers and infrared plasmonic meta-materials

Veeco has received an order from the Pennsylvania State University for its GENxplor R&D molecular beam epitaxy (MBE) system, to be used to enable the epitaxial growth of high-quality III-V compound semiconductor materials for applications including lasers and next-generation infrared plasmonic meta-materials.

Penn State purchased the GENxplor system for its capability to produce exceptional quality epitaxial films, according to professor Stephanie Law. "As a researcher familiar with the performance of Veeco's GENxplor R&D system, this was an easy decision to add this system to our research facility," says Law. "The reliable design

and superior technology of the GENxplor system will no doubt strengthen our efforts to drive significant advancements in meta-material and long-wavelength photonics research."

The GENxplor system deposits high-quality epitaxial layers on substrates up to 3-inch in diameter. Its efficient single-frame design combines all vacuum hardware with on-board electronics to make it up to 40% smaller than other MBE systems, it is reckoned, saving valuable lab space. Through Veeco's MBE engineering expertise, design optimizations have made the GENxplor platform a capable research system that is tailored to

meet the unique challenges of compound semiconductor material R&D. Its modular design supports existing research while enabling the integration of new materials and capabilities in the future.

"Since its introduction, the GENxplor has enabled essential compound semiconductor research at the top universities, such as Penn State, and institutions around the world," notes Matthew Marek, senior director of marketing & site leader for Veeco's MBE Group. "This second endorsement from professor Law further solidifies the GENxplor as the leading R&D MBE system in the industry."

www.eecs.psu.edu

Veeco releases 2021 sustainability report

Report highlights progress towards ESG goals

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has issued its 2021 sustainability report, highlighting its environmental, social and governance (ESG) initiatives. In particular, the third annual report spotlights Veeco's progress towards its ESG goals released earlier this year.

"I think of 2021 as an inflection point for Veeco," comments CEO Bill Miller. "We completed a company-wide transformation and are now squarely focused on

executing our growth strategy and strengthening our commitment to ESG. Our vision is to enable a future where technology improves the human experience, and we recognize that achieving our vision is dependent, in part, on our corporate sustainability efforts," he adds. "Our first set of ESG Goals, released earlier in 2022, was an important milestone on our sustainability journey."

The new report features, among other updates, details pertaining to the firm's ESG goals, including

baselines and the steps being taken to achieve them. A detailed account of the ongoing implementation of a hazardous chemical management program, disclosure 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.

www.veeco.com

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Riber's first-half revenue stable at €9.3m despite electronic component shortage

End-June order book up 76% to €30.6m

For first-half 2022, Riber S.A. of Bezons, France — which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells — has reported revenue of €9.2m, slightly below the €9.3m a year previously due to the difficulties in sourcing electronic components preventing further deliveries.

MBE system revenue was €2.9m, up 5% from about €2.8m in first-half 2021.

Revenue for Services & Accessories was €6.3m, down 3% from €6.5m.

Of total revenue, 39% came from Europe (up from 29%), 56% from Asia (down from 63%), and 5% from North America (down from 7%).

Order book development

In a context of MBE market growth, new orders received during first-half 2022 grew strongly, comprising

eight MBE systems (including four production systems) and a stronger level of orders for Services & Accessories.

The order book at the end of June was hence up strongly, by 76%, from €17.4m in 2021 to €30.6m in 2022.

Specifically, the order book for Services & Accessories rose by 10% from €6.9m to €7.6m, confirming the positive trend in MBE research and production activities.

The Systems order book more than doubled (up by 119%) from €10.5m to €23m. This included four production systems (versus just one in 2021) and seven research systems (versus four in 2021). Also, this does not include: (1) orders announced on 25 July for two research systems; and (2) the option to buy (announced on 8 June) covering four production machines for which firm orders will

be confirmed when the export license is obtained.

Outlook

Riber says that it continues to face a shortage of deliveries of electronic boxes (resulting from the current microprocessor shortage), which are crucial components for its MBE machines to operate. System revenue for second-half 2022 is therefore uncertain, as the planned system deliveries are dependent on the resumption of deliveries of electronic boxes.

"The reduced visibility in the short term does not detract from the robust positioning of the company's activities or their potential for growth over the medium and long term," the firm notes.

First-half earnings and the outlook for full-year 2022 will be issued on 28 September.

www.riber.com

CNRS-CRHEA and FOTON Institute order two Riber Compact 21 research MBE systems

Orders through NANOFUTUR Project funded by France's National Research Agency

Riber has received orders for two Compact 21 research MBE systems (to be delivered in 2023).

France's CNRS-CRHEA (Centre de Recherche sur L'Hétéro-Epitaxie et ses Applications – Centre National de la Recherche Scientifique) — which specializes in epitaxial growth of wide-bandgap semiconductor materials — has ordered a Compact 21 system to strengthen

its research capacity for emerging semiconductor materials.

Riber has also sold another Compact 21 system to France's FOTON Institute (Fonctions Optiques pour les Technologies de l'information - CNRS UMR) — a center of academic excellence in photonics for information technology — which will help to expand its research capabilities.

The acquisition of the systems was carried out through the NANOFUTUR Project. Funded by the French government via the National Research Agency, the project aims to structure the French nanotechnology community for the next ten years by providing it with the state-of-the-art equipment that will allow it to evolve at the highest level globally.

<http://foton.cnrs.fr>

Order received for multi-4" GSMBE 49 production system

System to be used to grow 1.3µm QD lasers

Riber has received an order for a multi-4"-wafer GSMBE 49 production system, for delivery to Asia in 2023.

The gas-source MBE system is intended for optoelectronic and

microwave applications, in particular for the growth of 1.3µm quantum dot (QD) lasers for next-generation datacom and telecom devices.

The new generation of datacom

devices requires very high-precision control of the epitaxial growth process, achieved by the performance of Riber's machines and by its control software.

ACM introduces post-CMP cleaning tool for silicon and SiC substrate manufacturing

Company leverages experience in single wet wafer cleans to enter post-CMP cleaning market

ACM Research Inc (ACM) of Fremont, CA, USA, which develops and manufactures wafer processing equipment for semiconductor device and advanced wafer-level packaging (WLP) applications, has launched its new post-CMP cleaning tool.

This is ACM's first tool of its kind, serving as a cleaning step following the chemical mechanical planarization (CMP) process used to manufacture high-quality substrates. It is available in 6- and 8-inch configurations for silicon carbide (SiC), and 8- and 12-inch configurations for silicon wafer manufacturing. The tool is available in wet-in dry-out (WIDO) and dry-in dry out (DIDO) configurations, with 2-, 4- and 6-chamber options to achieve maximum throughput of up to 60 wafers per hour (WPH).

"The global equipment supply chain continues to experience extended delivery times," notes president & CEO Dr David Wang. "This has created an opportunity for ACM to leverage its extensive experience in semiconductor cleaning process technology to enter the post-CMP cleaning market, further expanding its cleaning portfolio," he adds. "The post-CMP cleaning tool will allow ACM to help alleviate shortages facing our customers through delivery of our stable, reliable and cost-effective solution with shorter-than-average lead times."

Following the CMP step, a physical pre-clean process is needed to



The new post-CMP cleaning tool, in 4-chamber dry-in dry out (DIDO) form.

reduce the number of particles, using dilute chemicals at low temperatures. ACM's post-CMP cleaning tool is available in multiple configurations, including advanced cleaning technologies with ACM's Smart Megasonix.

The new WIDO online pre-clean tool attaches directly to an existing CMP tool. Wafers are automatically transferred into two brush chambers, where the front-side, back-side and bevel edge are processed concurrently with chemical and cold deionized water (CDIW). Wafers are then moved to either two or four clean chambers and are processed with multiple chemicals and CDIW. A nitrogen (N₂) dry and spin completes the process, which achieves a particle performance of <15 particles at or above 37nm and 20–25 particles greater than 28nm, with metallic contamination

of $\sim 1E+8$ (atoms/cm²). The WIDO pre-clean tool offers a throughput of up to 35WPH when using the four-chamber tool.

The new DIDO pre-clean tool is a stand-alone tool with four loadports and a smaller footprint than the WIDO pre-clean tool, intended for customers whose CMP platforms have a built-in cleaning chamber such that wafers come out of the tool dry. In this configuration, wafers are manually transferred to the pre-clean tool via the loadport, then processed identically to those in the WIDO pre-clean tool. The DIDO pre-clean tool is available in four- or six-chamber configurations, with two brush and two cleaning chambers or two brush and four cleaning chambers. The DIDO pre-clean tool achieves the same metallic contamination results as the WIDO pre-clean tool while delivering throughput up to 60WPH when using the six-chamber tool.

A third available configuration is a WIDO offline pre-clean tool for use where fab floor space is at a premium. When using this tool, wet wafers are transferred from the CMP tool to a DIW bath, and then manually moved to the WIDO offline pre-clean tool, which uses the same cleaning process with the same particle performance achieved and throughput of up to 60WPH.

www.acmrcsh.com

Obducat receives SEK7.1m order for fully automated Microcluster Track wet processing tool

System to be used for silicon carbide substrates cleaning

Obducat AB of Lund, Sweden says that its subsidiary Obducat Europe GmbH, a supplier of systems for lithography processing, has

received an order worth about SEK7.1m for a fully automated Microcluster Track wet processing tool.

For delivery in Q1/2023, the system will be used for silicon carbide substrates cleaning processes.

www.obducat.com

Palomar expands Singapore Innovation Center to support demand for specialty OSAT/process development

Second expansion focuses on customer-specific needs

Photonics and microelectronic device assembly & packaging equipment maker Palomar Technologies Inc of Carlsbad, CA, USA has expanded its Innovation Center in Singapore to meet growing demand in Southeast Asia for process development and specialty outsourced assembly and test (OSAT) for advanced semiconductor new product introductions.

Palomar opened its Innovation Center – Singapore in November 2018 to address a vital market need for process development, device package prototyping, test & measurement, process maturation, and low-volume production. In 2019, market demand pushed Palomar to make its first expansion. This second expansion gives the center the added ability to work more closely with customers on their specific needs.



“Strong demand from our regional Asia Pacific customer base has driven us to expand the footprint of our Singapore Innovation Center for the second time in five years,” says Rich Hueners, managing director, Palomar Technologies (SE Asia) Pte Ltd. “This expanded area will serve to host plasma cleaning, dry boxes and customer-specific test equipment while the original lab area will continue to host the die attach, wire bond and vacuum reflow

equipment. We are looking forward to forging ahead with new customer requirements in this larger space.”

The Palomar Innovation Center – Singapore supports a wide range of customer applications including:

- micro-optics used in 3D imaging, light detection and ranging (LiDAR) and optical sensors;
- RF LDMOS and RF gallium nitride (GaN) power amplifiers;
- high-reliability RF microwave modules;
- silicon photonics and laser diode placement bonding;
- thermal and motion sensors;
- packaging;
- active optical cable (AOC) packaging;
- VCSEL, EEL, EML, LED placement and bonding;
- lens placement and attach bonding.

www.palomartechologies.com

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In-situ monitoring of 2D materials epitaxy during CVD

EpiTT & EpiCurve TT can be used to increase reproducibility and yield

Graphene and other sp^2 -bonded 2D monolayer materials like hexagonal boron nitride (hBN) and tungsten disulfide (WS₂) are opening up new device and material possibilities. According to in-situ metrology system maker LayTec AG of Berlin, Germany, one of the most promising methods for synthesizing them is thermal chemical vapor deposition (CVD).

CVD process steps — precursor dissociation, adsorption, surface diffusion, island nucleation and growth — are usually thermally activated. Therefore, a reproducible process temperature measurement is of paramount importance for the control and repeatability of the deposition.

The process control frequently takes place after deposition by well-established ex-situ techniques like Raman spectroscopy, atomic force microscopy (AFM) etc. In contrast, LayTec's in-situ metrology systems EpiTT and EpiCurve TT can be integrated into a deposition reactor and thus enable close control of key parameters during epitaxial deposition of 2D materials.

For materials that are transparent at a wavelength of 950nm like sapphire, LayTec's EpiTT measures the temperature on the top side of the carrier. Reflectance is measured at 950nm, 633nm and 405nm. If the optical contrast between the substrate and the epilayer is sufficiently high, reflectance variations can also be measured during the growth of 2D materials with sub-monolayer coverage. In this case, the reflectance measures the surface coverage within the measurement spot, and its variation describes the different growth stages.

At the 12th Graphene and 2D Materials Conference in Aachen, Germany (5–8 July), LayTec's Marcello Binetti presented the latest results on characterization of 2D material growth, in particular in-situ reflectance, temperature and wafer bow of graphene on sapphire

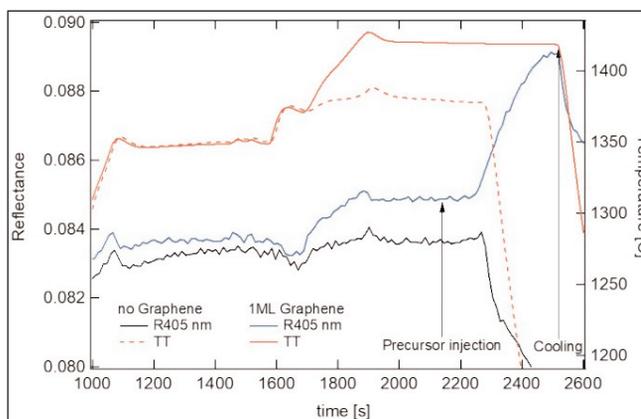


Figure 1: Data collected during two similar runs: 'no Graphene' and 1ML Graphene.

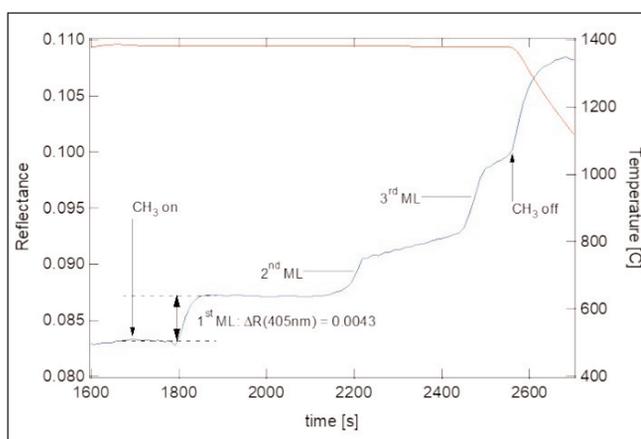


Figure 2: Evolution of _R405 with graphene coverage _ between _=0 and _=3.

during deposition. LayTec highlights some of the results achieved by monitoring graphene CVD on a single-side-polished (SSP) sapphire in Aixtron's CCS reactor, demonstrating how LayTec's metrology systems can help to increase reproducibility and yield in CVD production of 2D materials.

Figure 1 shows two runs of graphene growth on sapphire. In the first run ('no Graphene') the substrate only underwent the thermal cycle with temperature steps at 1347°C and 1370°C, but no precursor was injected into the chamber. In the run '1ML Graphene' the sapphire substrate was heated up to 1347°C and then to 1420°C, when the deposition of 1ML graphene took place while admitting the precursor for 380s into the chamber. Then the precursor flow was

stopped, and the reactor was cooled down. The 405nm reflectance tends toward a maximum, suggesting the existence of an energetic barrier for the nucleation of further monolayers.

Figure 2 illustrates the deposition of up to 3ML graphene. After the saturation of the first monolayer, between 1900s and 2100s, the reflectance remains constant despite the availability of the precursor because an energetic barrier prevents the nucleation of further monolayers. Then, the precursor partial pressure was increased, allowing the controlled growth of the second and third monolayers. This process is mirrored by the increase in R405.

To verify the results, ex-situ Raman spectro-

scopy measurements were performed which confirmed the presence of 1–2ML of graphene and 3ML of graphene on the two samples. Consequently, wafer temperature and surface coverage can be directly deduced right during deposition, which ensures accurate process control. Moreover, measuring the variation of the surface reflectance during the growth reveals details on the deposition kinetics and enables tighter control of the number of deposited monolayers already during the process.

LayTec concludes that its EpiTT and EpiCurve TT allow in-situ monitoring of 2D materials deposition and offer new means for controlling these complex processes, accelerating research on 2D materials and scale up for industrial production.

www.grapheneconf.com/2022

Thin-film metrology system maker k-Space celebrates 30th anniversary

University spinoff now has thousands of customers worldwide

k-Space Associates Inc of Dexter, MI, USA — which was founded in 1992 and produces thin-film metrology instrumentation and software for research and manufacturing of microelectronic, optoelectronic and photovoltaic devices — is celebrating 30 years of helping the world's leading technology makers develop, monitor, control and manufacture their products in the thin-film, semiconductor, solar and glass markets, to name a few.

"After 30 years it's still so satisfying to walk into a laboratory or a manufacturing facility and see our metrology tools being used in real-time

for process monitoring and control," comments CEO Darryl Barlett.

k-Space's thin-film metrology applications employ patented methods to accurately measure and monitor wafer temperature, stress, curvature, bow, deposition rate, thickness, reflectivity, spectral reflectance and transmission, and reflection high-energy electron diffraction (RHEED).

On the industrial metrology side, k-Space's tools are used in production facilities worldwide to measure precise part features, surface defects and more to ensure high yield and quality compliance.

Such measurements are vital for the manufacturing of semiconductor chips, solar panels, architectural glass, building materials, and other products.

k-Space has distributors in Europe, India, China, Japan, South Korea, and throughout the world. The firm says that, through extensive customer input, close collaboration with its worldwide customer base, and a strong commitment to technical support, it continues to develop new solutions that help its customers fulfill even their most complex metrology needs.

www.k-space.com

Soitec boosting SmartSiC wafer manufacturing yield using KLA Surfscan SP A2 unpatterned inspection system

Surfscan inspection technology adapted for wide-bandgap substrates

Engineered substrate manufacturer Soitec of Bernin, near Grenoble, France has selected process control and inspection systems provider KLA Corp of Milpitas, CA, USA to enable high-yield manufacturing of silicon carbide (SiC) devices for the automotive industry.

Soitec leverages its patented SmartSiC technology to produce SiC substrates, which aim to improve the performance of power electronics devices and boost the energy efficiency of electric vehicles (EVs).

Based on its track record of using KLA's inspectors for its silicon-on-insulator (SOI) wafers, Soitec has extended its partnership with KLA and selected the Surfscan SP A2 unpatterned inspection system for its SmartSiC wafers.

SmartSiC wafers provide what is claimed to be unique crystal quality, while KLA's Surfscan SP A2 leverages deep-ultraviolet (DUV) optics and advanced algorithms to support substrate quality control.

This partnership should enable SiC substrate production at more sophisticated levels, helping to bring high-quality SiC in high volume to the automotive market.

In March, Soitec announced the construction of a new fab, Bernin 4, dedicated primarily to the manufacturing of SmartSiC wafers in 150mm and 200mm diameters. The new fab is expected to be operational by second-half 2023.

"Coupling our unique SmartSiC engineered substrates with KLA's inspection and metrology systems will help us to assure supreme quality levels in the manufacturing of substrates and thus drive customer yield downstream," says Soitec's chief technology officer Christophe Maleville. "With KLA, we have demonstrated the great potential of their inspection system for our all-important SOI technology. We now apply it to our innovative SmartSiC technology for the automotive sector. This will help us

to drive our manufacturing efficiency, satisfy the growing demand from the electric vehicle market, and offer further added value to our customers," he adds.

"At KLA we strongly value our customer relationships and R&D investment as they provide us with the knowledge and technologies needed to deliver the required process control solutions at the right time," says Jijen

Vazhaeparambil, senior VP of the Surfscan, ADE and ECI group. "Through our close collaboration with Soitec, we were able to adapt our world-class Surfscan inspection technology for the wide-bandgap substrate segment. The resulting Surfscan SP A2 system provides the sensitivity and production capability needed to help Soitec achieve their stringent quality standards for SiC and other wide-bandgap substrates."

www.kla.com

www.soitec.com

MRSI and Lumentum collaborate on developing automotive LiDAR solutions

Firms to provide high-reliability photonic chip assembly and services

MRSI Systems (Mycronic Group) of North Billerica, MA, USA (which makes fully automated, high-precision, high-speed eutectic and epoxy die bonding systems) has announced a new collaboration with photonics chip and module designer and manufacturer Lumentum Operations LLC to develop light detection and ranging (LiDAR) solutions for the automotive industry.

With LiDAR technology becoming standard equipment in mid-range and high-end vehicles, it is forecasted that, in the next five years, the demand for automotive LiDAR in advanced driver assistance systems (ADAS) will grow at a compound annual growth rate (CAGR) of 94%. Compared to optical transceivers, automotive LiDAR needs to pass more stringent reliability verification, in which both the reliability of the photonic chips and their assembly technologies are critical. Assembling photonic chips with high reliability and zero defects in large-scale production is one of the great challenges facing the emerging automotive LiDAR industry, notes MRSI.

Based on its expertise in providing reliable diode laser solutions for communication and consumer applications, Lumentum has

developed a series of diode laser products that meet the quality, scope and reliability requirements of the automotive industry. The firm provides 1550nm narrow-linewidth distributed Bragg reflector (DBR) diode lasers for frequency-modulated continuous wave (FMCW) coherent LiDAR, 905nm and 940nm VCSEL arrays with corresponding power for long-distance LiDAR and in-cabin monitoring.

As a supplier of fully automated high-accuracy die bonders providing high-precision, high-flexibility, high-reliability and high-speed fully automatic chip assembly for the optoelectronic and microelectronic industries, for the automotive LiDAR industry MRSI provides high-reliability and fully automated assembling solutions for various die bonding processes.

Highlighted at the 2022 Compound Semiconductor Advanced Technology & Application conference in Suzhou, China (3–4 August), MRSI's collaboration with Lumentum will provide high-reliability photonic chip assembly and services for the automotive LiDAR industry. On behalf of both companies, MRSI's Dr Limin Zhou is delivering the presentation 'Discussion on Photonic Chips and Assembling Technologies in

Automotive LiDAR', focusing on the companies' collaborative work, including key assembly requirements and technologies, best mass-production solutions for high-reliability and zero defects, and experimental results.

"Reliability is critical for automotive LiDAR applications and both the laser chip and the module assembly technology are essential to passing the strict reliability requirements for vehicles," says Lu Yong, senior product line manager at Lumentum. "Our combined efforts will better support customers with a complete solution that includes high-reliability laser chip and assembly products," he adds.

"MRSI Systems, Mycronic Group will have more opportunities to work with the global leading photonics company to develop high-reliability chip assembly solutions for the fast-growing industry," says Dr Yi Qian, Mycronic Group's VP & general manager for MRSI Systems. "The end-to-end solutions from chip to module assembly provided by our collaboration will shorten time-to-market and play a very important role in enabling mass production of automotive LiDAR solutions."

www.lumentum.com

MRSI launches latest die bonder for high-power lasers

MRSI-H-HPLD+ uses parallel processing to improve throughput

MRSI Systems (Mycronic Group) of North Billerica, MA, USA (which makes fully automated, high-precision high-speed eutectic and epoxy die bonding systems) has launched the MRSI-H-HPLD+ (to be available in third-quarter 2022) as the latest advance in its MRSI-H/HVM-series product line.

Tailored for high-power laser die attachment applications, the new

variant of the MRSI-H-HPLD is said to significantly improve throughput by using parallel processing while maintaining high accuracy and flexibility.

"MRSI's die bonders have been widely used over many years by high-power laser manufacturers. This new HPLD+ version takes the performance to the next level," comments Dr Yi Qian, who is

vice president & general manager of MRSI Systems. "This new product continues with our proven track record of providing a combination of ultra-precision, high-speed, and high-flexibility. This is critical for our customers' high-mix high-volume flexible manufacturing," he adds.

www.mrsisystems.com
www.mycronic.com

AGIC Capital invests in UV lithography firm Eulitha

Funding to promote PHABLE globally for AR/VR, optical components

European-Asian private equity firm AGIC Capital says an investment fund under its management has invested in Eulitha AG of Kirchdorf, Switzerland (a spin-off of the Paul Scherrer Institute founded in 2006).

Eulitha offers non-contact, high-resolution nano-UV photolithography systems and customized patterning services for applications including DFB/DBR (distributed feedback/distributed Bragg reflector) lasers, AR/VR (augmented reality and virtual reality), telecommunications, optical components and bio-sensors/chips. The firm says that its proprietary PHABLE technology is considered to be a preferable option to traditional nanoimprint technology due to lower costs, higher throughput, better consistency, longer

mask lifetime and compatibility with non-flat substrates.

Eulitha says that AGIC Capital was attracted to its positioning as a unique technology provider in fast-growing markets including AR/VR industries and its promising commercialization pipeline backed by strong R&D abilities. AGIC Capital will work closely with the management team to support Eulitha's international development (particularly the Asia Pacific region) and use resources with large industrial players to help the company increase sales and customers.

"Eulitha is well poised to gain substantially from the underlying market trends favoring its proprietary equipment and process technology solutions," believes Heiko

von Dewitz, partner of AGIC Capital in Europe. "We will work with the Eulitha management team to scale up the business and accelerate its growth across a variety of industries," he adds.

"We are delighted to have AGIC Capital on board on our journey to become a global leader in offering lithography solutions to the growing photonics industries," says Eulitha's CEO & co-founder Dr Harun Solak. "With this investment Eulitha will be significantly expanding its resources, both financially and in terms of its market reach, to further develop and market its unique photolithography equipment and associated technologies."

www.eulitha.com

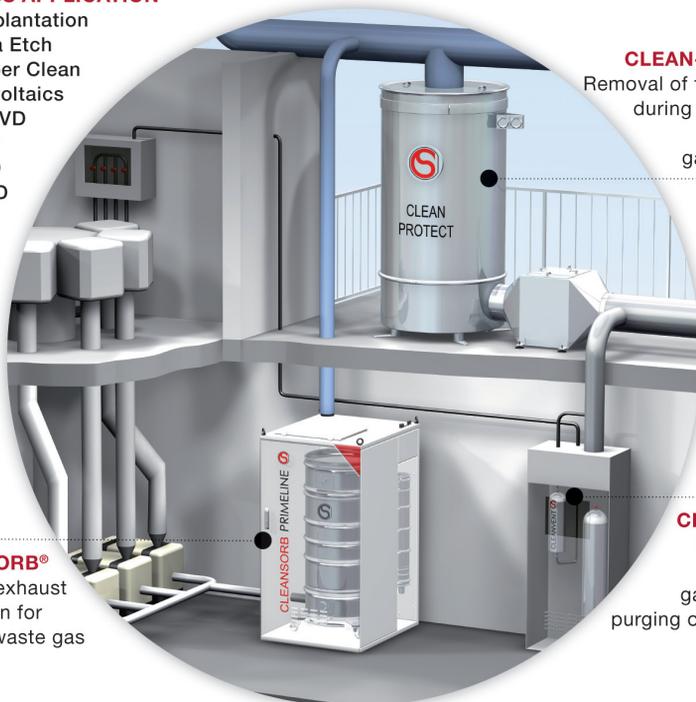
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www.csclean.com

UIUC demonstrates cubic GaN on large-area U-grooved silicon (100) dies

Selective etching of hexagonal-phase gallium nitride boosts internal quantum efficiency to 31.6%

Gallium nitride (GaN) and its alloys (i.e. III-nitride semiconductors) are the backbones of solid-state lighting, and next-generation RF and power electronics. Most R&D in this material system is currently focused on its conventional, hexagonal (i.e. wurtzite) phase.

However, its cubic (i.e. zincblende) phase has more inherent advantages. These include: no polarization in the $\langle 100 \rangle$ growth direction, smaller bandgap, smaller electron-heavy hole effective masses, less Auger loss, larger optical gain, shorter radiative recombination lifetime, lower p-doping activation energy, higher hole mobility and larger conduction-band offset.

Cubic III-nitride semiconductors might thus enable next-generation devices such as efficiency-droop-free III-nitride visible LEDs and as-grown, normally-off aluminium gallium nitride/gallium nitride (AlGaIn/GaN) power transistors. However, the synthesis of cubic GaN has not been an easy task due to its metastability.

In 'Structural and Optical Properties of Cubic GaN on U-grooved Si(100)' (J.Lee, Y. C.Chiu, M.A.Johar and C.Bayram, Appl. Phys. Lett. 121, 032101 (2022)), a team at University of Illinois at Urbana-Champaign (UIUC) has reported a III-nitride materials breakthrough: the synthesis — by metal-organic chemical vapor deposition (MOCVD) — of low-defect-density, stable and pure-phase cubic GaN on the scalable silicon platform.

Specifically, scanning electron microscopy (SEM), atomic force microscopy (AFM) and transmission electron microscopy (TEM) studies reveal that cubic GaN shows no discernible threading dislocations and a low stacking fault density of $3.27 \pm 0.18 \times 10^4 \text{cm}^{-1}$.

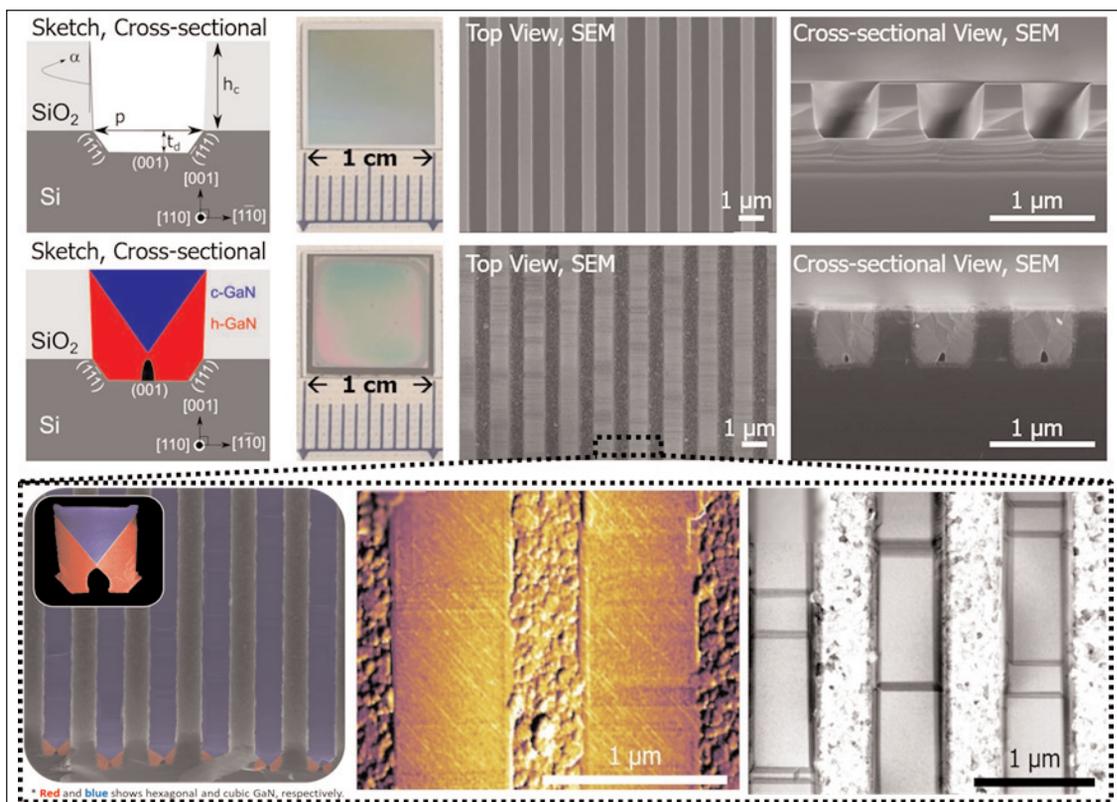
The researchers study the structural and optical properties and demonstrate, through temperature-dependent and time-resolved photoluminescence measurements, a high as-grown cubic GaN band-edge emission internal quantum efficiency (IQE) of $\sim 26\%$ ($25.6\% \pm 0.9\%$).

As well as further identifying the optical defect levels, the researchers report a technique for selective

etching of the low-temperature AlN buffer layer, SiO_2 sidewalls, and hexagonal-phase GaN. This increases the efficiency to $\sim 32\%$ ($31.6\% \pm 0.8\%$), attributed to the decrease in radiative recombination lifetime via the removal of defective hexagonal-phase GaN. It also points to the potential path of achieving a continuous cubic GaN film.

Overall, the UIUC team reckons that, in reporting cubic GaN on U-grooved silicon with high structural and optical quality, it has demonstrated a step towards creating next-generation cubic-phase-based III-nitride devices.

<https://doi.org/10.1063/5.0102026>
<http://icorlab.ece.illinois.edu>



Cubic GaN epitaxy on large-area ($\sim 1 \text{cm}^2$) U-grooved silicon (100) dies is demonstrated. (Top row) U-grooved silicon (100) and (middle row) cubic GaN atop (from left to right) Cross-sectional sketches, top-view photographs, top-view SEM images, and cross-sectional view SEM images of. (Bottom row) Cubic GaN structural characterization. (From left to right) Phase-mapping, tapping-mode AFM and bright-field top-view STEM images are shown. The plan-view STEM reveals that no threading dislocations or other types of dislocations on the cubic GaN surface. Stacking faults with a density of $3.27 \pm 0.18 \times 10^4 \text{cm}^{-1}$ are observed.

Everlight convicted for misappropriating Seoul Semi's trade secrets and technology

Korean appellate court imposes fines and prison sentences

South Korean LED maker Seoul Semiconductor Co Ltd says that the Korean Suwon District Court Appellate Division has found Taiwan-based Everlight Electronics Co Ltd guilty of criminal misappropriation of its trade secrets and industry technology.

The court awarded criminal fines against Everlight – the maximum fine so far for a foreign company for the commission of such a crime. Three former employees of Seoul Semiconductor who left the company and went to work at Everlight were also sentenced to 1–2 years in prison, with 2–3 years of probation

for trade secret and technology misappropriation.

The Korea Prosecutors' Office criminally indicted Everlight, together with Seoul's former employees, for criminal misappropriation of Seoul's trade secrets and industry technology. The lower court convicted Everlight on a charge of criminal misappropriation of trade secrets, and the appellate court affirmed the lower court's decision and also upheld a charge of criminal misappropriation of Seoul's industry technology by Everlight.

Seoul Semiconductor alleges that

some global companies still purchase cheaper copycat products that infringe its technology and sell those products under their branding, despite claiming their environmental, social and governance (ESG) compliance.

"Intellectual property is the only tool that enables small businesses and entrepreneurs to survive and grow," says Seoul Semiconductor's founder Chung Hoon Lee. "Companies stealing such hard-earned technology should be expelled from the market," he adds.

www.SeoulSemicon.com

www.everlight.com

Seoul Semi wins German injunction against Conrad Order for recall of cell-phone flash LED products

South Korean LED maker Seoul Semiconductor Co Ltd has obtained a permanent injunction in patent litigation against European retailer Conrad Electronic for infringement of an LED patent in Germany.

In July, the German District Court of Mannheim issued a permanent injunction against certain cell phones and a recall of those products in the patent litigation against Conrad. The accused products relate to flash LEDs for cell phones.

The patented technology in the cell-phone flash LEDs serves to

efficiently extract light emitted from the LED, significantly improving light intensity and brightness. This patented technology has been widely used for cell-phone flashlights, automobile headlamps, UV-LED home appliances, horticulture applications, and outdoor lighting.

Seoul has already won several patent litigations based on the asserted patent. For example, in December 2018, the District Court of Düsseldorf ordered a permanent injunction for patent infringement against various LED products and a recall of those products. In addition, the German Federal Court of

Justice has declared the validity of this patent.

Seoul and its affiliates have actively engaged in patent enforcement against companies that use what it describes as cheap infringing products despite claiming environmental, social and governance (ESG) compliance. In the past four years, as a result, Seoul has secured seven judgments of permanent injunctions and orders of recall in Europe against infringing products, including cell phones, lighting products, and UV-LED home appliances.

www.SeoulSemicon.com

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MICLEDI launches first micro-LED devices with integrated micro-lenses

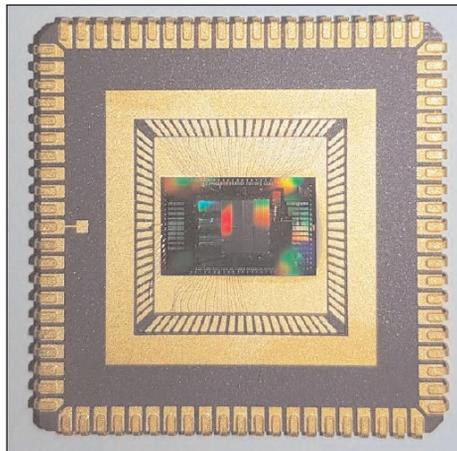
Integrated micro-lenses in tightly pitched device allows pixel-level beam shaping

MICLEDI Microdisplays B.V. of Leuven, Belgium – a fabless developer of micro-LED display modules for augmented reality (AR) glasses – has announced what it claims are the first micro-LED devices with integrated micro-lenses for pixel-level beam shaping, manufactured in the firm's proprietary 300mm manufacturing flow.

The new family is said to enable multiple benefits for waveguide-based AR glasses, including:

- improved power efficiency – by focusing light within the targeted waveguide cone;
- optimal waveguide in-coupling – offering additional flexibility for AR system integration and image quality improvements via controllable compensation of color dispersion;
- pixel scaling to sub- $3.0\mu\text{m}$ pitch – with highly reproducible beam shape performance.

Samples and test kits of blue and green micro-LED arrays, plus blue arrays with micro-lenses, have been delivered to customers this summer, with red micro-LEDs coming in fourth-quarter 2022. Available for both micro-LED device evaluation and for display integration with waveguides, customers



MICLEDI's micro-LED devices are first to offer integrated micro-lenses for pixel-level beam shaping. The micro-LED display die is in a JLCC84 package for ease of customer testing and characterization.

will see FHD display blocks and a variety of other micro-LED structures with mesa sizes down to $0.5\mu\text{m}$, and with micro-lens reference designs by MICLEDI.

"We are tremendously excited to reach this milestone with customer-quality samples of each of our RGB arrays," says CEO Sean Lord. "Customers have been clamoring for these enhanced devices. With micro-lenses, we are pleased to point out that one of the hottest

demands from the field, micro-LED wall-plug-efficiency at 'AR' pitch, will be at best-in-class levels.

In parallel, we are working on our first RGB modules and exploring approaches for polychromatic RGB integration."

MICLEDI has also pioneered the development of a modeling platform for micro-lens customization. The platform will be available for AR customers to evaluate the new technology in simulations and to design their own micro-lenses for specific waveguide configurations. Those can then be prototyped using MICLEDI's manufacturing capabilities.

"Integration of the micro-lenses in a tightly pitched micro-LED device is a highlight of MICLEDI's unique manufacturing capabilities using 300mm wafer fab equipment," says co-founder & chief technology officer Dr Soeren Steudel. "High-quality beam shaping requires extreme precision and nanometer-scale overlay accuracy that can only be met in a 300mm wafer fab," he adds.

MICLEDI is exhibiting at table #551 at the SPIE Optics + Photonics conference in San Diego, CA, USA (21–25 August).

www.micledi.com

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SemiLEDs' quarterly revenue falls back from \$2.176m to \$1.784m

Net loss up from \$172,000 to \$916,000

For its fiscal third-quarter 2022 (to end-May 2022), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of \$1.784m, down on \$2.176m last quarter, although this is still up on \$1.44m a year ago.

Operating expenses have risen from \$0.902m to \$1.11m, but this is still less than \$1.26m a year ago.

Gross margin has fallen back from 24% to 19% (down on 45% a year ago), and operating margin from -17% to -43% (slightly worse than -41% a year ago).

Net loss has risen from \$172,000 (\$0.04 per diluted share) to \$916,000 (\$0.20 per diluted share), compared with just \$64,000 (\$0.02 per diluted share) a year ago.

During the quarter, cash and cash equivalents fell from \$3.712m to \$3.023m, although this is still up on \$1.7m a year ago.

SemiLEDs says that, due to the continuing uncertain impact of COVID-19 on the economy and the firm, it cannot forecast revenue for fiscal Q4/2022 (to end-August).

www.semileds.com

TSLC-SemiLEDs to supply components for Cepton's LiDAR solutions

TSLC qualified to support the industry's largest ADAS LiDAR series production award

Optoelectronic system manufacturer TSLC Corp, a subsidiary of LED chip and component maker SemiLEDs Corp of Hsinchu Science Park, Taiwan, has been selected to supply key components for both automotive and non-automotive light detection and ranging (LiDAR) solutions made by Silicon Valley-based Cepton Inc, which has developed high performance micro-motion technology (MMT) LiDAR.

TSLC is a technology developer and manufacturer of ultra-precision optoelectronic systems, with more

than 10 years of experience innovating unique semiconductor package solutions such as wafer-level packaging. The firm has worked with Cepton for the past two years to qualify and validate TSLC's manufacturing processes in preparation for large-scale deployment of Cepton's LiDAR solutions. Specifically, TSLC is now qualified to manufacture components supporting what is reckoned to be the largest advanced driver-assistance system (ADAS) LiDAR series production award in the industry.

"Using TSLC's advanced micro-packaging technology together with our ultra-precision alignment technology, we have delivered thousands of components used in Cepton's LiDAR solutions," says TSLC's CEO Trung Doan, chairman/CEO of SemiLEDs. "We are excited to be selected as a supplier of key components for Cepton's LiDAR for large-scale deployment," he adds. "Cepton's LiDAR solutions are making our roadways safer by reducing accidents and enabling higher levels of autonomy."

Luminus launches rugged flip-chip mid-power 3030 LED

High lumens/Watt for high-performance outdoor lighting and harsh-environment applications

Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — has announced the launch and immediate availability of MP-3030-110F flip-chip LEDs, enabling the development of lighting solutions with maximum efficacy, brightness, and overall ruggedness.

The flip-chip design means no wire bond, creating higher reliabil-

ity, as well as enhanced sulfur resistance for robust performance suitable not only for horticulture applications but also for outdoor and harsh lighting environment applications. The LEDs provide low thermal resistance and come in a wide range of correlated color temperatures (CCTs of 2200-6500K) and color rendering indexes (CRIs of 80, 90 and 95 minimum).

"Luminus' MP-3030-110F provides state-of-the-art lumen and photo-

synthetic photon efficacies in an industry-standard 3030 package," notes senior business line director Yves Bertic. "Thanks to its flip-chip design, this LED delivers outstanding reliability with Q90 in excess of 50,000 hours, making it an excellent fit for traditional general lighting and horticulture applications".

The product line is available immediately through Luminus' authorized distributors.

www.luminus.com

NUBURU to go public via Tailwind Acquisition

Deal to provide gross proceeds of \$334m, plus \$100m from Lincoln Park Capital to help fund growth initiatives

High-power industrial blue laser technology firm NUBURU Inc (which was founded in 2015) and special-purpose acquisition company TWND Corp have announced a definitive agreement that puts NUBURU on the path to becoming a publicly listed company. The combined company named NUBURU Inc will continue to be based in Centennial, CO, USA, led by CEO, co-founder & president Dr Mark Zediker and other key executive leadership, and expects to be traded under the ticker symbol 'BURU'.

In 2017, NUBURU introduced what it claimed was the first industrial blue laser, starting with the standard AO laser and the extreme-brightness AI laser, which enable gains in speed and quality for metal processing across e-mobility and automotive, energy storage, aerospace and additive manufacturing.

In many industrial applications, critical materials such as copper, gold and aluminium do not absorb much of the infrared wavelengths transmitted by traditional industrial lasers, which leads to lower-quality joints than by using NUBURU's industrial blue lasers, which leverage a fundamental physical advantage to produce defect-free welds that are up to eight times faster than the traditional approaches — all with the flexibility inherent to laser processing. NUBURU's blue lasers also address complex situations such as the joining of dissimilar metals.

"As electrification and advances in manufacturing drive growth in our target markets, this capital infusion is intended to provide continued momentum for NUBURU," says CEO, co-founder & president Dr Mark Zediker. "Looking ahead, we are focused on growing our customer base, expanding our distribution channels, accelerating development of our ultra-high-

brightness product family and scaling our manufacturing operations to meet demand globally. Our partnership with TWND is expected to accelerate our expansion plans to allow us to benefit from a position of strength in the public markets," he adds.

"Our goal at TWND is to partner with a founder-led company that has a large addressable market and is positioned for rapid and sustainable long-term growth based on its technology, innovation and industry leadership," says TWND's CEO Chris Hollod. NUBURU's solutions for metal processing are critical to 3D printing, aerospace, consumer electronics and e-mobility, he adds.

Transaction overview

The business combination values NUBURU at a pre-money enterprise value of about

\$350m, at a price of \$10 per common share. The boards of directors of TWND and NUBURU have each unanimously approved the proposed transaction, which is expected to be completed in early 2023, subject to, among other things, the approval by NUBURU's stockholders and TWND's stockholders, expiration of certain diligence periods without

termination by TWND or Lincoln Park Capital and satisfaction or waiver of other customary closing conditions.

The transaction will result in gross proceeds of up to about \$334m to NUBURU (assuming no redemptions from the trust account by the TWND public stockholders and prior to the payment of transaction expenses), together with access to additional financing to help fund its growth initiatives through a funding agreement with Lincoln Park Capital for up to \$100m, subject to the closing of the transaction and other conditions set forth in the purchase agreement entered into between TWND, NUBURU and Lincoln Park Capital.

Each holder of Class A common stock of TWND will receive one unlisted share of Series A Preferred Stock of the surviving company upon the closing for each share of TWND Class A common stock held immediately following the closing. The preferred stock is a senior security with a \$10 per share liquidation preference, and the preferred shares, at the option of each holder, can be sold to the company for its liquidation value following the second anniversary of the closing. Holders of Class A common stock who elect to redeem their shares will receive \$10 plus any applicable interest per share at the closing, but will not receive any Preferred Shares.

"We thoughtfully designed this innovative preferred share structure so that holders of Class A common stock — whether individual or institutional — would be treated equally and would benefit from the ability to receive this additional consideration, rather than making the preferred share available only via a private placement that is not typically accessed by individual investors," says Hollod.

www.nuburu.net

We are focused on growing our customer base, expanding our distribution channels, accelerating development of our ultra-high-brightness product family and scaling our manufacturing operations to meet demand globally... TWND is expected to accelerate our expansion plans to allow us to benefit from a position of strength in the public markets

BluGlass appoints chief financial officer

CFO to lead finance functions as firm transitions to revenue generation

BluGlass Ltd of Silverwater, Australia – which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs for industrial, defence, display and scientific markets – has appointed Rob Ambrogio as chief financial officer to lead its finance functions through the next phase of the company's growth and transformation. Ambrogio commences on a part-time basis and may increase to full-time in-line with revenue generation activity.

A Chartered Accountant, Ambrogio has more than two decades of experience leading finance teams in



Rob Ambrogio.

high-growth public, private and not-for-profit enterprises. Ambrogio has previously held CFO roles at ASX-listed investment firm Gowing Bros Ltd, employment and training firm MTC Australia Ltd, and Australian marketing agency Creative Activation. During his time at Gowing, Ambrogio managed assets of more than \$300m, and he was key to Creative Activation's acquisition by Clemenger Group.

"Rob is an excellent addition to the BluGlass team, and will be instru-

mental as the business prepares for commercialization and profitability," says BluGlass' executive chair, James Walker. "Rob's extensive experience in strategic and finance leadership, risk management, corporate governance and M&A considerably strengthens our executive leadership team and will be invaluable as we bring our Silicon Valley semiconductor fab fully online. His demonstrated track record in overseeing business transformation and delivering significant shareholder value complements Jim's [BluGlass' president Jim Haden's] expertise and will be critical as we transition BluGlass to revenue generation."

www.bluglass.com.au

III-V Epi's revenue coming mostly from high-growth industrial customers for ongoing production

Telecoms, datacoms, additive manufacturing, LiDAR and optical sensing comprise 90% of revenue

III-V Epi Ltd of Glasgow, Scotland, UK says, in the last year, that most of its revenue has come from devices supplied for industrial applications with ongoing production requirements, demonstrating that it has met a clear need in the global photonics industry as a trusted manufacturer of prototype and lower-volume III-V epitaxial structures by molecular beam epitaxy (MBE) and metal-organic chemical

vapor deposition (MOCVD).

"As much as 90% of III-V Epi's turnover is coming from industrial customers in high-growth telecoms, datacoms, additive manufacturing, LiDAR [light detection & ranging] and multiple optical sensing industries," notes director Calum McGregor. "This is great commercially, as these customers are typically using our devices within live product ranges with

growing supply requirements. This industrial business is also informed by the fast-turnaround academic projects that make up the remainder of our portfolio," he adds.

"Industrial customers are using our specialist range of design, manufacture, test and characterization services to expedite device manufacture and bring new products to market as quickly as possible."

www.iii-vepi.com

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II-VI and Artilux demo longer-range, higher-resolution 3D camera operating at 1380nm

InP edge-emitting lasers combined with GeSi SWIR sensor arrays

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA and Artilux of Hsinchu, Taiwan, which specializes in germanium silicon (GeSi) photonics and CMOS short-wavelength infrared (SWIR) sensing technology, have jointly demonstrated a next-generation 3D camera with much longer range and higher image resolution.

Investments in the metaverse infrastructure are accelerating and driving the demand for sensors that enable more realistic and immersive virtual experiences, says the firms. II-VI and Artilux combined their proprietary technologies in indium phosphide (InP) lasers and GeSi sensor arrays, respectively, to demonstrate a miniature 3D camera that operates in the short-wavelength infrared at 1380nm, resulting in significantly higher performance than existing cameras operating at 940nm, it is reckoned.

"The longer infrared wavelength provides better contrasts and reveals material details that are

otherwise not visible with shorter-wavelength illumination, especially in outdoor environments," says Dr Julie Sheridan Eng, senior VP, Optoelectronic Devices & Modules business unit, II-VI. "By designing a camera that operates at 1380nm instead of 940nm, we can illuminate the scene with greater brightness and still remain well within the margins of eye-safety requirements. In addition, the atmosphere absorbs more sunlight at 1380nm than at 940nm, which reduces background light interference, greatly improving the signal-to-noise ratio and enabling cameras with longer range and better image resolution," she adds.

II-VI provided the highly integrated SWIR illumination module comprising InP edge-emitting lasers that deliver up to 2W of output power and optical diffusers, in surface-mount technology (SMT) packages for low-cost and high-quality assembly. Artilux's camera features a high-bandwidth and high-quantum-efficiency GeSi

SWIR sensor array based on a scalable CMOS technology platform. Combined, the products enable a broad range of depth-sensing applications in consumer and automotive markets.

"The miniature SWIR 3D camera can be seamlessly integrated into next-generation consumer devices, many of which are under development for augmented-, mixed- and virtual-reality applications," says Artilux co-founder & chief technology officer Dr Neil Na. "II-VI and Artilux demonstrated a key capability that will enable the metaverse to become a popular venue for entertainment, work and play," he adds. "The SWIR camera demonstration provides a glimpse of the future of 3D sensing in the metaverse, with displays that can identify, delineate, classify and render image content, or with avatars that can experience real-time eye contact and facial expressions."

www.ii-vi.com

www.artiluxtech.com

Vector Photonics appoints consultant program manager, overseeing new product introduction

Ian Caldwell to help fast-track PCSEL commercialization

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK has appointed Ian Caldwell as consultant program manager, overseeing the new product introduction (NPI) program. He brings extensive, industrial experience to the firm, as it continues to commercialize its all-semiconductor PCSEL technology for data-center and co-located optics markets.

"Ian is a highly respected engineer and programme manager, successfully leading similar national and international programmes for industry-leading companies



Ian Caldwell.

Motorola, Freescale, NXP Semiconductors, and Sivers Photonics," comments CEO Neil Martin. "Ian will help to manage development projects which raise the Technology Readiness Level (TRL) of our all-semiconductor PCSELS. This will expedite our move from prototype to volume production using a 'fab-less' multi-vendor supply model."

Caldwell has an Honours Degree in Electrical and Electronic Engineering

from the University of Strathclyde and is a Chartered Member of the Institute of Engineering and Technology. In 2017, he worked as a STEM (Science, Technology, Engineering and Maths) instructor at the Dumfries House Education Engineering Centre, part of 'The Princes Foundation' and home to many of HRH The Prince Charles, Duke of Rothesay's, flagship education programmes, where he developed and delivered workshops in local schools to inspire the next generation of scientists and engineers.

www.vectorphotonics.co.uk

VIGO's Q2 revenue grows 12.7% year-on-year to PLN20.3m Detection module revenue grows year-on-year by 37% for industrial & 57% for transport applications; semiconductor materials revenue up 21%

For second-quarter 2022, VIGO Photonics of Ozarów Mazowiecki, Poland (which makes mid-infrared photonic detectors, detection modules and semiconductor materials) has reported revenue growth of 12.7% year-on-year to PLN20.3m.

Sales of semiconductor materials rose by 21.2% to PLN1.31m (6.5% of total revenue). Sales of detection modules rose 12.2% to PLN19m (93.5% of total revenue), with transport, industry and science & medicine the best-growing applications.

The largest growth in detection modules was recorded among industrial applications (up 37.7% from just over PLN7m a year ago to PLN10m, 49.3% of total revenue) and transport applications (up 57.3% from under PLN2m to PLN3m, 14.9% of total revenue). The science & medicine division is also on the rise (up 36.2%, to just 5.9% of total revenue, but particularly important for the firm's growth). In the military segment (23.3% of revenue), the firm is still fulfilling orders, but their number has now decreased compared to last year.

VIGO's second-best-ever revenue quarter is attributed to the consistently implemented growth strategy adopted in 2021. The record of PLN22.3m in Q4/2021 was influ-

enced mainly by the execution of orders in the detector segment for two customers in the security systems and defence industries.

First-half 2022 revenue totalled PLN32m. "We are growing, despite many market challenges," notes Adam Piotrowski, president of the management board.

Asian orders up nearly three-fold year-on-year in first half 2022

Q2/2022 orders were up 36% year-on-year. A particularly significant increase in orders was recorded from the Asian market — up nearly three-fold year-on-year for first-half 2022. The US market grew by 28% and the European market by 18%.

"It confirms the constantly growing interest in VIGO products and the development of new applications for infrared detectors," notes Lukasz Piekarski, member of the management board. "It facilitates production planning, which is particularly important with the current problems of access to certain electronic components. Thanks to larger orders from existing and new customers, we are able to secure better prices and shorter delivery times," he adds.

New development strategy

After beginning operation in 1987 and being listed on the main market of the Warsaw Stock Exchange since

2014, in 2021 VIGO presented a new two-stage development strategy for 2021–2026, in which six development initiatives — technological areas, aimed at strengthening the company's position as one of the most innovative and dynamically developing companies on the market — were singled out (including, in December, beginning a rebranding involving changing the firm's name from VIGO System to VIGO Photonics). By 2023, the firm's objective will be to continue the R&D projects initiated in photonic technologies, integrated circuits, detectors made of III-V materials, epitaxy of semiconductor materials, and infrared source technologies. The technological and technical base will be developed.

The firm reckons that its development strategy will allow it to maintain a 20–30% annual revenue growth rate, to about PLN80m in 2022 and PLN100m in 2023. Earnings before interest, taxes, depreciation and amortization (EBITDA) is expected to rise to PLN40m in 2023 (totalling PLN103m of normalized EBITDA for 2021–2023). The second stage of the strategy will be executed until 2026 (inclusive) and will consist of the implementation of selected development initiatives.

www.vigo.com.pl/en

VIGO's IR detectors selected for environmental system monitoring on NASA's Orion spacecraft

VIGO's infrared detector products have been selected to monitor critical environmental systems — i.e. the Laser Air Monitor System (LAMS) crew habitable environment spectrometer instrument — on board NASA's Orion spacecraft. Part of the Artemis program, Orion is the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain

the crew during the space travel, and provide safe re-entry from deep space return velocities. Orion will launch on NASA's new heavy-lift rocket, the Space Launch System.

LAMS was built by NASA to measure the concentration of CO₂, H₂O and O₂ in both the cabin and suit environments. To address the challenging launch requirements, VIGO conducted qualification tests

for space environments on standard detector products in their catalog.

"We are excited and honored to support NASA on such a great project that will help to shape the future of space exploration to our moon and eventually Mars," says president & Adam Piotrowski. VIGO's support of space exploration began with the EXOMARS mission and included the Mars Curiosity Rover.

SMART Photonics and TU/e enter into long-term strategic partnership

Aim is to strengthen InP PIC technology development and provide industrial production capacity

Eindhoven-based independent pure-play indium phosphide (InP) photonic integrated circuit (PIC) foundry SMART Photonics and Technical University of Eindhoven (TU/e) in The Netherlands have signed a long-term strategic partnership agreement that aims to further strengthen the development of InP photonic integration technology and provide a smooth path of new technologies to end customers.

Ten years ago TU/e was one of the founding partners of SMART Photonics, which has developed rapidly since. Last year it featured in Europe's top-50 most promising scale-ups. TU/e and SMART Photonics have always worked closely together to their mutual benefit.

With this collaboration now formalized in the agreement, both parties commit to a long-term strategic partnership. The joint efforts will reinforce the continuous R&D of InP photonic integration and are expected to provide a path

to industrialization. This aims to provide the entire photonic ecosystem with industrial PIC production capacity to address a rapidly growing market.

The cooperation will involve activities such as developing new building blocks for SMART Photonics' already comprehensive process design kit (PDK), developing future, more sustainable PIC production processes, and other next-generation technologies such as hybrid integration of different photonic and electronic platforms. In addition, SMART Photonics will support TU/e in activities aimed at educating ambitious and highly qualified engineers for the benefit of the entire PhotonDelta ecosystem.

"Eindhoven University of Technology is world leading in photonics research and technology, and co-founder of the Photon Delta ecosystem," notes TU/e's rector Frank Baaijens. "We are committed to further solidify the strong position of The Netherlands and

its photonics ecosystem in which SMART Photonics, as an independent pure-play foundry, plays a system critical function. The objective is to enhance the position of Europe as powerhouse in integrated photonics," he adds.

"This agreement strengthens our collaboration with TU/e, one of the most powerful technology hubs in the world," comments SMART Photonics' chief technology officer Luc Augustin. "It provides us access to new research, ideas and inventions that we will be able to offer to our customers as part of our strong technology offering. At the same time, it offers TU/e the ability to perform their research on the basis of the latest industrially robust and stable processes," he adds. "Our combined efforts will strongly contribute to the further industrialization of PIC technology and our technology leadership, benefiting the full photonic ecosystem."

www.tue.nl

www.smartphotonics.nl

Mouser to distribute for Advanced Photonix globally

Global semiconductor and electronic component distributor Mouser Electronics Inc has announced a new global distribution agreement with Advanced Photonix of Camarillo, CA, USA (a division of OSI Optoelectronics), which provides photonics, optoelectronics and electronic systems for aerospace & defence, medical and industrial OEMs.

With more than 30 years of experience in optoelectronics and in-house semiconductor fabrication services, Advanced Photonix designs, develops and fabricates photodetectors, emitters and photoresistors. Mouser is hence now stocking the company's silicon,

indium gallium arsenide (InGaAs) P-I-N, APD photodiodes and hybrids, and cadmium sulphide (CdS) light-dependent resistor (LDR) photocells.

The firm's UV-enhanced silicon photodiode offers a high-performance solution for applications requiring highly sensitive devices in the ultraviolet region. The device features low noise, high shunt resistance, and increased response with an active area diameter of 2.54mm. Red-enhanced P-I-N and quadrant silicon photodiodes are available in various features and packages for a wide range of applications. The devices feature high accuracy with a large active area

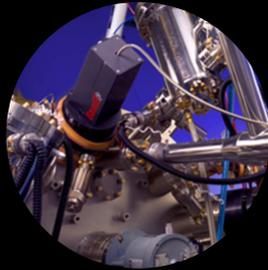
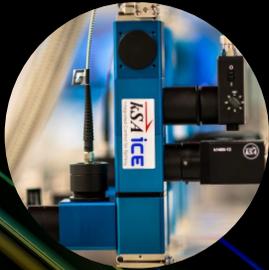
and low crosstalk, suitable for accurate nulling, centering or measuring small positional changes. The blue-enhanced P-I-N photodiodes offer high responsivity, large active area and low noise, and are suitable for high-speed response applications in the blue region of the electromagnetic spectrum.

Advanced Photonix CdS photocells have sensitivity in the 400-700nm visible light region. The LDRs, available in a wide range of resistances, decrease resistance as the light level increases with efficiency characteristics like those of the human eye.

www.advancedphotonix.com

www.mouser.com

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POET reports NRE revenue from multiple customers in Q2 Optical Interposer modified to accept lasers from global suppliers

For second-quarter 2022, POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — has reported non-recurring engineering revenue (NRE) of \$120,261, compared with \$209,100 a year ago and nil last quarter. The firm provided services under an NRE contract to one customer in 2021. In 2022, the firm is now providing similar services to multiple customers, one of which continued to contract services from last year. The revenue relates to unique projects that are being addressed utilizing the capabilities of the POET Optical Interposer.

Net loss was \$5.283m (\$0.14 per share), up from \$4.408m (\$0.13 per share) a year ago but cut from \$5.433m (\$0.15 per share) last quarter. The net loss included R&D costs of \$1.8m.

Also, the non-cash impact of the Super Photonics Xiamen (SPX) joint venture with Sanan Integrated Circuit Co Ltd of Xiamen City, Fujian province, China, was -\$0.746m compared to nil a year ago and -\$0.43m last quarter. POET's share of the operating loss in Super Photonics is about 88.5% due to the high value of its initial contribution.

Cash outflow from operating activities was -\$3.3m, worse than -\$2.7m a year ago but an improvement on -\$3.7m last quarter.

POET ended Q2 with \$13.8m in cash and marketable securities, no convertible debentures and no debt. Working capital was \$12.4m.

POET says that, during the quarter, it achieved the following milestones:

- Announced the availability of its 400G FR4 and 800G (2x400G FR4) Receive (RX) Optical Engines and the sampling of its 200G FR4 Transmit (TX) and Receive (RX) Optical Engines through SPX.

- SPX added two new customer engagements in China with module companies designing their transceivers to use the firm's 100G, 200G and 400G optical engines, bringing the total number of active customer engagements for both SPX and POET to 10.

- Appointed Theresa Lan Ende (chief procurement director of Arista Networks) and Michal Lipson PhD (professor of physics at Columbia University, and a pioneer in silicon photonics) as advisors to the board of directors. POET intends to nominate both as directors at its Annual General Meeting on 14 October.

- Joined the Singapore Hybrid-Integrated Next Generation μ -Electronics (SHINE) Centre in the College of Design and Engineering at the National University of Singapore (NUS). Participation as a founding member gives the firm access to advanced packaging tools and engineers, as well as opportunities to showcase its technology and collaborate with a global industrial and academic network of companies and universities.

- Presented 'A Wafer Scale Hybrid Integration Platform for Co-packaged Photonics using a CMOS-based Optical Interposer' at the 2022 IEEE Symposium on VLSI Technology & Circuits in Hawaii.

POET has identified two key milestone objectives for the balance of 2022:

- the development of a 400G FR4 multiplexed

TX engine that will be combined with the existing 400G RX to create a full transmit and receive sub-assembly for a 400G transceiver module; and

- the delivery of samples of a packaged light source assembly for Celestial AI, a lead customer in the emerging growth market for artificial intelligence-machine learning (AI-ML) accelerator chips.

The 400G FR4 TX and RX optical engines are the building blocks for an 800G FR4 optical engine that POET intends to introduce to the market in time to capture a major inflection point identified in the April LightCounting forecast report, in which deployments of 800G (2X400G) and 1.6T transceiver modules are expected to increase at a compounded annual growth rate (CAGR) of nearly 80% from about 2 million units in 2024 to 14 million units by 2027. For packaged light sources, the ultimate market potential is larger, with estimates of the total market size being about \$125bn by 2027, which the firm estimates will offer a serviceable market opportunity of over \$4bn by 2027.

To support its strategy to develop transceiver modules, the firm has also modified the Optical Interposer platform so that it can more readily accept lasers from leading global suppliers, and included the capability to assemble the necessary electronic components directly onto the interposer platform. POET has developed and will sample later this year a 400G RX with an integrated trans-impedance amplifier (TIA) and a 200G FR4 TX with an integrated laser driver. This integration of additional electronics components has demonstrated a further increase in performance of the optical engines and simplified module board design for customers.

"Following the live demonstration of our 200G FR4 multiplexed TX and RX optical engines and our ground-breaking live demonstra-

To support its strategy to develop transceiver modules, the firm has also modified the Optical Interposer platform so that it can more readily accept lasers from leading global suppliers

tion of our 400G/800G FR4 multiplexed RX engine at the Optical Fiber Conference in March, we received multiple requests for technical data, samples and meetings with interested customers and business partners," says chairman & CEO Dr Suresh Venkatesan. "We are executing well towards our dual strategy to make available integrated optical engines for 100/200G to promote market traction and acceptance, while simultaneously delivering more differentiated solutions at 400/800G and beyond. There is a strong desire among module companies to embrace our approach as we qualify our solutions and demonstrate the required levels of reliability and manufacturability by releasing our solutions to production. We have already begun the process of

validating performance, reliability and manufacturability with select customers who are designing modules with our 100G and 200G optical engines," he adds.

"Even though the vast majority of 100/200/400G optical transceivers sold today are built using discrete sub-assemblies, the discussions during the recent PIC conference strongly indicate that the industry is rapidly approaching a period in which hybrid integration will be recognized as one of the few paths to meeting the scale, size and energy performance requirements of the industry," Venkatesan says. "As the number of channels increase from 4 to 8 to 16 (in going from 400G to 1.6T), the balance between conventional assembly and integrated assembly transitions quickly in favor of chip-scale integ-

ration and wafer-level processing, both fundamental tenants of the POET approach. It is widely acknowledged that a small-form-factor 2x400G multiplexed FR4 integrated solution is needed at 800G and absolutely required at 1.6T, and we believe that POET is in a pole position to deliver it," he adds.

"Further, we believe the Optical Interposer platform is among a few, if not the only, packaging technology that can provide the scale, size, power and cost requirements needed for optoelectronic applications outside of datacom and telecom, including optical computing, AR/VR, wearables, LiDAR and other more consumer-oriented products, that will require vastly larger numbers of devices to be produced annually at lower cost and higher performance."

POET samples 200G FR4 Transmit and Receive optical engines for QSFP56 transceivers for Cloud data centers and 5G connectivity

Samples shipped to lead customers through Super Photonics JV

POET has begun sampling its 200G FR4 Transmit (TX) and Receive (RX) optical engines, which are based on the POET Optical Interposer (a unique hybrid integrated photonics packaging platform).

The firm has shipped samples to multiple lead customers through Super Photonics (its China-based joint venture formed in October 2020 with Sanan Integrated Circuit Co Ltd of Xiamen City, Fujian province) and expects the 200G FR4 TX and RX optical engines to be in production at Super Photonics by the end of 2022.

The 200G FR4 Transmit optical engine integrates four high-speed directly modulated lasers (DMLs), each operating at 50Gb/s speed, with a low-loss AWG (arrayed waveguide grating)-based multiplexer that is monolithically integrated on the Optical Interposer. Monitor photodiodes are

built into the optical engine for active power monitoring.

The 200G FR4 Receive optical engine integrates four high-speed photodetectors, each operating at 50Gb/s speed, with a low-loss AWG-based demultiplexer that is monolithically integrated on the Optical Interposer. A single-mode optical fiber with LC connector is attached to the TX and RX optical engines for seamless integration in a 200GBASE-FR4 transceiver module.

"We see significant customer interest in 200GBASE-FR4 transceivers," says Raju Kankipati, VP of product line management (PLM). "Our highly integrated optical engines will enable customers to offer cost-effective and scalable 200GBASE-FR4 and 2x200GBASE-FR4 transceivers to cloud data-center end customers," he adds. "We, through our joint venture

Super Photonics, have started sampling multiple lead customers, who we expect to work closely with through their transceiver design completion phase."

Key features of the 200G FR4 Transmit and Receive optical engines are listed as:

- supports 200GBASE-FR4 (4x50Gbps) PAM-4 transmission;
- uncooled DFB lasers (CWDM wavelengths) and PIN photodetectors;
- low-loss AWG-based quad-wavelength multiplexer and demultiplexer that are temperature independent and monolithically integrated into the optical waveguide layer of the Optical Interposer;
- A small-size form factor, which enables a 200GBASE-FR4 and 2x200GBASE-FR4 in a QSFP56 optical transceiver module.

www.poet-technologies.com

Lumentum acquires IPG Photonics' telecom transmission product lines

Digital communications ASICs complement silicon and InP PICs for vertical integration in optical transmission modules

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 acquired the telecom transmission product lines (optical transceivers and coherent components) of IPG Photonics Corp of Oxford, MA, USA (which makes high-power fiber-lasers and amplifiers primarily for materials processing and other diverse applications) in an all-cash transaction. The divested activities include the former Menara Networks and a subsidiary in Brazil.

"While we have made good progress in developing fundamental technologies in our telecom transmission business, our ability to scale these product lines would require a step-up in investment that we believe would be better spent on our core materials processing and adjacent markets," says IPG Photonics' CEO Dr Eugene

Scherbakov. "After an in-depth review, we have determined that participation in the broader telecom market is non-core to IPG's strategy. Our strategy is to remain focused on revenue diversification and growth opportunities in markets where we can increase our value proposition to customers by delivering advanced laser processing and technology solutions. We are exploring substantial new markets and applications where fiber lasers are replacing existing laser and non-laser technologies by improving efficiency, productivity, or enabling technological breakthroughs for our customers," he adds.

"I am very excited to add such highly complementary and differentiated transceiver product lines and ASIC capabilities, which help to expand our addressable market and augment our technology capabilities," says Dr Beck Mason, senior

VP & general manager, Telecom Transmission at Lumentum. "This acquisition brings a talented team developing digital communications ASICs, including coherent DSPs, which complements our silicon and indium phosphide photonic integrated circuit (PIC) capabilities and creates opportunities for increased vertical integration in future optical transmission modules," he adds. "Increasingly, customers in the cable MSO and wireless network operator space are turning to wavelength-tunable pluggable transceivers to help expand their network capacity and this acquisition brings highly synergistic product lines addressing this rapidly growing opportunity."

There is no impact to Lumentum's fiscal fourth-quarter 2022 due to this transaction and the terms of the transaction were not disclosed.

www.ipgphotonics.com
www.lumentum.com

Lumentum joins CEO Action for Diversity & Inclusion Alan Lowe joins over 2000 CEOs in pledge to cultivate ecosystem centered on collaboration and sharing

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes photonics products for optical networks and lasers for industrial and consumer markets) and its president & CEO Alan Lowe have joined the growing coalition CEO Action for Diversity & Inclusion to advance diversity and inclusion in the workplace.

The firm says that it is hence pledging to take action to cultivate a workplace where diverse perspectives and experiences are welcomed and respected and where employees feel encouraged to discuss diversity and inclusion. The collective of over 2000

signatories has already shared more than 1400 best known actions, exchanging tangible learning opportunities and creating collaborative conversations.

"We understand the critical importance of diversity and inclusion, which helps drive innovation and creativity, increases our competitive advantage, and ensures Lumentum is the best place to work for everyone," says Lowe. "Our pledge is another concrete step in the company's diversity, inclusion and belonging journey, and I am proud that we continue to cultivate an environment where employees can openly

and constructively address challenges, present opportunities, and share perspectives."

CEO Action for Diversity & Inclusion aims to cultivate a new type of ecosystem centered around collaboration and sharing. The actions showcase real-life examples of the open and transparent conversations to cultivate more diverse and inclusive workplace environments. The addition of new signatories expands the impact of this work beyond the office to communities and industries.

www.ceoaction.com
www.lumentum.com

NeoPhotonics' Q2 revenue up 46% year-on-year to \$95m Growth in 400G-and-above products to \$6m offsets \$10m impact from chip supply shortages

For second-quarter 2022, NeoPhotonics Corp of San Jose, CA, USA — a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications — has reported revenue of \$95m, up 6% on \$89.3m last quarter and up 46% on \$65m a year ago (the second consecutive quarter with year-on-year growth of over 45%). This was despite ongoing supply chain shortages (primarily of analog and power semiconductor chips) again constraining revenue by about \$10m.

This was due particularly to 105% year-on-year growth for 400G-and-above products to \$61m (64% of total revenue), up from \$54m (61% of total revenue) last quarter. Revenue from 400ZR small-form-factor coherent DCO transceiver modules for data-center customers has now reached the level of low single-digit millions per quarter.

"In addition to 400ZR, we are ramping our 96Gbaud components and sampling 130Gbaud for even higher data-rate applications

[800G and 1.6T links]," says chairman & CEO Tim Jenks. "These new component products, together with our ramping 400ZR and CFP2 400G module products, give us confidence in continued growth for the quarters ahead, despite the expected challenges with IC chip supply shortages," he adds.

Three customers comprised more than 10% of revenue, and the top five customers accounted for 83% collectively (up from 77% a year ago).

On a non-GAAP basis, gross margin was 35.2%, up from last quarter's 31.2% (after meaningful yield improvements) and 21.7% a year ago (due to improved factory utilization).

Operating expense was \$24.1m, cut by \$0.9m from \$25m last quarter due to lower R&D materials and operating costs for the firm's site in Fremont, CA.

Compared with an operating loss of \$10.3m (operating margin of -15.8% of revenue) a year ago and a profit of \$2.8m (3.1% margin) last quarter, operating income has improved further to \$9.4m (9.8% operating margin), based on the strength of the 400G product ramp.

Compared with a net loss of \$11.5m (\$0.22 per share) a year ago and net income of \$2.8m (\$0.05 per share) last quarter, net income per share improved further to \$8.3m (\$0.15 per share).

During the quarter, net inventory grew by \$5.8m to \$66m, as the firm increased 400ZR inventories to \$20m to ensure ongoing module supply. Capital expenditure was \$3m.

Overall, cash and cash equivalents, short-term investments and restricted cash hence fell by \$2m, from \$107m to \$105m.

"Our strong quarter with more than 46% year-over-year revenue growth, GAAP operating profit and significant growth from western customers, reflects our success in pivoting our business following the loss of revenue in 2020 due to Department of Commerce restrictions on certain Chinese customers," says Jenks.

Demand remains strong, but NeoPhotonics expects supply chain constraints to continue to impact revenue through 2022.

www.neophotonics.com

Lumentum completes acquisition of NeoPhotonics

After obtained anti-trust clearance from the People's Republic of China's State Administration for Market Regulation on 29 July, Lumentum Holdings Inc of San Jose, CA, USA has completed its acquisition (announced on 3 November) of San Jose-based NeoPhotonics Corp.

NeoPhotonics is a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications. Lumentum designs and makes photonics products for optical networks and lasers for

industrial and consumer markets.

"I am excited to unite NeoPhotonics' differentiated products and technology and talented team with those of Lumentum," says Lumentum's president & CEO Alan Lowe. "This acquisition better positions us for attractive growth opportunities created by the digital transformation of work and life, which is driving relentless growth in the needed volumes and performance of cloud and network infrastructure," he adds. "I want to thank NeoPhotonics' CEO Tim Jenks and the rest of NeoPhotonics' leadership team for their contributions in getting us to this important milestone."

Under the terms of the merger agreement, NeoPhotonics stockholders will receive \$16 in cash for each share of NeoPhotonics common stock.

Lumentum expects to achieve more than an estimated \$50m in annual run-rate synergies within 24 months of finalizing the transaction. Lumentum financed the transaction with cash from the combined companies' balance sheets.

Due to the timing of closing the NeoPhotonics acquisition, there is no impact to Lumentum's fiscal fourth-quarter 2022.

www.neophotonics.com

www.lumentum.com

US DOE launches \$20m NREL-administered Cadmium Telluride Accelerator Consortium

Led by University of Toledo, First Solar, Colorado State, Toledo Solar and Sivananthan Labs, initiative aims to reduce cost and speed deployment of US-made PVs

The US Department of Energy (DOE) has announced the launch of the Cadmium Telluride Accelerator Consortium — a \$20m initiative designed to make cadmium telluride (CdTe) solar cells less expensive, more efficient and develop new markets for solar cell products.

CdTe solar cells were first developed in the USA and are the second most common photovoltaic technology in the world after silicon. Without strengthened domestic manufacturing capacity, the USA will continue to rely on clean energy imports, exposing it to supply chain vulnerabilities while simultaneously losing out on the job opportunities associated with the energy transition, it is reckoned. The consortium's efforts to spur technological advancements aims to increase the USA's competitiveness, bolster domestic innovation, and support clean electricity deployment supporting President Biden's goal of achieving a net-zero economy by 2050.

"As solar continues its reign as one of the cheapest forms of energy powering our homes and businesses, we are committed to a solar future that is built by American workers," says US Secretary of Energy Jennifer M. Granholm. "DOE is proud to partner with leading solar researchers and companies to chart the future of CdTe technology, which presents an immense opportunity for domestic manufacturers to help ensure our nation's security while providing family-sustaining jobs," she says.

"To move America forward, we need an all-of-the-above strategy that propels our energy independence, lowers costs, and creates good-paying jobs," says Marcy Kaptur, US Representative for Ohio's 9th congressional district.

"Northern Ohio has already revolutionized the field of solar technology. Now, through this remarkable partnership between the US Department of Energy, the University of Toledo, and First Solar [whose US manufacturing plant is in Perrysburg, OH] — our region will become a hub of next-generation energy innovation that is built right here at home by Ohio's workers," she adds.

The new Cadmium Telluride Accelerator Consortium will work on continued cost and efficiency improvements that aim to make CdTe cheaper and more efficient, and more competitive on the global market. To achieve these goals, the team has a broad research plan that includes CdTe doping strategies, characterizing and exploring new CdTe contacting materials, and work to enable a bifacial CdTe module that absorbs light from the front and back of the module. DOE's National Renewable Energy Laboratory (NREL) will administer the consortium, whose leaders were chosen through a competitive solicitation that NREL released last year. The consortium will be led by the University of Toledo, First Solar, Colorado State University, Toledo Solar Inc, and Sivananthan Laboratories Inc.

NREL will serve as a resource, support and technical analysis center as the consortium develops a technology roadmap, conducts research to meet targets set within the roadmap, and regularly assesses the domestic CdTe supply chain for challenges and opportunities. The consortium aims to expand domestic CdTe photovoltaic material and module production, support the domestic CdTe supply chain, and enhance US competitiveness.

DOE's continued investment in CdTe technology

Through NREL and a long-standing partnership with First Solar, DOE has been a leader in CdTe research. DOE's Solar Energy Technologies Office (SETO) supports research focused on overcoming the current technological and commercial barriers for CdTe cells. SETO has awarded funding for research, development and demonstration of methods to improve reliability and lower the cost of CdTe technology.

DOE's Solar Photovoltaics Supply Chain Review Report identified

DOE's Solar Photovoltaics Supply Chain Review Report identified CdTe as an opportunity for expanding domestic production of solar panels, up to the limit that CdTe material availability allows, with little risk of being overtaken by low-cost foreign competition

CdTe as an opportunity for expanding domestic production of solar panels, up to the limit that CdTe material availability allows, with little risk of being overtaken by low-cost foreign competition.

The FY22 Solar Manufacturing Incubator funding opportunity, announced in July, will support projects that ready new technologies and manufacturing processes for commercialization and demonstrate solutions that can boost domestic manufacturing of thin-film photovoltaics made from CdTe.

www.firstsolar.com
www.nrel.gov

First Solar completes sale of Japan project development platform to PAG

Sale of operations & maintenance platform to follow in second-half 2022

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has completed the sale (announced in May) of a 293MW_{DC} utility-scale solar project development platform in Japan, to funds managed by PAG Real Assets (PAG), a Asia Pacific-focused private investment man-

ager with more than \$50bn in assets under management. As part of the sale, the majority of First Solar project development employees in Japan have joined PAG.

Also in May, First Solar announced that it had entered into a definitive agreement for PAG to acquire its solar operations and maintenance

(O&M) platform in Japan, which has about 665MW_{DC} under management. The transaction is expected to close in second-half 2022, after obtaining regulatory approvals, the receipt of third-party consents and satisfying other customary closing conditions.

www.pag.com

First Solar to supply 500MW of CdTe PV modules to France's Akuo

200MW_{DC} to be delivered in first-half 2024 for US utility-scale project; remainder in 2025–2026 for Europe and elsewhere

First Solar says that independent global renewable energy producer and developer Akuo of Paris, France has placed an order for 500MW_{DC} of its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules, comprising the delivery of 200MW_{DC} in first-half 2024 for a utility-scale project developed by Akuo in the USA, and the remainder in 2025 and 2026, potentially powering projects in Europe or other regions where Akuo is present.

Founded in 2007, Akuo has more than 450 staff and is present in 15 countries, including the USA, Spain, Greece, and Portugal. The firm ended 2021 with 1.4GW of assets in operation or under construction and a project development pipeline of over 7GW. The deal, which leverages First Solar's agile contracting approach, allows Akuo to benefit from the evolution of First Solar's cadmium telluride module technology platform over the span of the agreement.

"The solar industry operates against a backdrop of volatility and uncertainty, and this agreement is part of a broader effort to reduce

the long-term supply risks of our global portfolio to actually deliver our projects," says Akuo's CEO Eric Scotto. "First Solar's ability to provide supply chain traceability and its commitment to responsible manufacturing was crucial to us. It leads the industry with its long history of establishing benchmarks in supply chain transparency and the low environmental footprint of its technology, all of which reflects our shared value of responsible business practices," he adds. "As a European player, we are strongly committed to these values, echoing our ambition for the planet."

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance. First Solar also operates a high-value recycling program that recovers about 90% of CdTe semiconductor material (which can be used to manufacture new modules) as well as other materials (including aluminium, glass and laminates). The firm

operates commercial recycling facilities in the USA, Germany, Malaysia and Vietnam. Additionally, it is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain.

"We're pleased to welcome Akuo to a growing number of long-term strategic partnerships with experienced global developers that have placed their trust in First Solar and our technology," says First Solar's chief commercial officer Georges Antoun. "Developers in Europe are recognizing the risks associated with having a geographically concentrated solar supply chain and are electing to take a long-term approach to supply diversity and security by working with us. Our differentiation rests as much on our ability to help our customers navigate volatility and uncertainty as our technology."

www.akuoenergy.com/en
www.firstsolar.com

First Solar issues 2022 Sustainability Report showcasing progress on ESG metrics

Lower greenhouse gas emissions, manufacturing energy, water and waste intensity

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has issued its 2022 Sustainability Report highlighting its continued environmental, social and governance (ESG) progress.

The only US-headquartered company among the world's ten largest solar manufacturers, First Solar's modules are claimed to have the lowest carbon and water footprint and fastest energy payback time of any commercially available PV technology today.

"By placing 'Responsible Solar' at the heart of our business and investing in innovation and scale, First Solar is an example of how solar can be competitive without compromising on principles and purpose," says CEO Mark Widmar. "We have consistently demonstrated that the solar-at-any-cost approach, which turns a blind eye to human and environmental costs of PV manufacturing, does not have to be the norm and that Responsible Solar is now a competitive differentiator."

Highlights in the 2022 Sustainability Report include:

- A 13% year-on-year reduction in greenhouse gas emissions intensity. The firm remains on track to achieve its science-based target of reducing its absolute scope 1 and scope 2 greenhouse gas emissions, from a 2008 baseline, by 34% by 2028 and net-zero emissions by 2050 in line with limiting global temperatures to 1.5°C.

- An 8% year-on-year reduction in manufacturing energy intensity and a cumulative reduction in manufacturing energy intensity per watt by 65% since 2009. First Solar's manufacturing energy intensity includes all processes, from the beginning of its manufacturing process to finished module. The company set a target to improve global energy efficiency per watt produced by 74% by 2028, from a 2009 baseline.

- A 32% year-on-year reduction in manufacturing water intensity and a 78% reduction since 2009. Water recycling initiatives saved more than 268 million liters of water in 2021. After surpassing a previous water intensity target seven years early, First Solar set

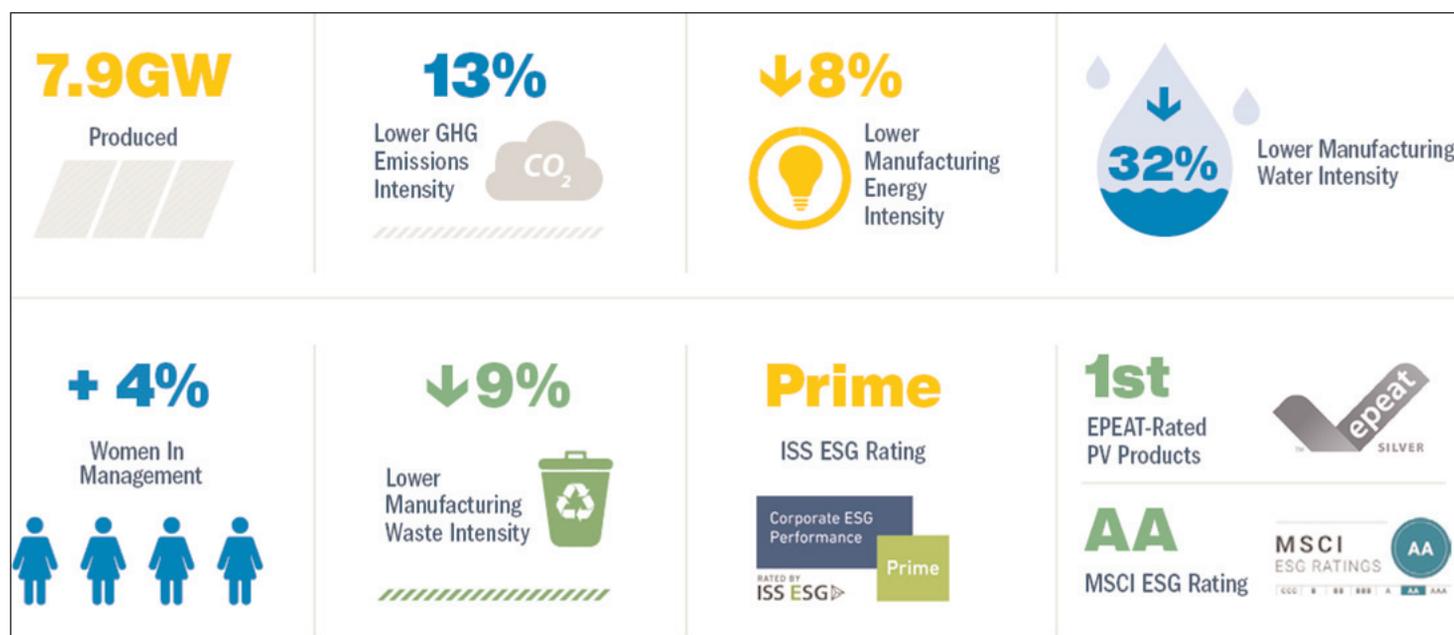
a new target of an 87% reduction in water intensity per watt compared with its 2009 baseline.

- An 8% year-on-year reduction in manufacturing waste intensity and a 55% reduction since 2012.

- A 4% increase in women in management positions compared with 2020. First Solar's board of directors is 33% diverse and the company was recognized as a '3+ company' by 50/50 Women on Boards for having at least three women serve on its board.

Earlier this year, First Solar announced that its 2.7GW_{DC} vertically integrated manufacturing complex in Ohio has achieved Platinum status in the Responsible Business Alliance's (RBA) Validated Audit Process (VAP), providing further validation to customers that they are working with a responsible partner. Platinum is the highest possible rating awarded on completion of a full VAP, which is considered the leading standard for onsite compliance verification and effective, shareable social and environmental audits across industries.

www.firstsolar.com/responsiblesolar



Intersect Power orders 2.4GW of First Solar's modules, for delivery in 2024–2026

Firm to deploy 6.4GW_{DC} of First Solar modules by 2027

First Solar Inc of Tempe, AZ, USA has entered into an agreement to supply 2.4GW_{DC} of its cadmium telluride (CdTe) thin-film photovoltaic (PV) solar modules to Intersect Power LLC. The modules are scheduled to be delivered from 2024 to 2026, making Intersect Power (which previously placed orders for a total of 4.1GW_{DC} in 2019 and 2021) one of the world's largest buyers and operators of First Solar's module technology, with about 6.4GW_{DC} expected to be deployed by 2027.

The modules will be deployed in Intersect Power's solar, storage and green hydrogen projects coming online across the USA in 2025 through 2027. A large proportion of the modules are expected to be produced in First Solar's Northwest Ohio manufacturing complex.

"Intersect Power's ongoing relationship with First Solar has been critical in rapidly scaling our business to meet our vision and reliably delivering our customers value and performance to support their decarbonization goals," says Intersect Power's CEO Sheldon Kimber. "We look forward to bringing this large-scale portfolio to operation, and creating good-paying, American jobs in both construction and manufacturing with First Solar's domestically produced modules."

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance. The modules have a carbon footprint that is 2.5 times lower and a water footprint that is three times lower than the average crystalline silicon solar panel made with cells produced in China. First Solar also operates a high-value recycling program that recovers about 90% of CdTe semiconductor material (which can be used to manufacture new modules) as



well as other materials (including aluminium, glass and laminates). The firm operates commercial recycling facilities in the USA, Germany, Malaysia and Vietnam. Additionally, it is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain.

"Intersect Power sets an important example by maximizing the impact of its investments on the US economy without compromising on competitiveness," comments First Solar's chief commercial officer Georges Antoun. "By powering its growth with American solar, Intersect Power is directly supporting US manufacturing and jobs and enabling a durable domestic supply chain," he adds. "It is also demonstrating the ability of American solar technology not just to compete, but to help drive our country's transition to a sustainable energy future."

First Solar is investing \$680m in expanding America's domestic PV solar manufacturing capacity by

3.3GW annually, by building its third US manufacturing facility, in Lake Township, Ohio. The new facility is expected to be commissioned in first-half 2023 and, when fully operational, will scale the firm's Northwest Ohio footprint to a total annual capacity of 6GW (making it the largest fully vertically integrated solar manufacturing complex outside of China). First Solar has invested over \$2bn in its US manufacturing footprint and, when its third factory is fully operational, will directly employ over 2500 people in Ohio, while supporting an estimated 15,000 indirect jobs through its American supply chain.

In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia, and is building a new 3.3GW factory in India that is expected to be commissioned in second-half 2023. With First Solar's expansion in the USA and India and optimization of its existing fleet, the firm expects that its nameplate manufacturing capacity will double to 16GW in 2024. First Solar is the only US-headquartered company among the world's ten largest solar manufacturers.

www.intersectpower.com

Manz terminates negotiations with Chinese partner on completion of CIGSfab solar project

Equipment maker Manz AG of Reutlingen, Germany — which has three Solar, Electronics and Energy Storage strategic business units, and supplies integrated production lines for copper indium gallium di-selenide (CIGS) solar cells and modules — is terminating negotiations with its Chinese customer Chongqing Shenhua Thin Film Solar Technology Co Ltd after no agreement could be reached on completion of the large-scale solar project CIGSfab. Manz is hence making a related non-cash impairment of €23.2m on a contractual asset.

Since 2017, Manz had been working on the major project for the Chinese partner with a planned total order volume of about €218m, which was interrupted in December 2020 at the customer's request. By the end of 2020, Manz had received payments of about €175m, but had already provided services with a

total value of €198m. As already described in detail in the Annual Report 2021 as well as the Annual General Meeting 2022, Manz's managing board had previously assumed that the customer would fulfill the associated contractually outstanding payments. Contrary to expectations, however, it has not been possible to reach a mutual solution between the contractual parties to date. Therefore, Manz is now pursuing the goal of asserting its claims through the courts.

Due to the impact on earnings from the decision and against the backdrop of the unexpectedly strong increase in raw material and energy costs, a changed project mix, ongoing challenges in global supply chains, and increased economic uncertainties among Manz's customers, Manz's managing board is adjusting its forecast for the 2022 fiscal year (to be announced

on 4 August, together with key financial figures for first-half 2022).

"We will now consistently focus our efforts on the implementation of our growth strategy in the automotive & electro-mobility, battery manufacturing, electronics, energy, and medical technology industries," says CEO Martin Drasch. "Accordingly, we are not undertaking any further technological developments in CIGS thin-film solar technology and have discontinued market development. In the e-mobility market in particular, we have established a strong position as a high-tech equipment manufacturer to benefit from the immense market potential." Manz says that it has recently been able to use this momentum to its advantage and convince numerous international customers with its years of experience in developing innovative production concepts and solutions.

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Optical transceiver market growing at 15% CAGR to \$24.7m in 2027

New applications are driving an expanding data-center infrastructure sector, says Yole.

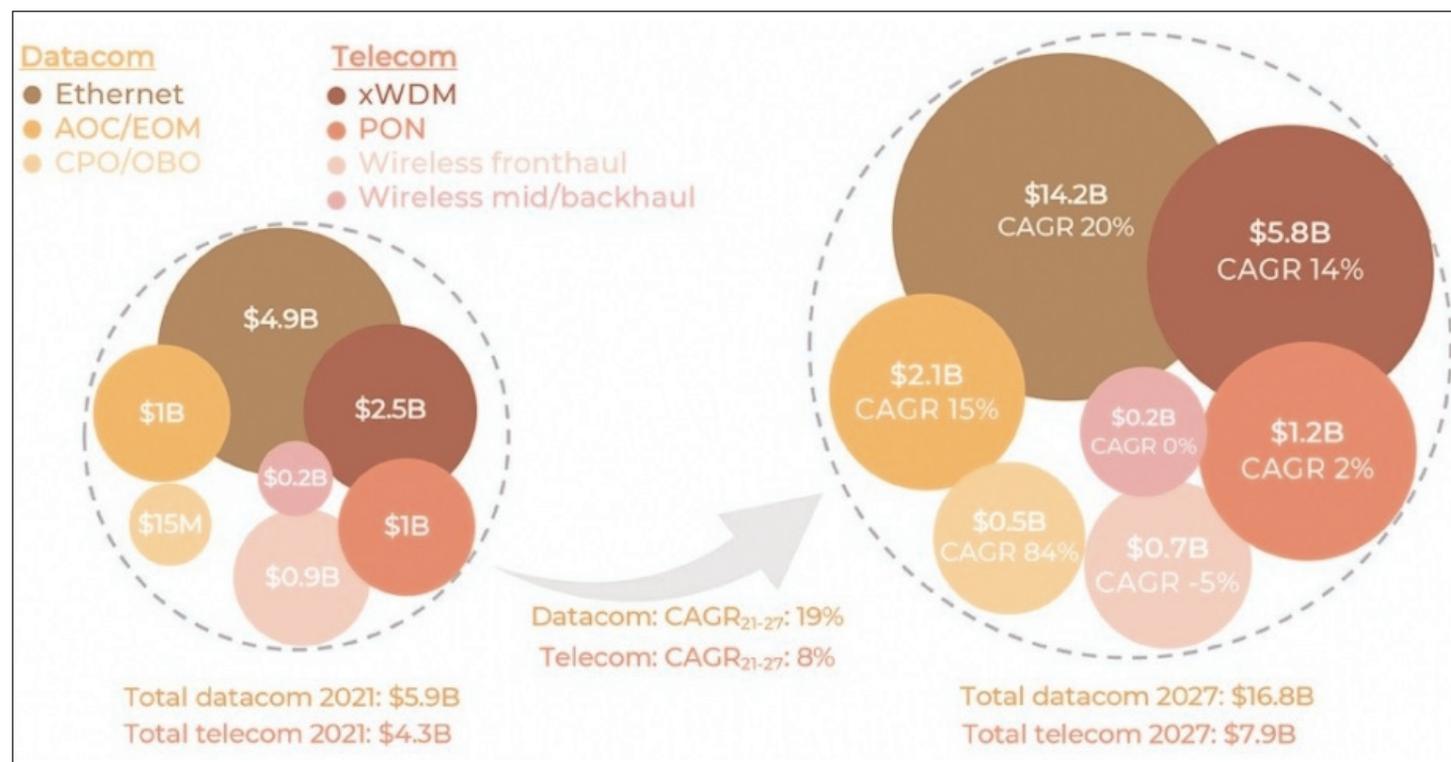
The optical transceiver market is rising at a compound annual growth rate (CAGR) of 15% from \$10.4bn in 2021 to about \$24.7bn in 2027, estimates the report 'Optical Transceivers for Datacom & Telecom 2022' from Yole Group.

Despite the profound implications of the COVID-19 outbreak for the telecom infrastructure supply chain, consumers and business users worldwide continue to demand new networking and cloud services. Social networking, business meetings, video streaming in ultra-high definition (UHD), e-commerce and gaming applications will continue to drive growth, notes the report. With the advent of new digital devices with improved capabilities and intelligence, adoption rates are increasing year by year.

In addition, expanding machine-to-machine applications, such as smart meters, video surveillance, healthcare monitoring, connected drives, and automated logistics, contribute significantly to device and

connection growth and push the expansion of data-center infrastructure. Optical modules have become an essential technology in telecommunication infrastructure. The development of semiconductor technologies such as lasers, modulators and digital signal processors (DSPs) has enabled increased bandwidth and accelerated data rates. Optical interconnects are ubiquitous and are intended to provide high bandwidth even for very short-reach applications, such as high-power computing and artificial intelligence/machine learning (AI/ML) applications within data centers. Silicon photonics (SiPh) as a technology platform, co-packaged optics assembly as a new switch architecture, and coherence in compact form factors are the trends that will drive the market for the next five years, reckons Yole.

"Growth is driven by high-volume adoption of high-data-rate modules above 400G by big cloud service operators and national telecom operators requiring increased fiber-optic network capacity," notes



Optical transceiver revenue growth forecast by datacom application, 2021–2027.

Martin Vallo Ph.D., senior analyst, Photonics (specializing in optical communication and semiconductor lasers within the Photonics and Sensing division at Yole Intelligence, part of Yole Group).

The evolution of multiple technologies has enabled data rates of 400G, 600G, 800G and beyond across data-center infrastructure and in long-haul and metro networks. 400GbE deployments are ramping across data-center networks. Many cloud providers and telecom operators are now starting to deploy an 800Gbps optical ecosystem to increase bandwidth capacity and keep pace with the growing demand for data. Today's modern Ethernet-switch application-specific integrated circuits (ASICs) providing 25.6Tb/s total capacity are running at a 50Gbps SerDes (serialization/deserialization) lane rate driven by 50G PAM-4 modulation technology. In line-cards, a re-timer is typically needed to synchronize PAM-4 data from the switch to the optical interface. In 400G optical modules, an additional silicon gearbox chip can be used to convert 50G PAM-4 electrical inputs and outputs (I/Os) to 100G per wavelength optical I/Os to connect to 100G single-wavelength optics. The next generation of ASIC chips expected in 2023 will provide 51.2Tb/s total capacity and run at a 100Gbps SerDes lane rate. This significantly simplifies electro-optic conversion within the switch system and accelerates the exchange of high-speed optical modules. Yole anticipates high popularity for 800G modules as



Datacom and telecom market shares, 2021.

they take advantage of 100G single-wavelength optics already proven in 400GbE systems and thus can be technically and cost-effectively implemented in QSFP-DD and OSFP form factors.

Yole Group is collaborating with the 24th China International Optoelectronic Expo (CIOE 2022) in Shenzhen, China to organize the Forum on Optical Transceivers and Silicon Photonics on 8 September. ■

www.yolegroup.com/product/report/optical-transceivers-for-datacom--telecom--market-and-technology-report-2022

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Green QD μ LED multi-Gbps visible light communication

Researchers claim record offline distance-rate product of 10Gbps-m.

Researchers based in China and Taiwan report record visible light communication (VLC) performance for quantum-dot micro-sized green light-emitting diodes (QD micro-LEDs) [Zixian Wei et al, ACS Photonics, published online 22 June 2022].

The team from Tsinghua University, Hong Kong Polytechnic University, Harbin Institute of Technology Shenzhen, China, and National Tsing Hua University, Taiwan, comment: "The proposed VLC system has achieved a real-time distance-rate product of 4.2Gbps-m and an offline distance-rate product of 10Gbps-m, which should be further emphasized as the highest record of all the VLC systems based on the single-pixel green LED, to the best of our knowledge."

Further, one QD green micro-LED achieved a claimed record data rate for a single green LED-based

point-to-point real-time non-return-to-zero on-off keying (NRZ-OOK) VLC system of 2.1Gbits/s (Gbps) with a bit-error rate (BER) of $2.7E-3$.

VLC is being proposed for near-field communication (NFC) for downlink or optical device-to-device (D2D) links. Heterogeneous high-speed VLC could use multi-color micro-LEDs in converged illumination, positioning, display, and communication systems. It can be deployed in free-space and underwater optical wireless communication (UOWC) formats.

The team comments: "There is an evolution using a LED array to provide a higher emitting optical power while maintaining the high modulation bandwidth. For the trade-off between single-pixel LED and LED array, we consider the latter is more promising because it can provide more illumination coverage or communication

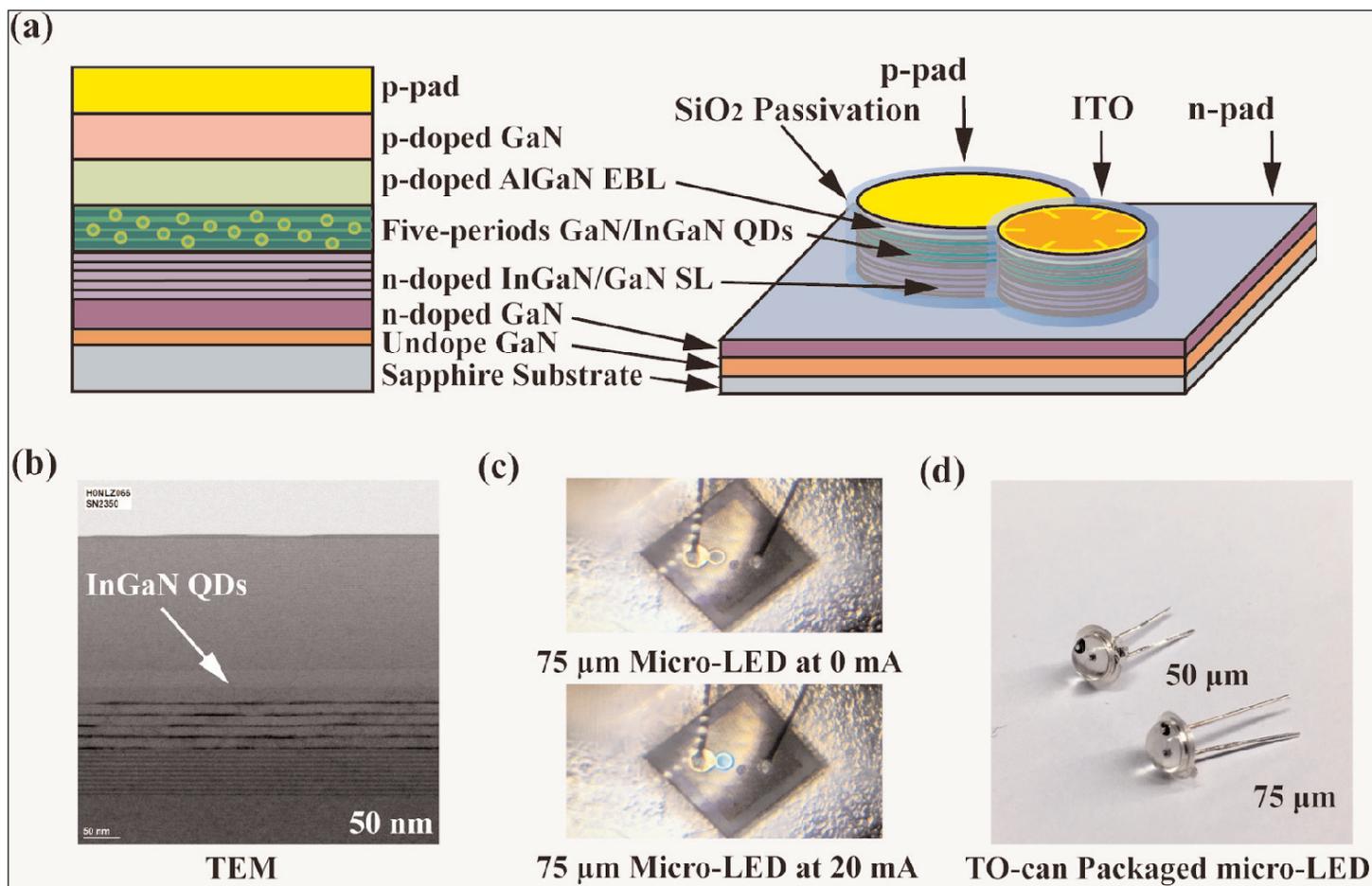


Figure 1. (a) Epitaxial and single-pixel QD micro-LED structure. (b) Transmission electron microscope images of green V-W mode QDs. (c) Packaging of QD micro-LED at 0mA and 20mA injected currents, respectively. (d) Corresponding TO-CAN macro picture with front lens of 50 μ m- and 75 μ m-diameter QD micro-LEDs.

distance for actual VLC applications in a specific space.”

Higher signal power from array formats could find deployment in inter-satellite links, structured light positioning, and multi-user VLC access.

The team describes some of the trade-offs for designing high-bandwidth LEDs: “As the size of the LED decreases, the current density increases and directly leads to an increase in the E–O bandwidth, but at the same time, the effect of sidewall defects also increases, accompanied by a larger leakage current. These factors also restrict E–O bandwidth from increasing indefinitely by shrinking the size.”

The indium aluminium gallium nitride (InAlGaN) epitaxial material for the QD micro-LEDs (Figure 1) was grown on 2-inch sapphire, using metal-organic vapor phase epitaxy: the undoped GaN buffer was 1 μ m thick; the n-GaN contact layer 3.5 μ m; the n-InGaN/GaN superlattice (SL) pre-strain layer 10x(3nm/3nm); the p-AlGaN electron-blocking layer (EBL) 20nm; and the p-GaN contact 180nm.

The active light-emitting QD region was grown in a Volmer–Weber (V–W) self-assembly mode, using a precursor-alternate-admittance method followed by growth of the upper InGaN layer. The QDs were typically 2–3nm high.

LED fabrication began with inductively coupled plasma etch of a gourd-shaped mesa. The light-emission window p-contact region was covered with indium tin oxide (ITO) transparent conductor. The sidewalls were passivated with plasma-enhanced chemical vapor deposition silicon dioxide (SiO₂).

After application of the p- and n-type metals, the devices were packaged in TO-cans, encapsulated in epoxy resin. The lens-shaped epoxy gave a slight convergence to the emitted light, along with protecting the devices from dust particles.

Measured carrier life-times in the quantum dot material were as short as 560ps, “owing to a weak QCSE and small QD sizes”, according to the team.

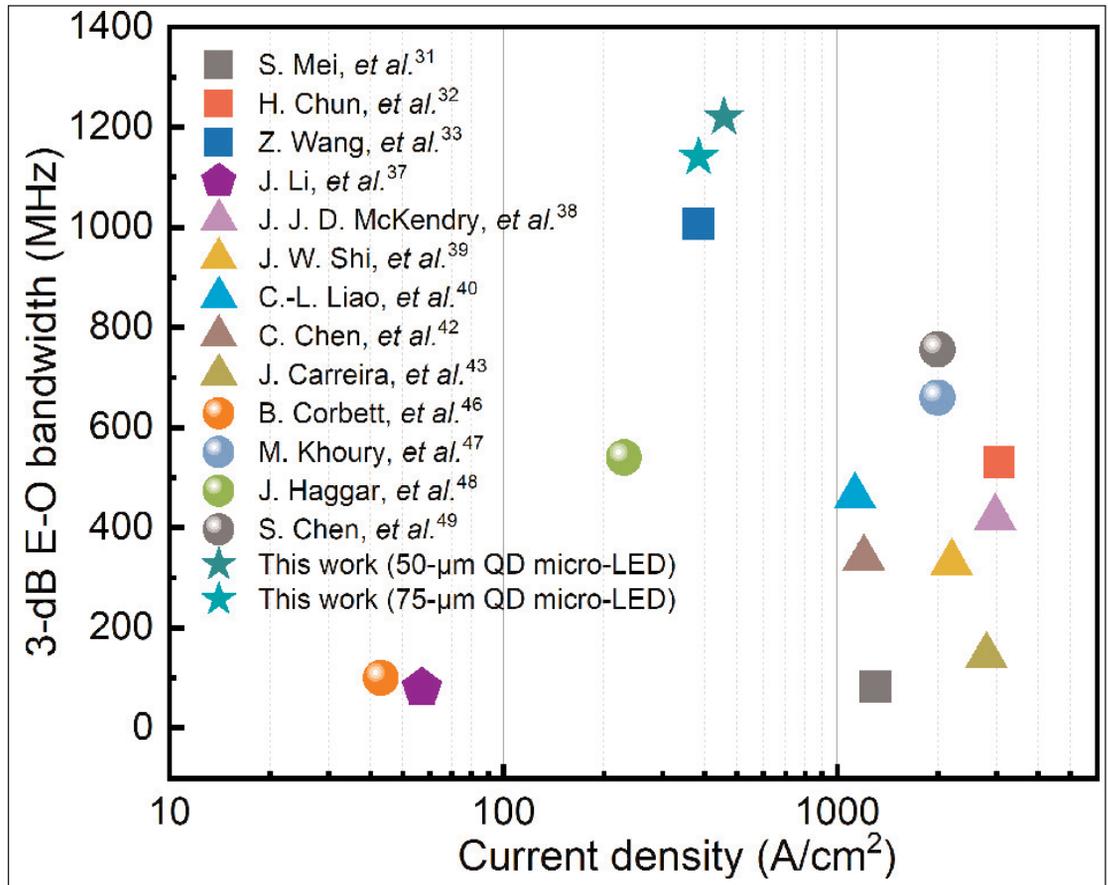


Figure 2. Benchmarks of 3dB E-O bandwidth of long-wavelength LEDs versus various current densities (square symbol: white-light LED; pentagon symbol: surface plasmon-coupled LED; triangle symbol: c-plane LED; sphere symbol: semipolar green LED; star symbol: QD green micro-LED in work reported here).

The quantum-confined Stark effect (QCSE) from charge polarization fields is a key impediment to fast modulation in III–N-based LEDs.

The emission wavelengths varied with current injection and micro-LED size between 492nm and 496nm. The smaller 50 μ m-diameter device tended to emit slightly shorter wavelengths, and the 75 μ m LED slightly longer wavelengths up to 40mA injection. The wavelengths blue-shifted up to around 20mA, and after that the tendency was in the red direction.

At 50mA, the light output powers were 180 μ W and 100 μ W for the 75 μ m- and 50 μ m-diameter LEDs, respectively.

The smaller 50 μ m device achieved a 1.22GHz 3dB bandwidth at 458A/cm² current density (Figure 2). The larger device had a slightly smaller bandwidth of 1.14GHz at 385A/cm². The electrical-to-optical (E–O) bandwidth of transmission over hard polymer-clad fiber reached 1.3GHz at 509A/cm² for the smaller device.

The devices were used in real-time NRZ-OOK and offline pulse-amplitude modulation four-level (PAM-4) experiments over a 2m free-space link.

Although the smaller device showed superior performance in small-signal measurements, the

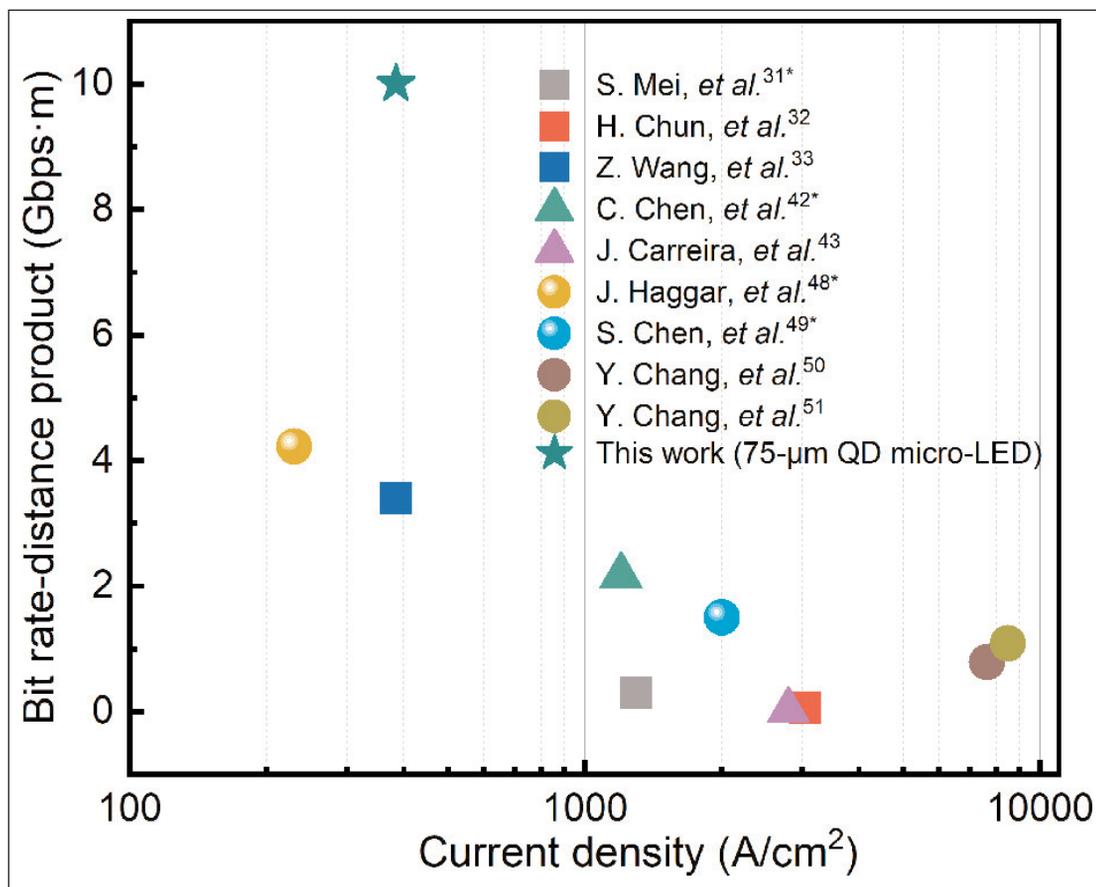


Figure 3. Benchmarks of bit rate-distance product of VLC systems based on long-wavelength single-pixel mini/micro-LEDs or mini/micro-LED arrays versus current density (square symbol: white-light LED; triangle symbol: c-plane LED; sphere symbol: LED; round symbol: semipolar green LED array; star symbol: QD green micro-LED in reported work. * Specific values of the propagation distance are lacking, which are reasonable to assume to be around 1m).

weaker emitted power was a problem in terms of the signal-to-noise ratio (SNR). The team therefore used the 75µm device in the modulation experiments.

The BER decreased as the device bias increased to 6.5V, giving a current density injection of 385A/cm².

At that bias, the device could transmit a 2.1Gbps before the forward error correction (FEC) BER limit of 3.8E-3 was reached.

Higher bias levels would result in more heat generation, a problem given the poor thermal dissipation capability of the TO can package, leading to earlier device breakdown.

The PAM-4 modulation experiments using a Volterra equalizer and a series offline digital signal processor (DSP) managed to reach 5Gbps data rates without breaking the FEC limit. At 407.45A/cm² and 452.72A/cm² current density, the BERs at 5Gbps were 3.6E-3 and 1.9E-3, respectively. The corresponding SNRs were 14.07 and 15.14.

The researchers were unable to go beyond 5Gbps due to the limitations of their arbitrary waveform generator (AWG) equipment.

The offline 10Gbps-m distance-rate product was benchmarked against other reports (Figure 3). ■

<https://doi.org/10.1021/acsp Photonics.2c00380>

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Full-color μ LED pixels for displays and optical near-field communication

Researchers in China have claimed the highest data rates for multi-color LEDs.

Researchers based in China report on all-in-one micro-light-emitting diode pixels (μ LEDs) with integrated red-green-blue super-pixels (RGBSPs) aimed at simultaneous display and optical near-field communication (ONFC) capability [Xinyi Liu, et al, *Optics Express*, v30, p24889, 2022].

"To the best of our knowledge, the proposed integrated μ LED achieves the highest data rate compared to published results based on other multi-color, low-capacitance, high-bandwidth LEDs," reports the team from Hong Kong University of Science and Technology, Southern University of Science and Technology, and HKUST Shenzhen-Hong Kong Collaborative Innovation Research Institute.

The researchers also see potential for the μ LEDs in general lighting applications based on a wide range of color temperatures from warm to cool white.

The researchers fabricated $100\mu\text{m}\times 200\mu\text{m}$ RGBSPs.

The red super-pixels (Figure 1) were created from aluminium gallium indium phosphide (AlGaInP) multiple quantum wells (MQWs) on gallium arsenide (GaAs) substrate by metal-organic chemical vapor deposition (MOCVD). The material was then glued to sapphire and the growth substrate removed by wet etching.

The device mesa was formed using inductively coupled plasma (ICP) etch with silicon dioxide (SiO_2) hard mask. The cathode consisted of 200nm gold/germanium/nickel (Au/Ge/Ni) on the n-GaP contact layer, and the anode was 200nm gold/zinc (Au/Zn) on the p-GaP layer. Plasma-enhanced CVD SiO_2 was used as a 600nm passivation layer. The n- and p-contact pads were electron-beam evaporated indium.

The green and blue super-pixels used MOCVD indium gallium nitride (InGaN) MQWs on sapphire.

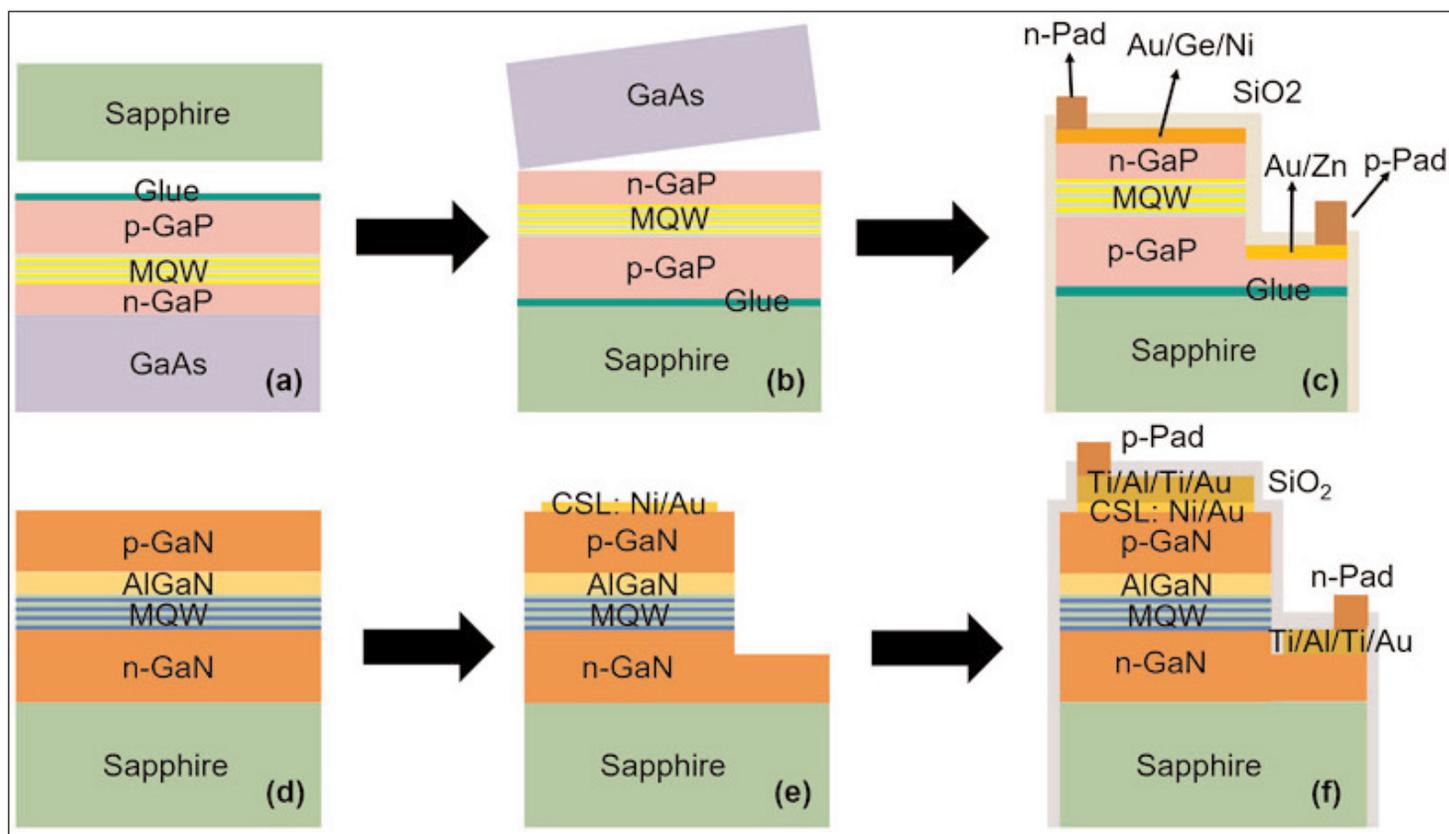


Figure 1. (a–f) Fabrication process flow of AlGaInP red super-pixel (top) and InGaN green/blue super-pixel (bottom) in proposed all-in-one μ LED.

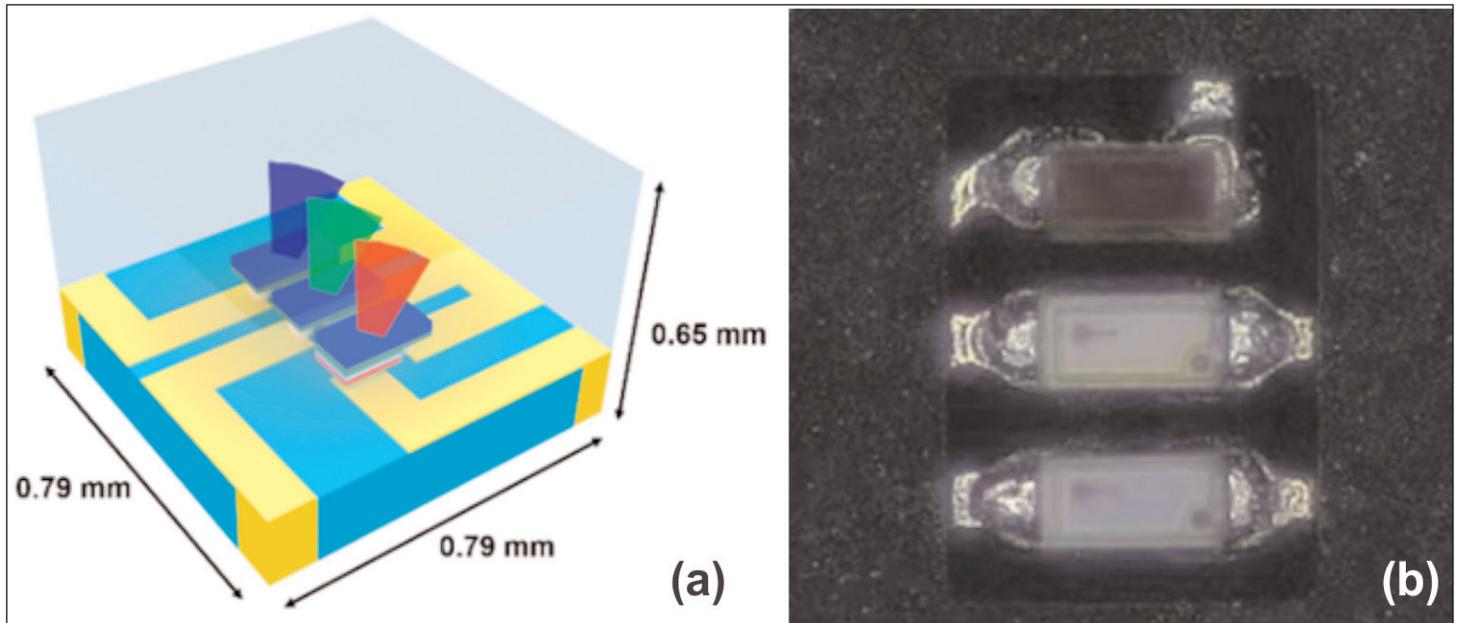


Figure 2. (a) 3D perspective view of μ LEDP internal package structure. (b) Microscope image.

The mesa was again formed by ICP etching. A 10nm layer of Ni/Au was then evaporated on the p-GaN contact material as a current-spreading layer (CSL). The CSL was subjected to rapid thermal annealing to ensure an ohmic contact behavior.

The n-electrodes and p-electrodes consisted of titanium/aluminium/titanium/gold (Ti/Al/Ti/Au). The pad metal was again indium, applied after the deposition of SiO₂ passivation.

The μ LEDP was assembled and packaged by first applying solder bumps to the devices and then singulating the wafers using laser cutting. The RGBSPs were individually transferred and flip-chip bonded at 50 μ m pitch onto a circuit with a common p-pad. Black silicone was used as encapsulation to improve the contrast ratio. The final device measured 0.79mmx0.79mmx0.65mm (Figure 2).

The 10⁻⁴A/cm² turn-on voltages were 1.44, 2.00, and 2.33V for the RGB sub-devices, respectively. The peak light powers were 1.86/2.08/4.33mW, recorded respectively in the same order at 20/55/55mA current injection.

The spectral performance of the RGB devices showed peaks at 640nm, 515nm and 463nm, respectively, with full-widths at half-maximum (FWHM) of 23nm, 38nm and 28nm.

The modulation bandwidth of red-green-blue super-pixels in this report still has room to be improved due to the limitation of transferring sub-pixels from different substrates. The size of RGBSPs was chosen based on the consideration of display and communication link performance

The devices were biased to give 30mA, 55mA and 55mA injection, respectively, for these measurements.

The color gamut of the RGB combination was 109% of the NTSC standard used for analog color TV. Apart from display applications, the device could also meet demands for smart lighting with correlated color temperatures (CCTs) ranging between 2831.7K and 10016.8K — warm through neutral to cool white.

The RGB bandwidths for ONFC derived from S-parameter measurements were 62MHz, 58MHz and 61MHz at 45mA, 70mA and 75mA injection, respectively. The team considers these values to be sufficient for practical ONFC systems. The known parasitic effects of the PCB test fixture and packaging suggest the intrinsic bandwidths were more than 100MHz.

The researchers comment: "The modulation bandwidth of RGBSPs in this report still has room to be improved due to the limitation of transferring sub-pixels from different substrates. The size of RGBSPs was chosen based on the consideration of display and communication link performance."

Bit-error rate (BER) testing with pseudo-random binary sequences showed that data rates up to 220, 170 and 195Mbits/s for RGB, respectively, could be reached without breaking the forward-error correction (FEC) limit of 3.8e-3. The data rates for 10e-9 BER were 201/148/179Mb/s, respectively.

The researchers also developed a compact equivalent circuit model of the device to enable the exploration of various data modulation schemes in simulation such as non-return to zero (NRZ) and 4-level pulse amplitude modulation (PAM-4). The maximum simulated data rates for these schemes were 0.3Gb/s and 1.1Gb/s, respectively. ■

<https://doi.org/10.1364/OE.461762>

Author: Mike Cooke

Stabilizing colors for micro-displays

Sheffield University proposes micro-cavity III-nitride micro-LEDs.

The UK's University of Sheffield has used a simple micro-cavity structure to create micro light-emitting diodes (μ LEDs) with a stable emission wavelength over a range of injection currents [Guillem Martinez de Arriba et al, ACS Photonics, published online 27 May 2022]. Such wavelength stability is one of the key requirements for one of the projected applications of μ LEDs: full-color micro-displays for augmented reality (AR)/virtual reality (VR) imaging.

Indium gallium nitride (InGaN) LEDs suffer from large wavelength shifts with current for a variety of reasons, with one of leading causes being the quantum-confined Stark effect (QCSE). The Stark effect refers to a shift in energy in the presence of electric fields. Applying a

bias to the structure changes the electric field and hence shifts the emission wavelength.

In InGaN LEDs charge polarization of the chemical bonds leads to spontaneous and strain-dependent electric fields in the material even at zero bias. As the indium content of the light-emitting regions of such devices increases to enable longer-wavelength LEDs, the InGaN suffers from increasing strain relative to the base GaN material of its surroundings. Moving to semi-polar or non-polar orientations of the GaN crystal structure does not significantly improve color stability.

The Sheffield approach to stabilizing the wavelength was to create a Fabry-Perot optical cavity that selected a stable wavelength from the μ LED (Figure 1). The

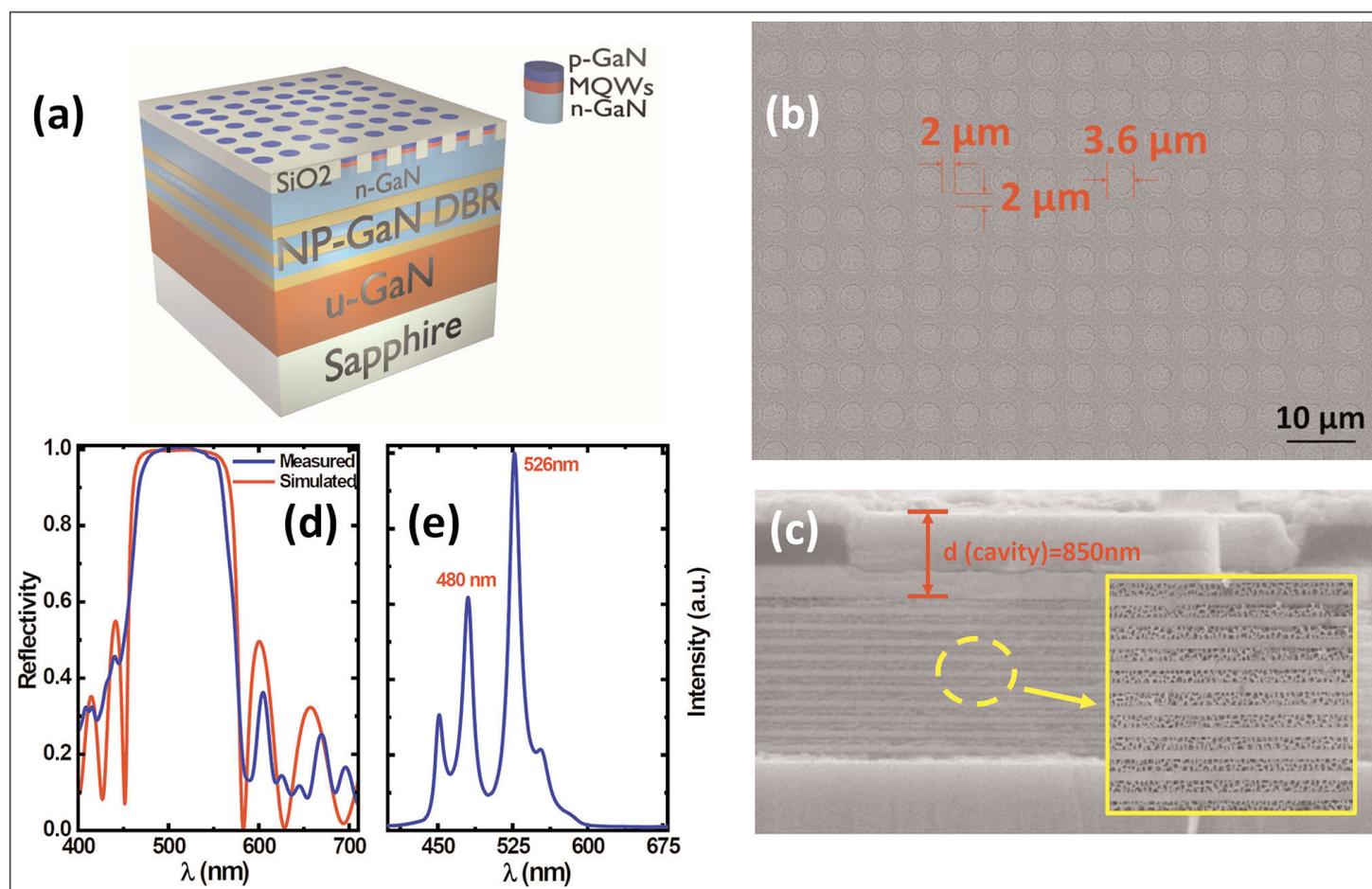


Figure 1. Schematic of μ LEDs with bottom NP GaN DBR with lattice matching (a); (b) plane-view scanning electron microscope (SEM) image of regularly arrayed μ LED epilayer with 3.6 μ m-diameter devices at 2 μ m; interpitch (c) cross-sectional SEM image of NP-GaN/undoped GaN DBR (inset: zoomed image); (d) reflectance spectra of NP GaN DBR and FDTD simulated results; (e) mode spectrum, which is obtained by using the 3D FDTD simulations to confirm the existence of optical modes.

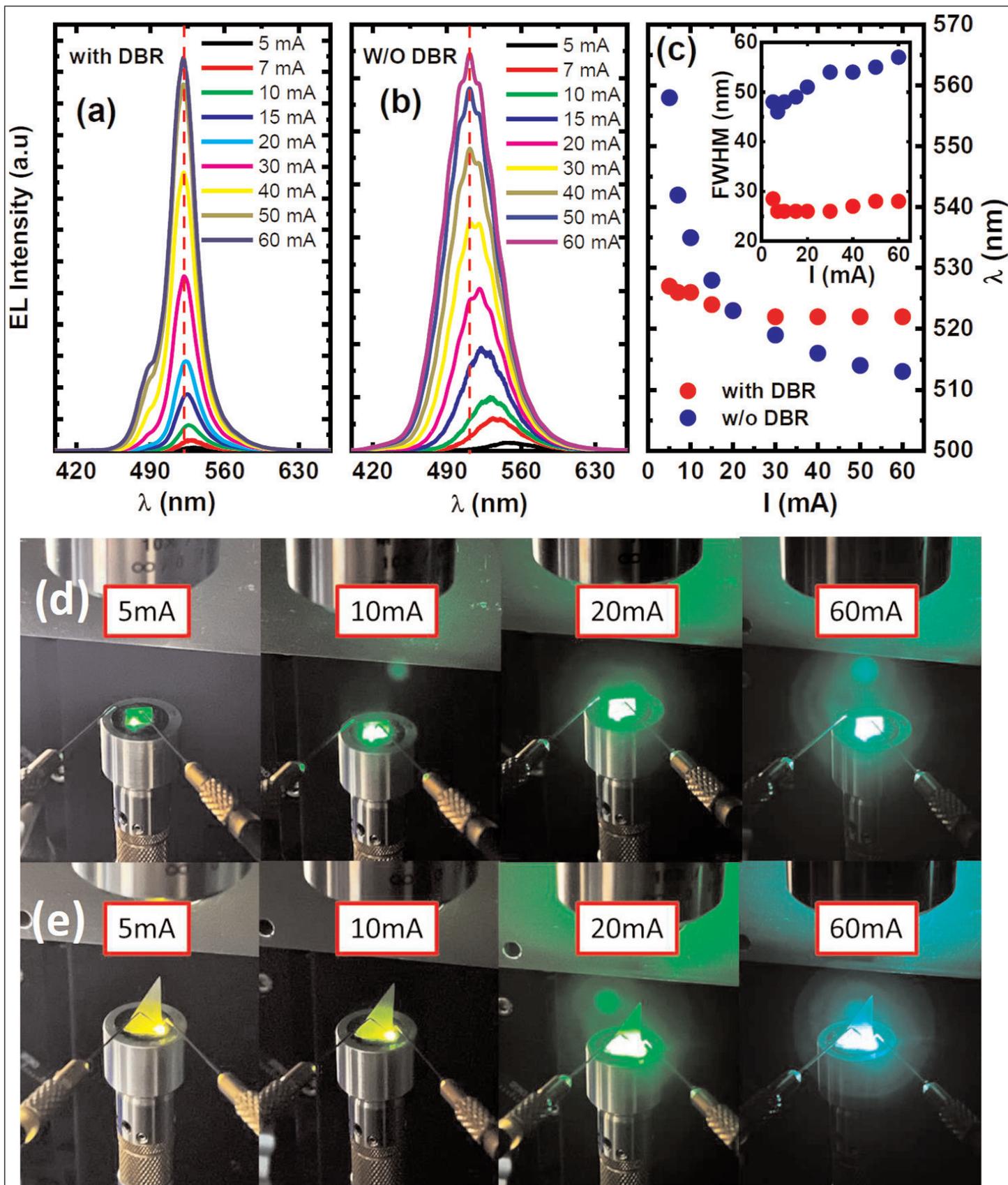


Figure 2. Electroluminescence (EL) spectra μ LEDs with (a) and without (b) DBR as function of injection current; EL emission wavelength and full-width half-maximum (FWHM) of EL spectra versus injection current (I) (c); EL emission images of μ LEDs with DBR (d) and without DBR (e) as function of injection current.

cavity was formed between a distributed Bragg reflector (DBR) and the top interface with the air. The team comments: "This approach provides a simple solution

to resolving the 30-year issue in the field of III-nitride optoelectronics."

The DBR was formed from the large refractive index

contrast between solid and nanoporous (NP) GaN layers. The nanoporosity was achieved by an electrochemical (EC) etch process.

The NP-GaN DBR was fabricated on an undoped GaN template on sapphire, created using a two-step metal-organic vapor phase epitaxy (MOVPE) process. The DBR region material consisted of 11 pairs of alternating heavily n^{++} -doped (10^{19} - $10^{20}/\text{cm}^3$) and undoped GaN.

The initial material was completed with a 300nm n -GaN ($5 \times 10^{18}/\text{cm}^3$) layer and 500nm plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2).

The top SiO_2 dielectric layer was punctured with an array of circular holes by inductively coupled plasma etch. The μLEDs were formed using MOVPE selective epitaxial overgrowth in these holes. This avoided the usual plasma etch normally used to fabricate μLED , which tends to create sidewall damage, resulting in increased current leakage.

The LED layers were n -GaN contact, $\text{In}_{0.05}\text{Ga}_{0.95}\text{N}$ pre-layer, $5 \times (2.5\text{nm InGaN}/13.5\text{nm GaN})$ multiple quantum well, 20nm aluminium gallium nitride electron-blocking layer, and 200nm p -GaN contact. The total thickness of the LED structure came to an approximate level with the 500nm SiO_2 dielectric.

The NP-GaN was then formed from the electrically conductive n^{++} -GaN layers being subjected to EC etching. The reflectance properties of the resulting material showed a 122nm stop-band around a central wavelength of 520nm, matching the designed performance from finite-difference time-domain (FDTD) simulations.

The DBR formed an effective cavity length for the μLEDs of more than 1 μm (850nm physical + electric field penetration into the DBR). The researchers estimated

the refractive index of the NP-GaN at 1.75, based on an observed 0.6 porosity. The refractive index of solid GaN is around 2.3.

The EC process used an indium anode, platinum cathode, and 0.3 molar concentration nitric acid solution. The EC bias was 5.5V.

The μLED material with and without being subjected to EC etching was fabricated into $330\mu\text{m} \times 330\mu\text{m}$ devices with indium tin oxide (ITO) transparent conductor on the p -GaN and titanium/aluminium/nickel/gold metal for the n -contact. The electrodes were titanium/gold. No extra measures were applied to enhance light extraction such as optical coatings, passivation, epoxy encapsulation, or reflectors.

While the μLEDs without DBR (Figure 2) show a strong shift in wavelength with increased injection current (560–510nm for 5–60mA increase), the device with DBR shows a relatively stable emission (less than 10nm around 525nm). Also, the DBR narrows the spectral line by about half. "Only at a high injection current, a weak shoulder at 480nm appears due to the second optical mode," the team explains.

Visibly, while the DBR μLED has a stable green emission throughout the injection range, without the DBR there is a clear transition through yellow, yellow-green, green, and ending up at blue-green. This region of the spectrum is the one to which the human eye is most sensitive to color changes.

The researchers comment: "Such a blue-shift in emission wavelength with increasing injection current is the fingerprint of QCSE. Such μLEDs cannot be used for the fabrication of a micro-display. In contrast, the μLEDs with DBR constantly emit green light throughout all the injection current." ■

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Buffers for GaN power on AlN substrate

Closer thermal expansion performance could enable larger-diameter growth substrates.

Researchers based in Belgium and Germany report on gallium nitride (GaN) buffer structures on 200mm polycrystalline aluminium nitride (poly-AlN) substrates aimed at >1200V hard breakdown power applications such as electrical vehicles [Anurag Vohra et al, Appl. Phys. Lett., v120, p261902, 2022].

One advantage of using poly-AlN as a substrate is that the coefficient of thermal expansion is much closer to that of the GaN/AlGaIn used in buffers than for other substrates, such as silicon Si (111).

According to the team from Belgium's Imec vzw, Germany's Aixtron SE, and CMST imec and Ghent University in Belgium, this paves the way to thicker buffer structures on large-diameter substrates, while maintaining and enabling higher-voltage operation.

The researchers used Imec's proprietary reversed stepped superlattice (RSSL) buffer scheme. They comment: "The RSSL buffer scheme features a much larger flexibility in stress engineering and, hence, becomes a more promising candidate for the growth of thick buffer structures on the engineered substrates of

large size, which show different mechanical behaviors than regular silicon substrates."

The researchers used 200mm engineered poly-AlN Qromis Substrate Technology (QST) substrates supplied by Qromis Inc. The epitaxial growth was performed in an Aixtron G5+ C planetary reactor. The growth substrates included a Si (111) top layer bonded to the QST poly-AlN by silicon (di)oxide (SiO).

The RSSL buffer stacks (Figure 1) were grown with (Ex C-doped) and without intentional carbon doping. Of course, in metal-organic chemical vapor deposition (MOCVD) some intrinsic C-doping is almost unavoidable. One can affect this intrinsic C incorporation by tuning of the growth temperature V/III (N/AlGa) ratio, for example.

The aim of the work was to maximize the breakdown voltage of the buffer stack through optimizing the Al contents, C-doping and buffer thickness. Higher Al content should increase the critical field for breakdown. Thicker buffers should have a lower field at the AlN/Si nucleation interface for a given potential. The layers

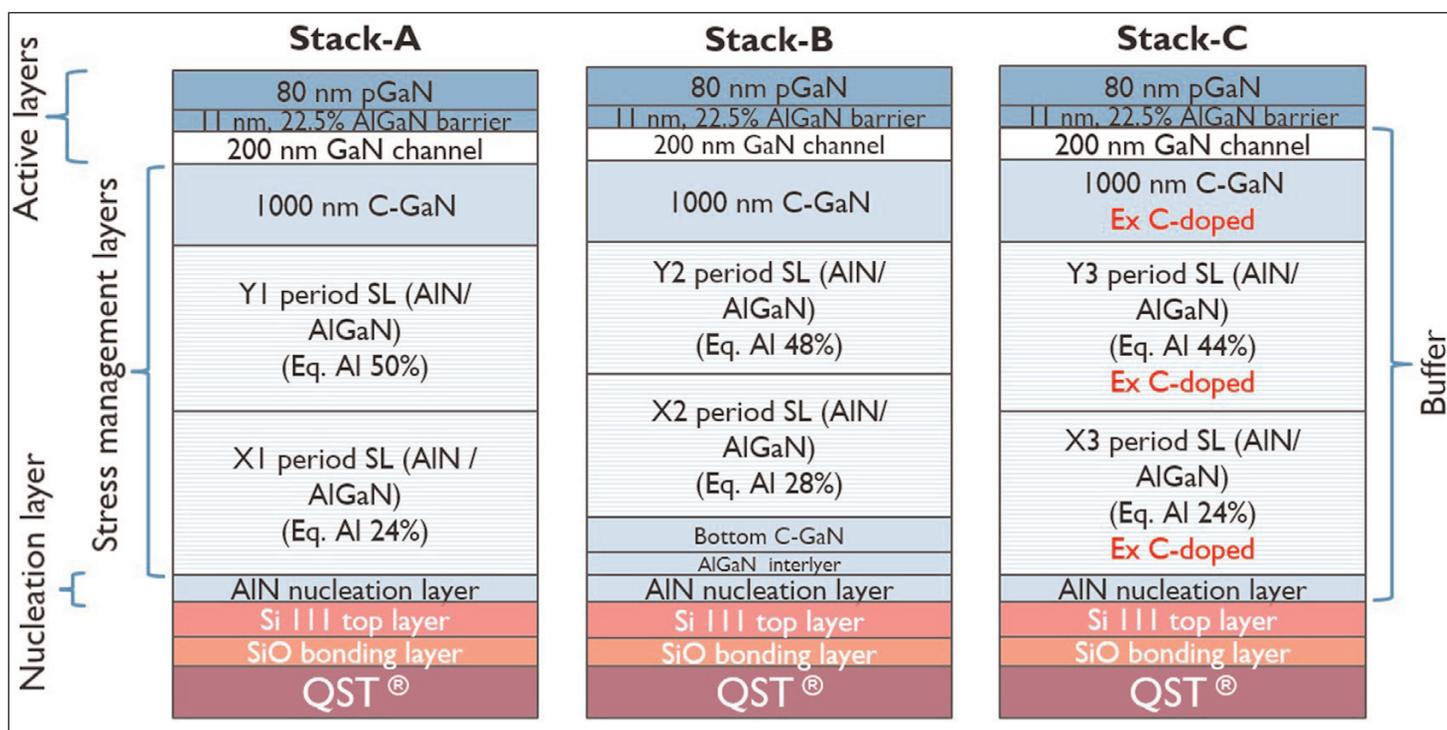


Figure 1. High-electron-mobility transistor (HEMT) stacks based on intrinsic (stack A and stack B) and extrinsic (stack C) C-doping. Buffer thicknesses of stack A and stack B varied from 5.3–7.4µm to 4.8–6.1µm, respectively. Stack C had a thickness of 6.8µm.

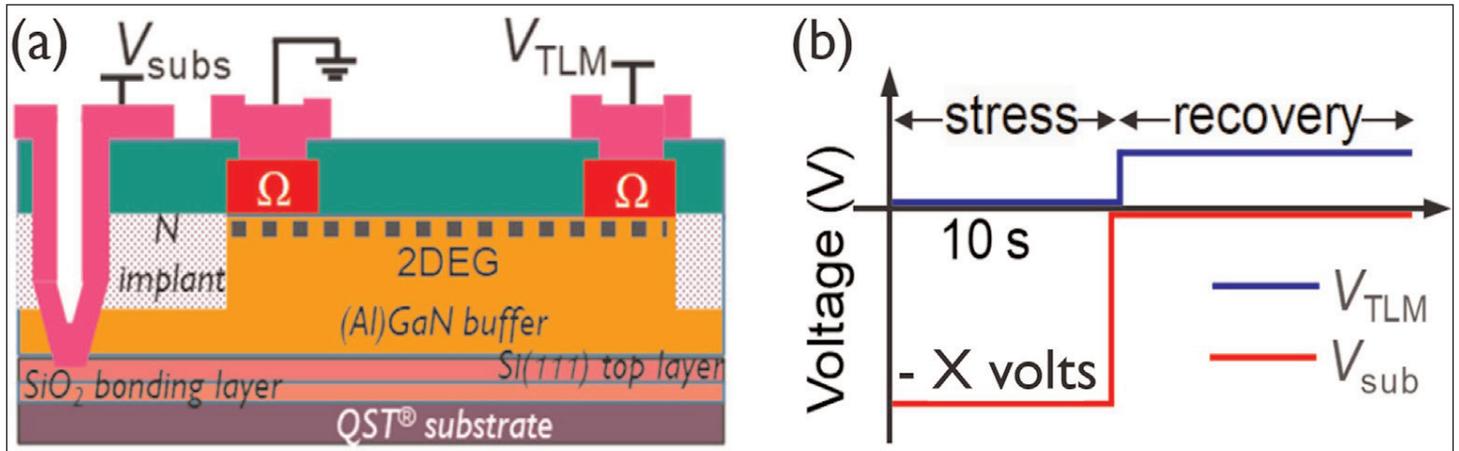


Figure 2. (a) Test structure and (b) test procedure to measure buffer dispersion. X varies from -650V to -1200V, depending on stack thickness.

were designed to manage the stress and thus avoid excessive wafer bowing.

The researchers were unusually relaxed about a high threading dislocation density emanating from the AlN/Si nucleation interface: "Defect control has not been focus of this study as it is known on the contrary that large density of these defects might actually help to reduce the dispersion for intentionally C-doped buffers."

Low dispersion is a key need of dynamic power management where the device performance needs to be almost the same as in DC operation when switched on and off, and for recovery from high voltage stress.

The vertical breakdown of the buffers was measured at 25°C and 150°C. The target limits for leakage current density were 1 μ A/mm² and 10 μ A/mm², respectively.

Stack A with 7.2 μ m thickness met the target of more than 1200V, but there was asymmetry in the breakdown voltage for forward bias and reverse bias, a difference of 300V at 150°C.

Stack B only managed a ~900V breakdown rating for 6.1 μ m thickness, but the team is confident that a thicker 7 μ m stack with this structure could meet the 1200V requirement. On the plus side, the performance was more symmetrical between forward and reverse biasing. The researchers attribute this to the insertion of bottom C-GaN and AlGaN interlayers.

The extrinsic C-doped stack C showed negligible difference in current-voltage performance in forward and reverse bias. **The RSSL buffer scheme features a much larger flexibility in stress engineering and, hence, becomes a more promising candidate for the growth of thick buffer structures on the engineered substrates of large size, which show different mechanical behaviors than regular silicon**

For stacks A and B the non-uniformity in C concentration caused the

center part of the wafers to have lower breakdowns than the mid and edge regions. The team expects that improvements in uniformity could be seen from adjusting local V/III ratio and flow distributions.

The researchers prefer the extrinsic doping approach, commenting: "Adjusting the C-level by an intrinsic doping level requires unfavored process conditions for crystal quality and limits the process parameter space significantly. As a preferred choice, the C-level and uniformity can be controlled by using an external C-doping source. This allows a very wide process window and combines very high crystal quality with C-density optimized for high breakdown and with little to no buffer dispersion."

Stack C met the 1200V rating at 25°C, but exhibited some failures in the 1000–1100V range at 150°C. The researchers comment: "The root cause for these sudden failures is not yet understood. For the moment, we can exclude extrinsic C-doping as the origin of these failure, as earlier experiments in GaN-on-Si have shown improved device yield."

The team believes that the higher temperature would also meet the 1200V rating for all test structures at 150°C if the thickness were increased from 6.8 μ m to 7.2 μ m.

Two-dimensional electron gas (2DEG) transmission line method (TLM) structures (Figure 2) were used to find the dispersion of the buffers. Resistances before and after a 10s back-gate negative bias were compared to give the dispersion.

For stack A the dispersion was in the range \pm 25%. For stack B the range was \pm 5%, but the back gate stress was -900V rather than -1200V. The team comments: "The extrinsically C-doped stack C shows advantages over the intrinsic doping in stack A with a very narrow distribution for buffer dispersion even at -1200V."

The dispersion range was below 7% for stack C, both at 25°C and 150°C. ■

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Gallium oxide power switching

A US-based team has reported a record Huang material figure of merit for β -Ga₂O₃ MESFETs without field plates.

Researchers based in the USA report record performance for metal-semiconductor field-effect transistors (MESFETs) without field plates constructed from β -polytype gallium oxide (β -Ga₂O₃) material [Daniel M. Dryden et al, IEEE Electron Device Letters, published online, 13 June 2022]. The record performance came in the form of an estimated Huang material figure of merit (HMFOM) of $17.5(W/C)^{1/2}$ and a 2.45kV breakdown (the latter a record for devices without field plates). The HMFOM is considered "competitive with commercial wide-bandgap devices".

The absence of field plates reduces parasitic capacitance, increasing switching speed. The team from KBR Inc., Air Force Research Laboratory, Cornell University, and Teledyne Scientific Company, see the potential for deployment in power switches and switch-mode amplifiers.

The electrical properties β -Ga₂O₃ have recently prompted much research as the next stage for high-voltage/high-power devices. The ultra-wide bandgap of 4.8eV results in a high critical electric field of order 8MV/cm.

The theoretical limit for the Baliga power FOM (PFOM) is 28GW/cm², compared with 8.6GW/cm² and 3.35GW/cm²

for gallium nitride (GaN) and silicon carbide (SiC), respectively. The HMFOM limit for β -Ga₂O₃ comes in at $126(W/C)^{1/2}$ (GaN: 104, SiC: 79).

The power figure of merit represents the trade-off between on-resistance and breakdown. By contrast, the HMFOM is aimed at the storage charge lag/resistance trade-offs involved in power-switching.

The device material (Figure 1) consisted of silicon (Si)-doped β -Ga₂O₃ on semi-insulating iron (Fe)-doped substrate. The device layer growth was through ozone molecular beam epitaxy. The crystal structure was (010) oriented. The substrate was supplied by Japan-based Novel Crystal Technologies. Hall measurements suggested a carrier density of $1.1 \times 10^{18}/\text{cm}^2$ and $84\text{cm}^2/\text{V-s}$ mobility.

The device isolation was created by inductively coupled plasma etch using boron trichloride and chlorine. The ohmic contact regions were subjected to silicon implantation.

After 900°C annealing to activate the implants, the source/drain (s/d) titanium/aluminium/nickel/gold electrodes were applied using electron-beam evaporation. The device was completed with a gate and s/d contact pads consisting of nickel/gold, and plasma-enhanced

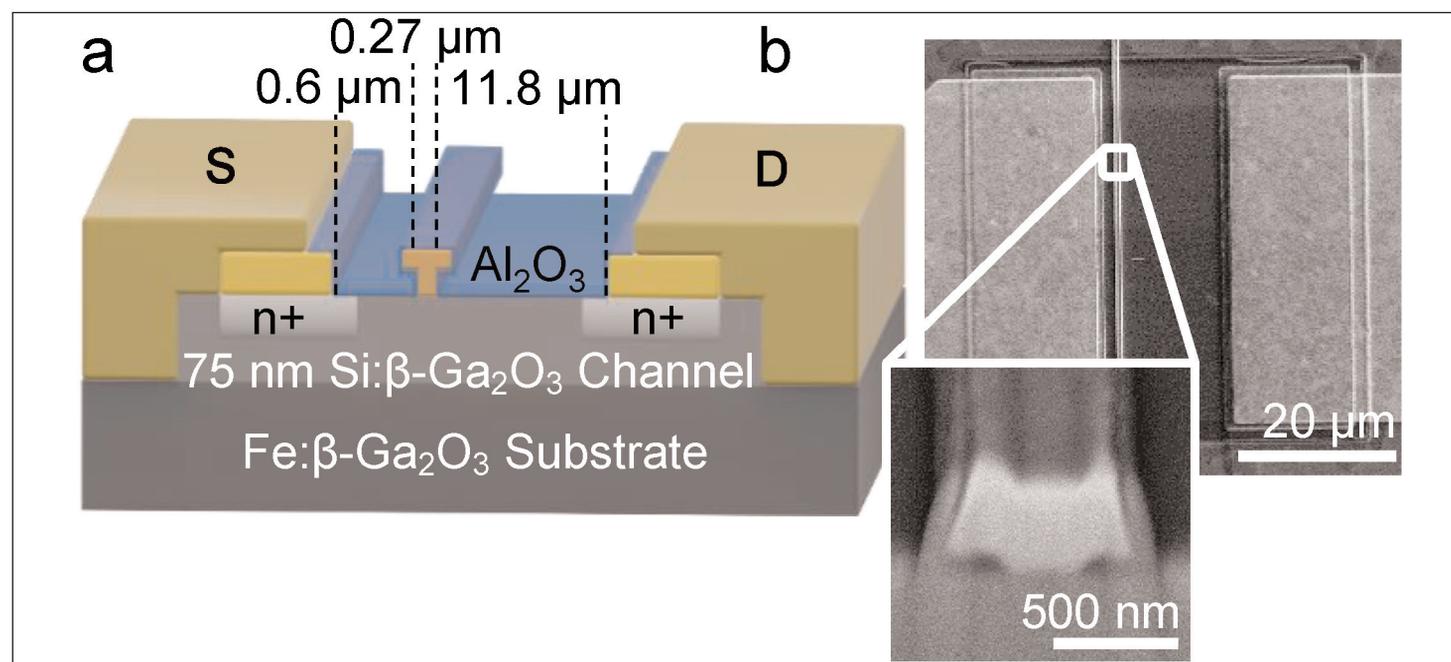


Figure 1. (a) Cross-sectional schematic of MESFET, and (b) scanning electron microscope (SEM) plan view; inset, SEM focused ion-beam cross section of scaled T-gate.

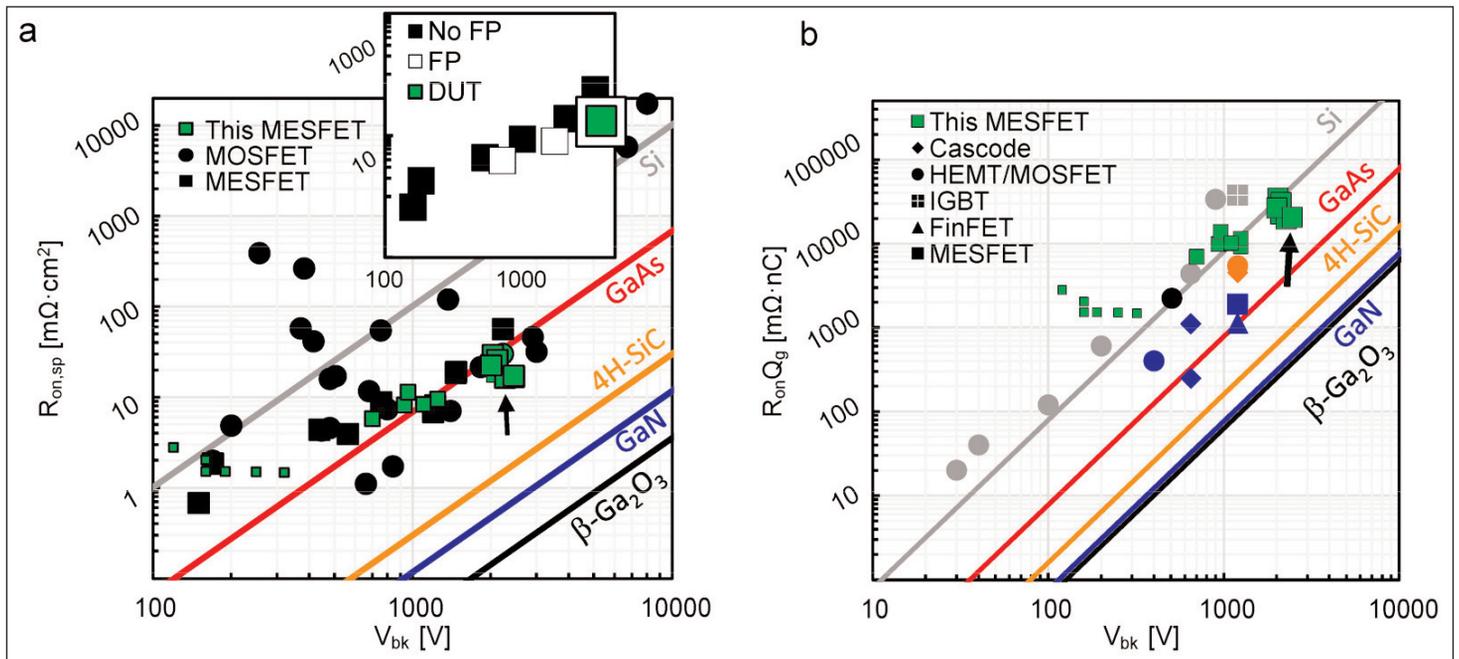


Figure 2. (a) Baliga PFOM for team's (green) and other (black) reported β -Ga₂O₃ devices. Devices with L_{sd} of 3μm, 8μm and 13μm indicated by small, medium and large symbols, respectively. Inset: Comparison of team's MESFET (green) to devices with (empty) and without (filled) field plates. (b) Huang's MFOM $R_{on}Q_{gd}$ versus V_{bkr} including team's (green) and other reported devices. Color indicates material system and shape device geometry.

atomic layer deposition (ALD) aluminium oxide passivation on the channel region outside the gate. The devices were 50μm wide.

A device with 13μm source–drain distance (L_{sd}) had –6V off voltage, –4.2V threshold, 10^4 on/off ratio, and 329mV/decade subthreshold swing at 10V drain bias. The maximum drain current and peak transconductance at 10V drain bias were 60mA/mm and 26.5mS/mm, respectively. The conduction at zero gate potential was ohmic with a high resistance of 17.3mΩ·cm² normalized to the active device area.

The breakdown (V_{bk}) in Fluorinert liquid came at 2.45kV, claimed as a record for β -Ga₂O₃ MESFETs without field plates. The average electric field between the source and drain was estimated at 2.08MV/cm. Field plates and more passivation could increase this performance, but at the cost of increasing parasitic capacitance, impacting switching speeds in applications.

The Baliga power figure of merit (PFOM, $V_{bk}^2/R_{on,sp}$) was 347MW/cm² (Figure 2). The researchers point out that this exceeds the theoretical performance of silicon and gallium arsenide. Further, the result is “nearly as high as record field-plated β -Ga₂O₃ MESFETs and a record for non-field-plated MESFETs, three times higher than the previously reported record of 115MW/cm²”.

The researchers seem a little puzzled by an increase of PFOM with gate–drain distance (L_{gd}). The team comments: “Larger devices appear to spread the applied potential over longer distances (higher depletion widths) than predicted, leading to decreased peak

fields and thus higher V_{bk} than expected. The head of the T-gate likely provides some degree of electric field management in all devices, independent of L_{gd} . This observed deviation in the device depletion profile from the 1D approximation — as well as the apparent increase in average field with increasing L_{gd} — is not intuitive, and determining the underlying mechanism is a subject of ongoing modeling and investigation.”

There was little current collapse due to gate pulses, as seen in other β -Ga₂O₃ devices. The current collapse due to drain switching from 25V quiescent to 10V on was less than 30%. The researchers comment on the small gate lag: “The lack of gate oxide and its associated defect traps plays a role, though previously reported β -Ga₂O₃ MOSFETs also show low gate lag.”

The estimated HMFOM ($\mu^{1/2}Ec = V_{bk}/(R_{on}Q_G)^{1/2}$) was estimated at 17.5(W/C)^{1/2}. The researchers made the estimate on the basis that the Miller charge (Q_{gd}), 7.89pC, was the dominant contribution to the switching charge (Q_G). The source-side charge (Q_{gs}) was estimated at 0.128pC. The team comments: “This estimated HMFOM is the highest reported for β -Ga₂O₃, competitive with commercial SiC devices, and comparable to some GaN devices but at a markedly higher V_{bk} .”

The researchers suggest improvements could result from lower contact resistance, self-aligned gates, and increasing carrier mobility. ■

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Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

Kayaku Advanced Materials Inc

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

Praxair Electronics

(see section 5 for full contact details)

Versum Materials

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

8 Wafer processing equipment

Evatec AG

Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

EV Group

DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com

EV Group is a technology and market leader for wafer processing equipment. Worldwide industry standards for aligned wafer bonding, resist processing for the MEMS, nano and semiconductor industry.

Logitech Ltd

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

Plasma-Therm LLC

(see section 6 for full contact details)

SAMCO International Inc

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

SPTS Technology Ltd

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

SUSS MicroTec AG

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

Synova SA

Ch. de la Dent d'Oche,
1024 Ecublens,
Switzerland
Tel +41 21 694 35 00
Fax +41 21 694 35 01
www.synova.ch

TECDIA Inc

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

Veeco Instruments Inc

(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd

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

PLANSEE High Performance Materials

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Austria
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info@plansee.com
www.plansee.com

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

10 Gas and liquid handling equipment

Cambridge Fluid Systems

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

CS CLEAN SOLUTIONS AG

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

Entegris Inc

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

IEM Technologies Ltd

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

Vacuum Barrier Corporation

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

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11 Process monitoring and control

Conax Technologies

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

k-Space Associates Inc

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

KLA-Tencor

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

LayTec AG

Seesener Str.
10-13,
10709 Berlin,
Germany
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Fax: +49 30 89 00 180
www.laytec.de



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Tel: +1 781 933 3570

Fax: +1 781 933 9428

www.vacuumbARRIER.com

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WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)

Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald,
Germany

Tel: +49 7723 9197 0

Fax: +49 7723 9197 22

www.wepcontrol.com

12 Inspection equipment**Bruker**

Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187, Germany

Tel: +49 (0)721 595 2888

Fax: +49 (0)721 595 4587

www.bruker.com

KLA-Tencor

160 Rio Robles, Suite 103D,
San Jose, CA 94538-7306,
USA

Tel: +1 408 875-3000

Fax: +1 510 456-2498

www.kla-tencor.com

13 Characterization equipment**J.A. Woollam Co. Inc.**

645 M Street Suite 102,
Lincoln, NE 68508, USA

Tel: +1 402 477 7501

Fax: +1 402 477 8214

www.jawoollam.com

Lake Shore Cryotronics Inc

575 McCorkle Boulevard,
Westerville, OH 43082, USA

Tel: +1 614 891 2244

Fax: +1 614 818 1600

www.lakeshore.com

14 Chip test equipment**Riff Company Inc**

1484 Highland Avenue, Cheshire,
CT 06410, USA

Tel: +1 203-272-4899

Fax: +1 203-250-7389

www.riff-co.com

Tektronix Inc

14150 SW Karl Braun Drive,
P.O.Box 500, OR 97077, USA

www.tek.com

15 Assembly/packaging materials**ePAK International Inc**

4926 Spicewood Springs Road,
Austin, TX 78759, USA

Tel: +1 512 231 8083

Fax: +1 512 231 8183

www.epak.com

Gel-Pak

31398 Huntwood Avenue,
Hayward, CA 94544, USA

Tel: +1 510 576 2220

Fax: +1 510 576 2282

www.gelpak.com

Wafer World Inc

(see section 3 for full contact details)

Materion Advanced Materials Group

2978 Main Street,
Buffalo, NY 14214, USA

Tel: +1 716 837 1000

Fax: +1 716 833 2926

www.williams-adv.com

16 Assembly/packaging equipment**CST Global Ltd**

4 Stanley Boulevard,
Hamilton International
Technology Park,

Blantyre, Glasgow G72 0BN, UK

Tel: +44 (0) 1698 722072

www.cstglobal.uk

Kulicke & Soffa Industries

1005 Virginia Drive,
Fort Washington,
PA 19034,
USA

Tel: +1 215 784 6000

Fax: +1 215 784 6001

www.kns.com

Palomar Technologies Inc

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Carlsbad, CA 92010,
USA

Tel: +1 760 931 3600

Fax: +1 760 931 5191

www.PalomarTechnologies.com

PI (Physik Instrumente) L.P.

16 Albert St . Auburn ,
MA 01501, USA

Tel: +1 508-832-3456,

Fax: +1 508-832-0506

www.pi.ws

www.pi-usa.us

TECDIA Inc

2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA

Tel: +1 408 748 0100

Fax: +1 408 748 0111

www.tecdia.com

17 Assembly/packaging foundry**Quik-Pak**

10987 Via Frontera,
San Diego, CA 92127, USA

Tel: +1 858 674 4676

Fax: +1 8586 74 4681

www.quikicpak.com

18 Chip foundry**CST Global Ltd**

4 Stanley Boulevard, Hamilton
International Technology Park,
Blantyre, Glasgow, G72 0BN,
UK

Tel: +44 (0) 1698 722072

www.cstglobal.uk

United Monolithic Semiconductors

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

19 Facility equipment**RENA Technologies NA**

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

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4 Barton Lane, Woburn, MA 01801,
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20 Facility consumables**PLANSEE High Performance Materials**

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

W.L. Gore & Associates

401 Airport Rd, Elkton,
MD 21921-4236,

USA

Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

21 Computer hardware & software**Crosslight Software Inc**

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

Semiconductor Technology Research Inc

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

22 Used equipment**Brumley South Inc**

422 North Broad Street,
Mooresville,
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24 Resources**Al Shultz Advertising Marketing for Advanced Technology Companies**

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

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Tel: +1 408 943 6900
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31 August – 2 September 2022 (postponed)

PCIM (Power Conversion, Intelligent Motion) Asia 2022

Shanghai New International Expo Centre, China

E-mail: pcimasia@china.messefrankfurt.com

www.pcimasia-expo.com

7–9 September 2022

CIOE 2022 (24th China International Optoelectronic Exposition)

Shenzhen World Exhibition & Convention Center, China

E-mail: cioe@cioe.cn

www.cioe.cn/en

11–16 September 2022

19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2022)

Davos, Switzerland

E-mail: info@icscrm2022.org

www.icscrm2022.org

14–16 September 2022

SEMICON Taiwan 2022

TaiNEX 1, Taipei, Taiwan

E-mail: semicontaiwan@semi.org

www.semicontaiwan.org/en

19–21 September 2022

48th European Conference on Optical Communication (ECOC 2022)

Basel, Switzerland

E-mail: info@ecoc2020.org

www.ecoco2020.org

19–22 September 2022

IEEE 48th European Solid-State Circuits Conference (ESSCIRC 2022)

IEEE 52nd European Solid-State Device Research Conference (ESSDERC 2022)

Università degli Studi di MILANO – BICOCCA, Milan, Italy

E-mail: essxxrc2022@MBTechnoServices.com

www.esscirc-essderc2022.org

25–30 September 2022

25th European Microwave Week (EuMW 2022) including:

52nd European Microwave Conference (EuMC 2022)

17th European Microwave Integrated Circuits Conference (EuMIC 2022)

19th European Radar Conference (EuRAD 2022)

Milano Convention Centre (MICO), Milan, Italy

E-mail: eumwreg@itnint.com

www.eumweek.com

2–6 October 2022

Light + Building Autumn Edition 2022

Frankfurt, Germany

E-mail: tickets@messefrankfurt.com

<https://light-building.messefrankfurt.com/frankfurt/en.html>

5–7 October 2022

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www.semiconchina.org

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9–14 October 2022

International Workshop on Nitride Semiconductors (IWN 2022)

Berlin, Germany

E-mail: carolin.geppert@conventus.de

www.iwn2022.org

16–19 October 2022

28th International Semiconductor Laser Conference (ISLC 2022)

Kunibiki Messe, Matsue, Japan

E-mail: islc2022@or.knt.co.jp

www.islc2022.org

16–19 October 2022

2022 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)

Sheraton Phoenix Downtown, Phoenix, AZ, USA

E-mail: cs@cshawevent.com

www.bcipts.org

16–21 October 2022

International Workshop on Bulk Nitride Semiconductors — XI (IWBNS-XI)

Lehigh Valley, PA, USA

E-mail: iwbn-xi@gmail.com

www.iwbns-xi.org

23–27 October 2022

4th IEEE Workshop on Gallium Oxide and Related Materials (IWGO 2022)

Saihokukan Hotel, Nagano, Japan

E-mail: secretary@iwgo2022.org

www.iwgo2022.org

7–9 November 2022

9th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA 2022)

Sonesta Redondo Beach and Marina, CA, USA

<https://wipda.org>

15–18 November 2022

SEMICON Europa 2022 (co-located with electronica)

Messe München, Munich, Germany

E-mail: semiconeuropa@semi.org

www.semiconeuropa.org

18–20 November 2022

3rd International Congress on Optics, Electronics, and Optoelectronics 2022 (ICOEO-2022)

Xiamen Software Park Fliport Hotel, Xiamen, China

E-mail: sally@istci.org

www.istci.org/icoeo2022

3–7 December 2022

68th annual IEEE International Electron Devices Meeting (IEDM 2022)

Hilton San Francisco Union Square hotel, San Francisco, CA, USA

E-mail: iedm-info@ieee.org

www.ieee-iedm.org

7–9 December 2022

LASER World of PHOTONICS INDIA

Bombay Exhibition Centre, Mumbai, India

E-mail: info@world-of-photonics-india.com

www.world-of-photonics-india.com/en

14–16 December 2022

SEMICON Japan 2022

Tokyo Big Sight, Tokyo, Japan

E-mail: jcustomer@semi.org

www.semiconjapan.org/en

19–23 February 2023

2023 IEEE International Solid- State Circuits Conference (ISSCC 2023)

San Francisco, CA USA

E-mail: Issccinfo@yesevents.com

www.isscc.org

5–9 March 2023

Optical Fiber Communication Conference and Exhibition (OFC 2023)

San Diego Convention Center, San Diego, CA, USA

E-mail: custserv@optica.org

www.ofconference.org

17–21 March 2023

4th International Congress on Advanced Materials Sciences and Engineering (AMSE-2023)

Hilton Vienna Danube Waterfront, Vienna, Austria

E-mail: eve@istci.org

www.istci.org/amse2023

19–23 March 2023

IEEE Applied Power Electronics Conference and Exposition (APEC 2023)

Orange County Convention Center, Orlando, FL, USA

E-mail: apec@apec-conf.org

www.apec-conf.org

20–21 March 2023

China Semiconductor Technology International Conference (CSTIC) 2023, in conjunction with SEMICON China 2023

Shanghai, China

E-mail: cstic@semichina.org

www.semiconchina.org/en/5



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