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COMPOUNDS & ADVANCED SILICON

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Wide-bandgap adoption expanding

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Porotech & Powerchip partner • First Solar India inaugurated

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p17 Infineon has partnered to combine its CoolGaN technology with circuit control technology of Tokyo's OMRON to shrink V2X charging systems.

p19 Transphorm's CEO Dr Primit Parikh and Renesas' CEO Hidetoshi Shibata agree a deal for Transphorm to be acquired by Renesas.

p56 First Solar's new facility in India has been inaugurated by Tamil Nadu's Minister for Industries, Promotions & Commerce, with the US Ambassador to India and the CEO of the US International Development Finance Corporation.

Cover image: Torrance mayor George Chen and Dustin McDonald from the Office of the Governor of California joined Navitas' CEO & co-founder Gene Sheridan to cut the ribbon opening the gallium nitride power IC and silicon carbide technology firm's new headquarters. **p26**

editorial

Power semi firms investing in GaN

Mid-January saw news that Transphorm — which was spun off from University of California at Santa Barbara (UCSB) in 2007 to design gallium nitride (GaN) field-effect transistors for high-voltage power conversion, made at its plants in Goleta, CA, USA and Aizu, Japan — is to be acquired by Tokyo-based Renesas Electronics (see page 19). Renesas manufactures predominantly silicon-based microcontrollers, analog, power and system-on-chip devices. But, in response to the increasing demand for power semiconductors, last year it announced the restart of its Kofu Factory to produce silicon insulated-gate bipolar transistors (IGBTs), and the establishment of a silicon carbide (SiC) device production line at its Takasaki Factory.

The latter led to Renesas last July paying a $2bn deposit to secure a 10-year supply of SiC bare and epitaxial wafers from US-based Wolfspeed. Now, Renesas is investing $339m to acquire in-house GaN manufacturing, expanding into fast-growing power semi markets such as electric vehicles (EVs), computing (data centers, AI, infrastructure), renewable energy, industrial power conversion and fast chargers/adapters.

This follows GaN Systems of Ottawa, Canada (a fabless developer of GaN-based power switching semiconductors for power conversion and control applications) being acquired for $830m last October by Germany's Infineon Technologies, boosting the latter's resources to 450 GaN specialists and more than 350 GaN patent families. While Infineon had a long history of manufacturing silicon and SiC devices and (since its acquisition of International Rectifier of El Segundo, CA, USA in 2014) gallium nitride on silicon (GaN-on-Si)-based power semiconductors, the firm reckoned that its acquisition of GaN Systems would "significantly accelerate our GaN roadmap, based on unmatched R&D resources, application understanding and customer project pipeline".

International Rectifier had previously collaborated on GaN-on-silicon technology with North Carolina State University spin-off Nitronex, which was acquired by US-based silicon chip maker MACOM in 2014. This led to MACOM suing Infineon in 2016 over its rights to use Nitronex's technology. Most recently, in December, MACOM acquired the RF business of Wolfspeed, which decided to divest its GaN operations to focus purely on silicon carbide material and power devices.

Founded by International Rectifier's former CEO Alex Lidow in 2007 (and joined by several other former IR employees), El Segundo-based GaN-on-Si power transistor and IC firm EPC survived legal disputes with IR (settled by EPC paying royalties to IR from 2015 to 2023) and remains independent. However, since last May it has itself sued China's Innoscience Technology for patent infringement after recruiting former EPC staff. Given US efforts to constrain China's tech development and China's urgency to develop home-grown chip supply, such legal disputes may become increasingly important in trade disputes.

Founded in 2014 — like GaN Systems and EPC as a US firm designing GaN power devices made by Tawainese foundries — Navitas Semiconductor has, since July 2022, diversified by acquiring US-based SiC power semi device manufacturer GeneSiC Semiconductor. While it is the "only pure-play, next-generation power semiconductor company", this is nevertheless amid the trend of much larger power device manufacturers such as Renesas and Infineon diversifying from silicon to SiC and, increasingly, GaN.

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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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- feature articles (technology, markets, regional profiles);
- conference reports;
- event calendar and event previews;
- suppliers' directory.

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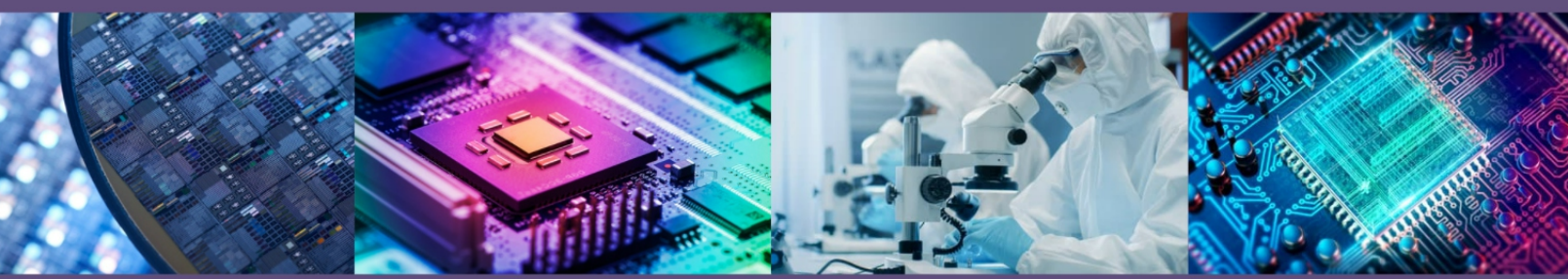

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Consumer electronics 3D sensing VCSEL market to rebound at 11% CAGR to $1.404bn in 2028

Market fell to US$847m in 2023 due to weak consumer demand and pricing pressure

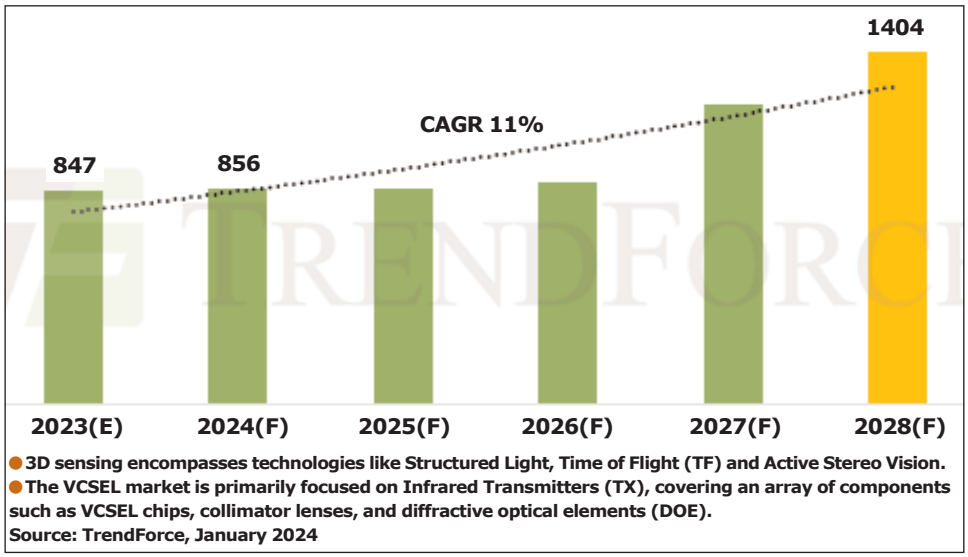
According to the latest report 'TrendForce 2024 Infrared Sensing Application Market and Branding Strategies', the market for consumer electronics 3D sensing vertical-cavity surface-emitting lasers (VCSELs) fell to US$847m in 2023 due to weak consumer demand and pricing pressure.

Major brands incorporating 3D sensing into their 2023 consumer electronics include Apple (smartphones and tablets), Honor (smartphones), Meta Quest 3 and Magic Leap 2. The iPhone 15 Pro, featuring Sony's stacked technology, integrates a VCSEL/drive IC and SPAD/ISP (ASIC chips) in a compact stack. This not only reduces system size but also enhances the performance of light detection & ranging (LiDAR) scanners at the same power level — extending battery life and improving camera and augmented-reality (AR) functionalities.

Major Apple developments include the adoption of MetaLenses in 2024 to minimize the size of transmitters. Furthermore, the company intends to implement under-display 3D sensing by 2027 to increase display-screen ratios. Using a short-wave infrared (SWIR) VCSEL, this technology reduces interference from sunlight and ambient light while mitigating white-spot phenomena. The adoption of SWIR VCSELs is expected to drive VCSEL prices up. TrendForce research indicates that ams OSRAM's 1130nm VCSEL demonstrates superior performance by achieving power conversion efficiency (PCE)>30% in second-half 2023.

The upcoming 2024 launch of the Apple Vision Pro, equipped with a trio of cutting-edge 3D sensing technologies — Structured Light, Direct Time of Flight (dToF), and Active Stereo Vision — is poised to significantly propel the 3D sensing market, notes TrendForce. This growth trajectory is further bolstered by the sustained introduction of AR and VR products from tech giants like Sony, Meta, Microsoft and Google. As a result, the consumer electronics 3D sensing VCSEL market is forecasted to rise at a compound annual growth rate (CAGR) of about 11% from 2023 to US$1.404bn in 2028.

www.trendforce.com



Market for consumer electronics 3D sensing VCSELs, 2023–2028 (in US$m).

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X-FAB acquires M-MOS from Xtrion for €22.5m

MOSFET design firm to accelerate X-FAB's discrete business development

Analog/digital (mixed-signal) integrated circuit, sensor, micro-electro-mechanical system (MEMS) and specialty semiconductor foundry X-FAB Silicon Foundries SE of Tessenderlo, Belgium plans to acquire M-MOS Semiconductor Hong Kong Ltd from Xtrion NV for €22.5m.

Also based in Tessenderlo, Xtrion held a majority stake in X-FAB until mid-November, when Xtrion sold its stake to Elex NV and Sensinnovat BV (the investment vehicles and holding companies of the Duchâtelet family and De Winter-Chombar family, respectively). Since Elex and Sensinnovat were already indirect shareholders in Xtrion, the transaction represented a restructuring of the shareholdings in X-FAB of the Duchâtelet and De Winter-Chombar families which (along with fellow X-FAB investor Sarawak Technology Holdings Sdn Bhd) were subsequently free to pursue individual, independent investment strategies.

M-MOS is a fabless company specialized in the development of MOSFET technologies and the design of custom MOSFET devices. Its MOSFET wafers sell mainly into the industrial, consumer and automotive markets are manufactured by X-FAB. In 2022, M-MOS recorded revenue of US$32m.

"X-FAB started its discrete devices business more than 20 years ago in Erfurt, Germany, followed by trench MOSFETs we have been producing for M-MOS at our Malaysian site in Kuching," says X-FAB group CEO Rudi De Winter. "Since then, more and more discrete business has been developed, such as the silicon carbide (SiC) technology at X-FAB Texas and gallium nitride (GaN) at X-FAB Dresden," he adds. "I am convinced that the process and product design know-how but also the market know-how of M-MOS will help to accelerate X-FAB's discrete business development going forward."

www.m-mos.com
www.xfab.com

Guerrilla RF's Q4 revenue almost doubles year-on-year to record $4.7m

Growth driven by automotive and SATCOM markets

For fourth-quarter 2023, Guerrilla RF Inc (GRF) of Greensboro, NC, USA — which develops and manufactures radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has reported revenue of $4.7m, up 38% on $3.4m in Q32023 and up 95.8% on $2.4m a year ago.

Full-year revenue has hence grown by 30.2% from 2022's $11.6m to $15.1m for 2023 (near the upper end of the $14.7–15.2m guidance range), driven by increased orders from automotive and satellite communications (SATCOM) markets.

Revenue for new products (in production for less than three years) reached 22.1% of product revenue in 2023 compared with less than 1% in 2022, reflecting the positive results of previous R&D investments.

Gross margin has grown from 55.7% in Q3/2023 to 56.8% in Q4/2023.

Reflecting the continued impact of existing expense management efforts, operating expense fell by $0.8m (14.4%) from Q3/2023. In particular, R&D expenses were cut by $0.5m to $2.3m. This contributed to operating loss being cut by $1.6m (43.2%) from $3.7m in Q3/2023 to $2.1m in Q4/2023.

During Q4/2023, Guerrilla RF reached a preliminary agreement with its primary lender to extend the loan maturity into 2025, contingent upon the firm achieving certain milestones in first-quarter 2024.

Distribution channel inventory days reached their lowest level in two years, at 50 days as of end-December 2023, leading management to believe that the inventory overhang is behind it.

Consequently, order bookings exceeded $5.1m in Q4/2023, matching the prior record in Q1/2023. Order backlog remained steady quarter-over-quarter, ending 2023 at $6m, but this is up $1.5m on $4.5m at the end of 2022. Subsequent to year-end, due to new orders, backlog rose further, to a record $7.9m on 12 January.

During Q4/2023, Guerrilla RF announced an initial production purchase order (PO) for a point-to-multipoint wireless infrastructure design win. It also announced a first production PO and shipment to the SATCOM market, with a PO from a tier-1 SATCOM company. Guerrilla RF expects 2024 SATCOM revenues to exceed $1m, and the total market opportunity to exceed $560m.

For full-year 2024, Guerrilla RF expects revenue to grow to $21–26m. Also, the continued focus on expense reduction is expected to enable the firm to achieve its operational cash flow breakeven target in 2024, excluding interest expense, and other non-operating and non-recurring expenses.

www.guerrilla-rf.com

MACOM gains Shanmugaraj as independent director

General manager of Cisco's Coherent Products & Components Group to serve on Compensation and Nominating & Governance Committees

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog, mixed-signal and optical semiconductors, components and subassemblies) has appointed Murugesan 'Raj' Shanmugaraj as an independent director to its board. He will serve on the Compensation and Nominating & Governance Committees of the board.

Shanmugaraj has extensive telecoms experience, having led the development of innovative products including packet switching and optical systems and components. He is currently senior VP & general manager of the Coherent Products and Components Group at Cisco Systems Inc, which he joined in March 2021 when Acacia Communications Inc was acquired by Cisco. Shanmugaraj served as president & CEO and a member of the board of directors of Acacia for over ten years. In 2017, he was awarded the Ernst & Young Entrepreneur of the Year Regional Award.

Prior to joining Acacia, Shanmugaraj served in leadership roles for various technology companies, including Alcatel–Lucent and as founder & CEO of Astral Point Communications. He holds an M.S. in electrical and computer engineering from the University of Iowa and a B.E. (Honors) in electronics and communications from the National Institute of Technology, Trichy.

"Raj has a track record of successful leadership and extensive industry experience, and we look forward to his future contributions," comments Stephen G. Daly, president, CEO & chair of the board.

www.macom.com

Tower collaborates with Renesas to manufacture SiGe-based beam-forming ICs

Design wins already gained with tier-1 customers in satcom, 5G, and aerospace & defense applications

Specialty analog foundry Tower Semiconductor Ltd of Migdal Haemek, Israel is collaborating with Renesas, leveraging Tower's high-volume and high-performance silicon germanium (SiGe) BiCMOS technology to manufacture SiGe-based beam-forming ICs. Renesas' portfolio of beam-forming products has already achieved design wins with key worldwide players across 5G, satcom, and aerospace & defense markets.

The satcom terrestrial terminal market is growing rapidly as satellite-based Internet services proliferate globally. According to market research firm Euroconsult, 71 million people were connected to satellite broadband services in 2022. With the rapid deployment of LEO satellite constellations, this is expected to double to over 150 million users in 2031. This translates to an increase of $400m in the average annual total addressable market (TAM) for SiGe wafers over the coming decade.

"The unique advantages of Tower's SiGe BiCMOS technology have empowered us to design and manufacture highly integrated and power-efficient semiconductors that set new industry benchmarks," says Naveen Yanduru, VP of RF Communications at Renesas. "As evidenced by our design wins and volume shipments, the displacement of mechanical antennas by highly agile electronically steered antennas (ESAs) is well underway and will continue to drive exponential SAM [serviceable addressable market] growth for beam-forming ICs in the coming years," he adds. "With the continuously surging demand for millimeter-wave technology, our collaboration with Tower Semiconductor has positioned Renesas as a market leader."

Renesas provides solutions for the telecoms industry and, through its collaboration with Tower, has made strides in the satcom and 5G markets. This capability played a significant role in enabling Renesas to establish and solidify its market leadership.

"Our global capacity and engineering agility will ensure Renesas has both the ability to develop new, high-performance products and deliver these in high-volume to their tier-1 customers," says Tower's president Dr Marco Racanelli.

Renesas' portfolio of beam-forming products has achieved design wins with several strategic global customers including a tier-1 base-station manufacturer, a tier-1 satellite broadband service provider, a major defense contractor, and an antenna supplier for a major aircraft manufacturer, among others.

"Production for these design wins has commenced, and we are now shipping in volumes," says Tumay Kanar, director at Renesas. "Volume production is being supported by Tower with its high yield and high reliability," he adds.

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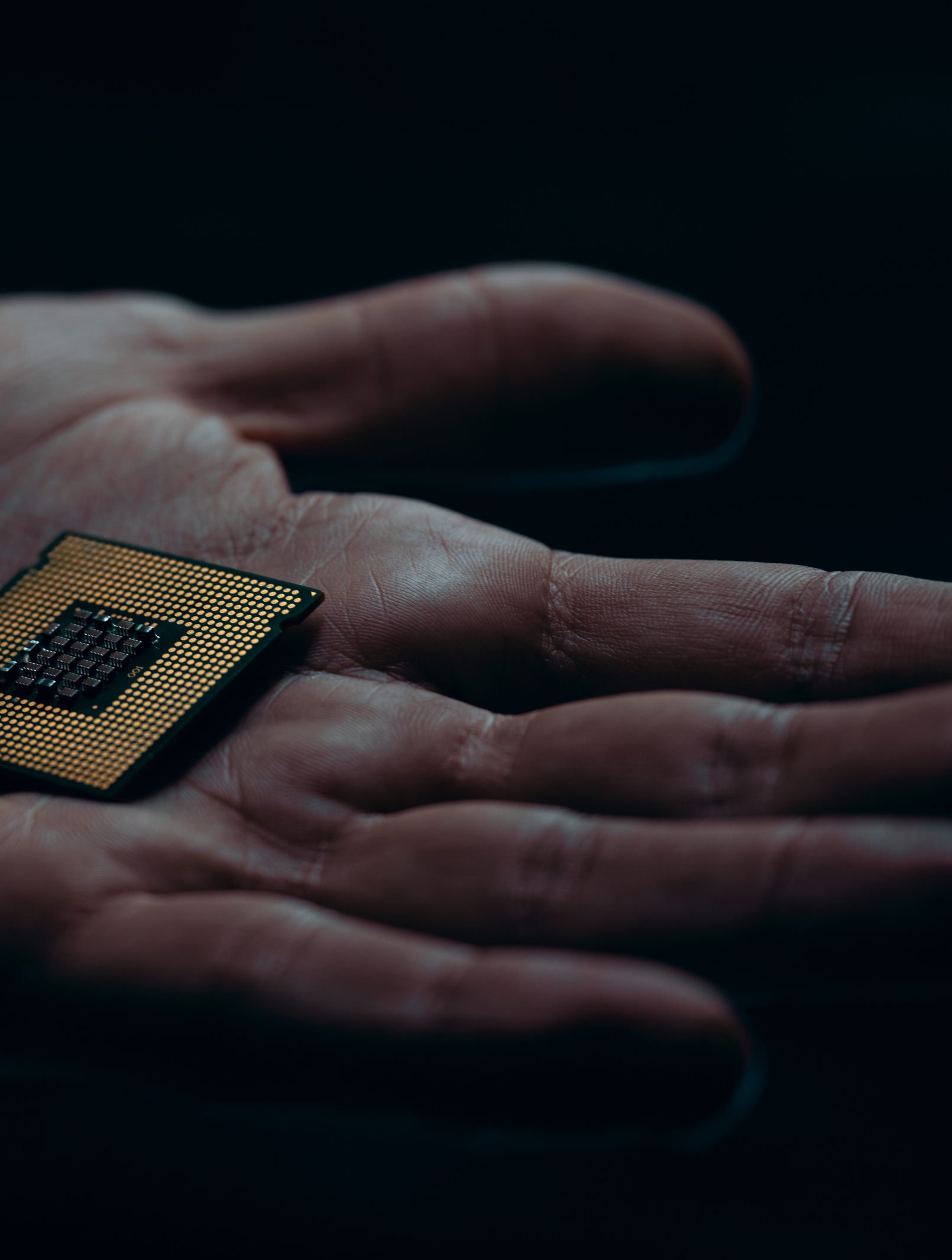


onsemi releases DC ultra-fast EV charging solutions to address critical barriers to adoption

EliteSiC power integrated modules enable smaller, lighter fast charging platforms with bidirectional charging

Intelligent power and sensing technology firm onsemi of Scottsdale, AZ, USA has announced the availability of nine new EliteSiC power integrated modules (PIMs) enabling bidirectional charging capabilities for DC ultra-fast electric vehicle (EV) chargers and energy storage systems (ESS). The silicon carbide (SiC)-based solutions should dramatically improve system cost, with higher efficiency and simpler cooling mechanisms that can reduce size by up to 40% and weight by up to 52% compared with traditional silicon-based IGBT solutions, it is reckoned. With more compact, lighter charging platforms, designers will have all the key building blocks that are needed to quickly deploy a reliable, efficient and scalable network of DC fast chargers that can charge EV batteries up to 80% in just 15 minutes, says the firm.

According to J.D. Power's 2023 Electric Vehicle Consideration Study, nearly half of US consumers note the reason for not purchasing an electric vehicle is the access to charging and the ability to do so quickly, to ensure that the driving experience is as easy and seamless as with a traditional internal combustion engine (ICE) vehicle. In the USA, the availability of EV chargers needs to quadruple by 2025 and to grow by 8x by the end of the decade to keep up with demand (according to S&P Global Mobility Forecasts) and to ensure that drivers have equitable access to public charging stations.

In turn, this rapid increase in demand for electricity will also put a tremendous strain on existing electrical grids, potentially overloading them. To mitigate this problem, bidirectional charging has emerged as a key solution to implement vehicle-to-grid which allows both regular battery charging and the ability to use an EV as an energy storage system to power your home when needed.

This solution helps to enable a DC fast charging network and vehicle-to-grid power transfer systems, addressing access and speed with its ability to recharge a vehicle faster than other methods that take hours or even days, it is claimed.

onsemi offers a portfolio of PIMs to address the key topologies on the market, giving designers the flexibility to pick the appropriate PIM for power conversion stages in DC fast charging or energy storage system applications. To accelerate the design cycle, advanced piecewise linear electrical circuit simulation (PLECS) models through onsemi's Self-Service PLECS model Generator and application simulation with the Elite Power Simulator of this portfolio will also be made available to designers.

For each module, onsemi uses die from the same wafer to ensure more consistency and reliability so designers don't have to use discretes from different suppliers, which can lead to varying performance results, the firm says. In addition to its reliability, the module portfolio is said to offer the following benefits:

- Gen3 M3S SiC MOSFET technology offers the lowest switching losses and highest efficiency in the industry, it is claimed;
- support for key topologies such as multi-level T-type neutral point clamp (TNPC), half-bridge and full-bridge topologies;
- support for scalable output power from 25kW to 100kW, enabling multiple DC fast charging and energy storage systems platforms including bidirectional charging;
- industry-standard F1 and F2 packages with the option of pre-applied thermal interface material (TIM) and press-fit pins;
- optimal thermal management, avoiding system failure due to overheating;
- full-SiC modules, which offer energy conservation by minimizing power losses, directly translating to cost and energy savings;
- more robustness and dependability, ensuring consistent operations.

www.onsemi.com

ST supplying silicon carbide MOSFETs to Li Auto

Chinese electric vehicle maker using third-gen 1200V SiC MOSFETs in the traction inverter of upcoming 800V BEV platform

STMicroelectronics of Geneva, Switzerland has signed a long-term agreement to supply its silicon carbide (SiC) MOSFET devices to China-based Li Auto (which designs, develops and makes electric vehicles) to support Li Auto's strategy around high-voltage battery electric vehicles (BEVs) in various market segments.

As the automotive industry is transitioning towards electrification and decarbonization, high-voltage BEVs offer higher energy efficiency and extended mileage. Known for its extended-range electric vehicles (EREVs), Li Auto is entering the BEV market with its first high-tech flagship family MPV BEV model, premiered in fourth-quarter 2023. With plans to introduce more high-voltage BEV models soon, Li Auto will need large volumes of SiC MOSFETs that it will integrate into the traction inverters of its EVs.

ST's silicon carbide devices are said to increase performance and efficiency through higher switching frequencies, breakdown voltages, and thermal resistance, which are all particularly critical characteristics at the higher operating voltages required for BEVs. Li Auto is adopting ST's third-generation 1200V SiC MOSFET in the traction inverter of its upcoming 800V BEV platform, in order to ensure process stability and performance, efficiency and reliability.

Claiming to hold more than 50% market share in SiC MOSFETs worldwide, ST says that its silicon carbide technology is widely used in EV onboard chargers and power modules.

"ST has established long-term supply agreements with major car makers and tier-1 suppliers. The silicon carbide supply agreement with Li Auto marks a significant step building upon our existing long-term relationship in other automotive applications," says Henry Cao, executive VP of sales & marketing, China Region, STMicroelectronics. "ST is committed to supporting Li Auto's ambition to become a top premium electric vehicle brand in China, offering their customers superior vehicle performance and range with our innovative SiC technologies," he adds.

www.lixiang.com
www.st.com

SemiQ debuting QSiC 1200V MOSFET modules at APEC

Modules tested at voltages exceeding 1350V

In booth #2245 at the Applied Power Electronics Conference (APEC 2024) in Long Beach, CA (25–29 February), SemiQ Inc of Lake Forest, CA, USA — which designs, develops and manufactures silicon carbide (SiC) power semiconductors and 150mm SiC epitaxial wafers for high-frequency, high-temperature and high-efficiency power semiconductor devices — is debuting new portfolio of QSiC 1200V MOSFET modules, which are designed to operate reliably in challenging conditions and enable high-performance, high-density implementation while minimizing both dynamic and static losses. Crafted from high-performance ceramics, the modules are available in SOT-227, half-bridge and full-bridge options.

The new QSiC MOSFET modules support a variety of automotive and industrial power applications where efficiency, power density and performance are critical design criteria. These include electric vehicle (EV) charging, on-board chargers (OBCs), DC–DC converters, E-compressors, fuel cell converters, medical power supplies, energy storage systems, solar and wind energy systems, data-center power supplies and UPS/PFC circuits.

"Our power modules stand out not just for their high performance, but also for the rigorous testing that ensures reliability," says president Dr Timothy Han. "All modules have undergone testing exceeding 1350V. From gate burn-in testing to stress tests like HTRB and H3TRB, we prioritize stability and quality."

https://semiq.com/semiq-to-

SemiQ adds 5mΩ, 10mΩ and 20mΩ variants in half-bridge packages to QSiC range of 1200V MOSFET power modules

Photovoltaic inverter, battery charger, energy storage and high-voltage DC–DC converter applications targeted

SemiQ Inc of Lake Forest, CA, USA — which designs, develops and manufactures silicon carbide (SiC) power semiconductors and 150mm SiC epitaxial wafers for high-frequency, high-temperature and high-efficiency power semiconductor devices — has expanded its QSiC power module portfolio with the introduction of a new series of 5mΩ, 10mΩ and 20mΩ 1200V silicon carbide power MOSFETs in industry-standard half-bridge packages.

Engineered and tested to operate reliably in demanding environments, the new compact, high-performance modules enable high-power-density implementations while minimizing dynamic and static losses. Featuring high breakdown voltage (>1400V), the new QSiC modules support high-temperature operation (T_j=175°C) with low $R_{ds(On)}$ shift over the full temperature range. In addition, the modules exhibit what is claimed to be industry-leading gate oxide stability and long gate oxide lifetime, avalanche unclamped inductive switching (UIS) ruggedness and long short-circuit withstand time.

With a solid foundation of high-performance ceramics, the new SiC modules are suitable for electric vehicle (EV) charging, on-board chargers (OBCs), DC–DC converters, E-compressors, fuel cell converters, medical power supplies, photovoltaic inverters, energy storage systems, solar and wind energy systems, data-center power supplies, UPS/PFC circuits, Vienna rectifiers, and other automotive and industrial applications.

To ensure that each module has a stable gate threshold voltage and high-quality gate oxide, SemiQ's modules undergo gate burn-in testing at the wafer level. Besides the burn-in test, which helps to stabilize the extrinsic failure rate, stress tests such as gate stress, high-temperature reverse bias (HTRB) drain stress, and high humidity, high voltage, high temperature (H3TRB) allow the required automotive- and industrial-grade quality levels to be achieved. The devices also have extended short-circuit ratings. All modules have undergone testing exceeding 1350V.

"SemiQ's commitment to reliability and testing sets us apart in the semiconductor industry," reckons president Dr Timothy Han. "Our high-performance QSiC 1200V MOSFET modules are proven to withstand challenging conditions, enabling engineers to develop reliable systems for the renewable, automotive, medical and industrial sectors."

www.semiq.com

Luminus to bring Sanan's SiC and GaN power semiconductors to Americas market

Fellow subsidiaries of China's Sanan Optoelectronics target high-growth markets

Wide-bandgap power semiconductor materials, component and foundry services provider Sanan Semiconductor Co Ltd of Hunan, China has announced Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — as its exclusive sales channel in the Americas. Both companies are subsidiaries of China's Sanan Optoelectronics, the world's largest LED chip maker.

The firms state that customers in a wide range of power-related industries have suffered in recent years from long lead-times, especially for silicon carbide (SiC) wafers, Schottky diodes and MOSFETs. Having recently completed construction of a US$2bn 'Megafab' in Changsha, China, Sanan says that it is now equipped to provide products and foundry services with aggressive lead-times (as low as eight weeks for most products). The Megafab's capacity also positions Sanan as the largest vertically integrated SiC manufacturer in China, and the third largest in the world, it is reckoned.

Sanan plans to focus on foundry services to support already established semiconductor companies that need a secure supply of SiC substrates, epiwafers or bare die. In parallel, Sanan offers turnkey solutions of SiC Schottky diodes and SiC MOSFETs to support emerging customers in renewable energy and diverse applications such as industrial power supplies, wind power, energy storage, motor driving, data centers, HVAC, electric vehicle (EV) charging, photovoltaics, and other high-power scenarios where the advantages of silicon carbide provide essential robustness, value and efficiency.

"We are excited to leverage the well-established Luminus sales team in the Americas, including their regional manufacturers reps and distributors, to deliver our wide-bandgap technology and products to customers who have been suffering from limited allocation and long lead-times in recent years," says Tony Chiang, CEO of Hunan Sanan Semiconductor.

The Sanan Semiconductor SiC Megafab's vertical integration ranges from the production of raw powders and turning them into silicon carbide boules before slicing into wafers, through epitaxial deposition, then chip fabrication and finally packaging and testing. Sanan is already breaking ground on a mirror image of the Megafab next door that will more than double the capacity by early 2025. This is separate from the $3.2bn STMicroelectronics–Sanan SiC joint venture in Chongqing, China that was announced in June 2023.

"Since we became part of the Sanan family 10 years ago, our worldwide customers have benefitted from the massive scale and advanced technology of our parent company," says Luminus Devices' CEO Mark Pugh. "Now customers in the Americas will enjoy local service, rapid delivery, and technical support from Luminus as we expand into the high-growth silicon carbide and gallium nitride power semiconductor materials, foundry and components markets," he adds.

www.luminus.com
www.sanan-semiconductor.com

Mitsubishi Electric to sample new J3-Series SiC and silicon power modules

Six-model lineup of compact modules for smaller, more efficient inverters in xEVs

Tokyo-based Mitsubishi Electric Corp is to release six new J3-Series power semiconductor modules for various electric vehicles (xEVs), featuring either a silicon carbide metal-oxide-semiconductor field-effect transistor (SiC-MOSFET) or a silicon-based RC-IGBT (insulated-gate bipolar transistor), with compact designs and scalability for use in the inverters of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs). All six J3-Series products will be available for sample shipments from 25 March.

The new power modules are being exhibited at the 38th Electronics R&D, Manufacturing and Packaging Technology Expo (NEPCON JAPAN 2024) at Tokyo Big Sight, Japan (24–26 January), as well as other exhibitions in North America, Europe, China and additional locations.

Development of these SiC products was partially supported by Japan's New Energy and Industrial Technology Development Organization (NEDO).

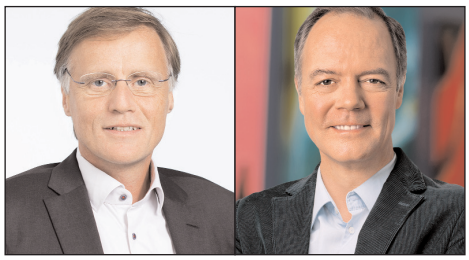
www.mitsubishielectric.com/semiconductors/powerdevices

Infineon and Wolfspeed expand and extend multi-year 150mm SiC wafer supply agreement

Extended partnership includes capacity reservation agreement

Infineon Technologies AG of Munich, Germany and Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide (SiC) materials and power semiconductor devices — have expanded and extended their existing long-term 150mm silicon carbide wafer supply agreement, originally signed in February 2018 (when Wolfspeed was known as Cree). The extended partnership includes a multi-year capacity reservation agreement. It contributes to Infineon's general supply chain stability, also with regard to the growing demand for silicon carbide semiconductor products for automotive, solar and electric vehicle (EV) applications and energy storage systems.

"As the demand for silicon carbide devices continues to increase, we are following a multi-source strategy to secure access to a high-quality, global and long-term supply base of 150mm and 200mm SiC wafers. Our prolonged partnership with Wolfspeed further strengthens Infineon's supply chain resilience for the coming years," says Infineon's CEO Jochen Hanebeck. "We have been working with Wolfspeed for more than 20 years to bring the promise of silicon carbide to the automotive, industrial and energy markets, and to help customers leverage this energy-efficient technology to foster decarbonization."



Infineon Technologies' CEO Jochen Hanebeck (left) and Wolfspeed's president & CEO Gregg Lowe (right).

The adoption of SiC-based power solutions is rapidly growing across multiple markets. Silicon carbide solutions enable smaller, lighter and more cost-effective designs, converting energy more efficiently to unlock new clean energy applications. To better support these growing markets, Infineon is continuously diversifying its supplier base to secure access to high-quality silicon carbide substrates.

"We are the catalyst in the industry transition to silicon carbide, providing high-quality materials to key customers like Infineon, a leading supplier in both the automotive and industrial markets, while also scaling our capacity footprint," says Wolfspeed's president & CEO Gregg Lowe. "Industry estimates indicate demand for silicon carbide devices, as well as the supporting material, will grow substantially through 2030, representing a $20bn annual opportunity," he adds. "We are very pleased to continue our partnership with Infineon and to serve as a major supplier of silicon carbide wafers in the years ahead."

www.wolfspeed.com
www.infineon.com/coolsic

SK Siltron CSS to supply silicon carbide wafers to Infineon

New supplier agreement strengthens Infineon's multi-sourcing strategy

Infineon Technologies AG of Munich, Germany has formalized an agreement for compound semiconductor wafer maker SK Siltron CSS of Auburn, MI, USA (a subsidiary of South Korea-based SK Siltron, a part of the SK Group) to provide it with 150mm silicon carbide (SiC) wafers, supporting the production of SiC semiconductors. In a subsequent phase, SK Siltron CSS will assist Infineon's transition to 200mm-diameter SiC wafers.

"For Infineon, supply chain resiliency is about implementing a multi-supplier strategy and thriving in times of adversity to create new growth opportunities and drive decarbonization," says Infineon's chief procurement officer Angelique van der Burg. "We are excited to partner with SK Siltron CSS to serve the growing SiC demand of our broad customer base with new energy-efficient and top-quality products, matching the highest standards in the SiC market," she adds.

SK Siltron CSS's CEO Jianwei Dong.

"With decades of experience in silicon carbide materials and manufacturing, we bring unparalleled knowledge to our sustainably manufactured compound semiconductor solutions," claims SK Siltron CSS's CEO Jianwei Dong Ph.D. "This long-term supply agreement marks the synergy of our extensive expertise and Infineon's vision to make life easier, safer and greener for generations to come."

www.sksiltron.com
www.infineon.com/coolsic

OMRON's V2X charging systems use Infineon's CoolGaN

CoolGaN combined with circuit topology and control technology

Infineon Technologies AG of Munich, Germany has partnered to combine its gallium nitride (GaN)-based power solutions with the circuit topology and control technology of Tokyo-based OMRON Social Solutions Co Ltd, enabling what is reckoned to be one of Japan's smallest and lightest vehicle-to-everything (V2X) charging systems. The partnership is expected to further drive innovation towards wide-bandgap materials in power supplies, helping to accelerate the transition to renewable energies, a smarter grid, and the adoption of electric vehicles, while fostering decarbonization and digitalization.

For the KPEP-A series V2X system, Infineon's CoolGaN technology is combined with a unique control technology. OMRON Social Solutions has upgraded its EV charger and discharger system, now allowing for bi-directional charging and discharging paths between renewable energy sources, the grid, and EV batteries. The KPEP-A series is reckoned to be one of the smallest and lightest multi-V2X systems in Japan, with a 60% reduction in size and weight compared with similar conventional charger and discharger designs, yet providing a charging capability of 6kW. With the integration of Infineon's CoolGaN, the power efficiency of the V2X systems has increased by more than 10% at light load and around 4% at rated load. Through the improved efficiency and a reduction in size and weight, the new system allows easier installation and maintenance while enabling more elegant designs and offering a wider range of options for installation locations.

OMRON's KPEP-A series V2X system.

"Our CoolGaN-based solutions directly contribute to speed up the transition to renewable energies which reduces CO_2 emissions and drives decarbonization," says Adam White, division president Power & Sensor Systems at Infineon. "It will also make charging of electric vehicles easier and more convenient for consumers, helping to overcome one of the biggest barriers to EV adoption," he adds.

"Having access to a broad portfolio of WBG solutions significantly increases the functionality, performance and quality of our products," says Atsushi Sasawaki, managing executive officer and senior general manager for Energy Solutions Business at OMRON Social Solutions. "With Infineon, we get the best-in-class application know-how for creating new and improved charging and discharging systems, providing a high level of satisfaction for our customers and end-users," he adds. "We look forward to further developing GaN- and SiC-based power solutions together with Infineon to help drive renewable energy and electric vehicles."

www.omron.com
www.infineon.com

South Korea's Key Foundry renamed SK keyfoundry

Firm begins GaN process development, reviews development of SiC

Following shareholder approval, Key Foundry of Cheongju, South Korea — which provides specialty analog and mixed-signal foundry services on 8-inch wafers for consumer, communications, computing, automotive and industrial applications — has changed its corporate name to SK keyfoundry.

Spun off from Magnachip Semiconductor in September 2020, Key Foundry became a subsidiary of SK hynix in August 2022. As part of the post-merger integration, the new name aims for business continuity with existing customers.

With a capacity of about 100,000 wafers per month, SK keyfoundry mostly produces mixed-signal & analog chips, including display driver ICs (DDI), micro-controller units (MCU) and 8-inch wafer-based power ICs, suitable for small-quantity production of diverse products. In particular, there has recently been growing demand for 100V-or-higher BCD (bipolar–CMOS–DMOS) in the power IC market to achieve high-speed electric power delivery and high power efficiency. As a provider of HV BCD foundry processes, SK keyfoundry has therefore been positioning itself in the global power IC market for automotive and industrial applications. In addition, for continuity in supplying next-generation power semiconductor devices, the firm has begun process development for gallium nitride (GaN), and is also reviewing the development of silicon carbide (SiC).

"SK keyfoundry will work hard to gain more ground in the 8-inch foundry market by actively engaging in the market of power ICs for automotive," says CEO Derek D. Lee.

SK keyfoundry also recently reorganized its internal structure, aiming to secure new customers by improving its sales networks in the USA and China and by providing differentiated foundry process development.

www.skkeyfoundry.com

Infineon and Anker open joint Innovation Application Center in Shenzhen

R&D hub for higher-power-density PD fast-charging solutions

Infineon Technologies AG of Munich, Germany has announced its joint Innovation Application Center in Shenzhen with mobile charging and consumer electronics products firm Anker Innovations of Changsha, Hunan, China. With the center already fully operating, it is paving the way for more energy-efficient and CO_2-saving charging solutions that support decarbonization.

Driven by the growing consumer demand for faster-charging solutions due to increasing usage of mobile devices, laptops and other battery-powered devices, the idea of establishing an Anker-Infineon Innovation Application Center dates back to 2021. After two years of preparation, the joint lab now serves as R&D hub for industry experts to develop power-delivery (PD) fast-charging solutions with higher power density, mainly based on Infineon's next-generation Hybrid Flyback (HFB) controller product family and the CoolGaN IPS (integrated power stage) for fast chargers above 100W.

Anker has already brought several products to market, such as the 100W+ fast-charger device powered by Infineon's CoolGaN in 2022. With the Innovation Application Center, Anker and Infineon aim to further shorten the application cycle and accelerate the time to market for future products.

"Anker is an important customer for Infineon," notes Christian Burrer, VP of systems & application marketing for Infineon's Power & Sensor Systems Division. "We have already started a strong cooperation in the charging field, with product and system solutions covering several Infineon product lines," he adds. "In the field of PD charging, we provide our customers a comprehensive product portfolio, including state-of-the-art power controllers, first-class switching power supplies, leading silicon MOSFET and GaN transistor performance, and more."

Infineon and Anker business representatives as well as project managers joined the ribbon-cutting ceremony for the joint Innovation Application Center.

Beyond charging solutions, the joint lab is focusing on a more diversified range of consumer applications, driven by Infineon's expertise in wide-bandgap materials such as gallium nitride (GaN). Infineon reckons that the acquisition of GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) in late October 2023 has significantly accelerated its GaN roadmap and further strengthens its leadership in power systems through expertise in all relevant power semiconductor technologies.

"In 2023, Anker achieved success in many markets such as China and Europe. This would not have been possible without Infineon's GaN technology solutions and the strong collaboration between our companies," says Kang Xiong, general manager of Anker's charging business unit. "We look forward to even intensifying our partnership with Infineon."

www.anker.com
www.infineon.com

Renesas to acquire Transphorm for $339m

Renesas' accelerates wide-bandgap roadmap for EV, data-center & AI power and renewable energy applications

Transphorm Inc of Goleta, CA, USA is to be acquired by a subsidiary of Renesas Electronics Corp of Tokyo, Japan for $5.10 per share in cash (a premium of about 35% to Transphorm's closing stock price on 10 January, and about 56% to the volume-weighted average price over the last 12 months and 78% to that over the last six months). The transaction values Transphorm at about $339m.

Spun off from University of California at Santa Barbara (UCSB) in 2007, Transphorm designs JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion, and has manufacturing operations in Goleta and in Aizu, Japan.

The acquisition will provide Renesas with in-house GaN technology, expanding its reach into fast-growing power semiconductor markets such as electric vehicles (EVs), computing (data centers, AI, infrastructure), renewable energy, industrial power conversion and fast chargers/adapters.

To address the industry-wide transition toward wide-bandgap (WBG) materials due to them allowing a broader range of voltage and switching frequency than conventional silicon-based devices, Renesas has already announced the establishment of an in-house silicon carbide (SiC) production line, supported by a 10 year SiC wafer supply agreement.

Renesas now aims to further expand its WBG portfolio with Transphorm's expertise in GaN, since it enables higher switching

Transphorm's CEO Dr Primit Parikh and Renesas' CEO Hidetoshi Shibata.

frequency, lower power losses, and smaller form factors. These benefits allow systems with greater efficiency, smaller and lighter composition, and lower overall cost. Demand for GaN is hence predicted to grow by more than 50% annually, according to an industry study. Renesas aims to implement Transphorm's automotive-qualified GaN technology to develop new enhanced power solutions, such as X-in-1 powertrain solutions for EVs, along with computing, energy, industrial and consumer applications.

"Transphorm is a company uniquely led by a seasoned team rooted in GaN power and with origins from the University of California at Santa Barbara," notes Renesas' CEO Hidetoshi Shibata. "The addition of Transphorm's GaN technology builds on our momentum in [silicon-based] IGBT and SiC. It will fuel and expand our power portfolio as a key pillar of growth, offering our customers the full ability to choose their optimal power solutions," he adds.

"Combined with Renesas' worldwide footprint, breadth of solution offerings and customer relationships, we are excited to pave the way for industry-wide adoption of WBG materials and set the stage for significant growth," say Transphorm's co-founder, president & CEO Dr Primit Parikh and co-founder & chief technology officer Dr Umesh Mishra. "This transaction will also allow us to offer further expanded services to our customers and deliver significant immediate cash value to our stockholders. Additionally, it will provide a strong platform for our exceptional team to further Transphorm's leading GaN technology and products," they add.

Transphorm's board of directors has unanimously approved the acquisition and recommended that stockholders adopt the definitive agreement and approve the merger. Concurrently with the execution of the definitive agreement, KKR Phorm Investors L.P., which holds about 38.6% of Transphorm's outstanding common stock, has entered into a customary voting agreement with Renesas to vote in favor of the transaction.

The deal is expected to close in second-half 2024, subject to Transphorm stockholder approval, required regulatory clearances and the satisfaction of other customary closing conditions.

www.transphormusa.com
www.renesas.com

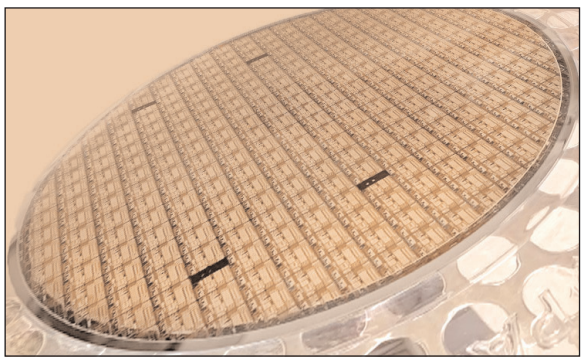
CEA-Leti develops CMOS-compatible 200mm GaN-on-silicon process close to state-of-the-art GaN/SiC performance

Technology suitable for 5G/6G infrastructure, satcom, radar for UAV detection and earth observation

Micro/nanotechnology R&D center CEA-Leti of Grenoble, France has developed a 200mm gallium nitride/silicon (GaN/Si) process technology compatible with CMOS cleanrooms that preserves the high performance of the semiconductor material but costs less than existing GaN/SiC technology.

In one of nine presentations at the 69th annual IEEE International Electron Devices Meeting (IEDM 2023) in San Francisco (9–13 December), the institute noted that existing GaN high-electron-mobility transistor (HEMT) technologies used in telecom or radar applications come on small GaN/SiC substrates and require processing in dedicated cleanrooms.

The high-performance SiC substrates used to grow GaN layers are very expensive and available only in relatively small size. The CEA-Leti R&D project developed GaN/silicon technology (GaN/Si) on 200mm and later for 300mm wafer diameters in CMOS-compatible cleanrooms to reduce substrate cost and to benefit from existing high-performance cleanroom facilities.



As a result, CEA-Leti's GaN/Si technology performance at 28GHz is gaining ground on GaN/SiC technology in terms of power density.

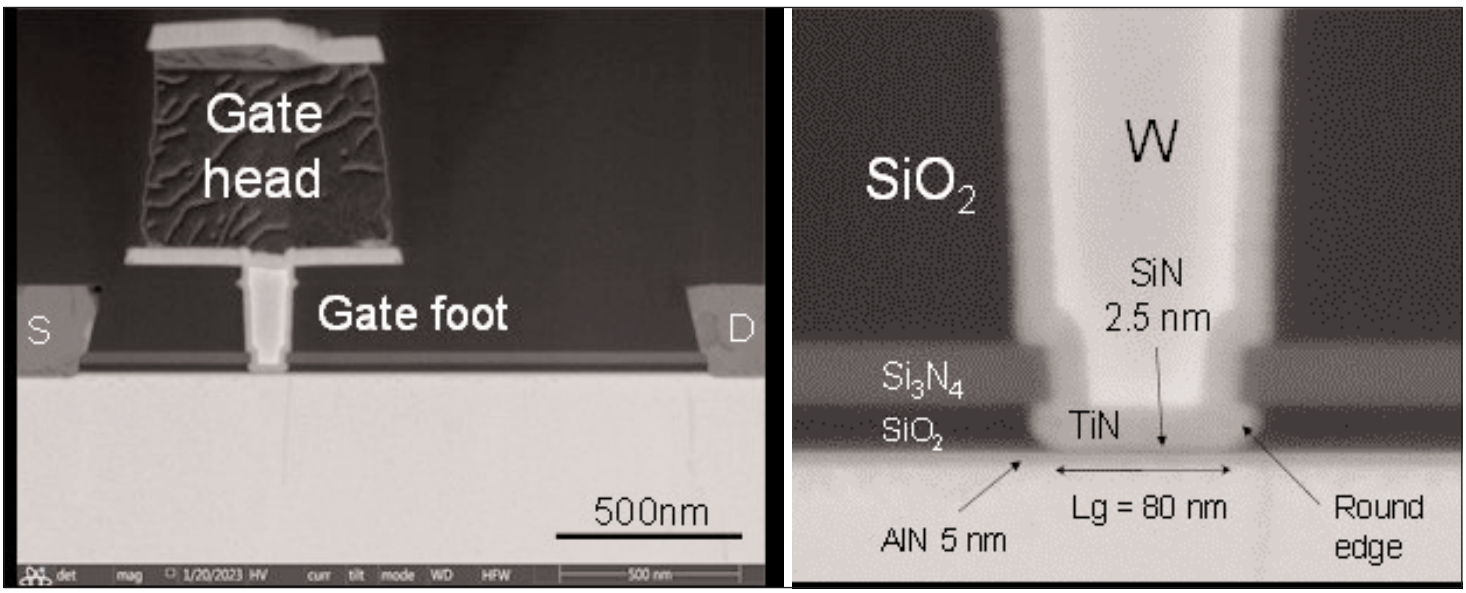
"Our goal was to reach existing state-of-the-art GaN HEMT performance at ~30GHz with a 200mm CMOS-compatible GaN/Si technology and to compete with GaN/SiC technology," said Erwan Morvan, CEA-Leti scientist and lead author of the paper '6.6W/mm 200mm CMOS Compatible AlN/GaN/Si MIS-HEMT with In-Situ SiN Gate Dielectric and Low Temperature Ohmic Contacts'.

"This work demonstrates that CMOS-compatible 200mm SiN/AlN/GaN MIS-HEMT on silicon technology is a promising candidate for applications like 5G/6G infrastructure, satcom, radar for UAV detection or earth observation," he added. "It should enable less expensive devices while keeping high power density, high efficiency, light weight and compactness."

The devices developed in this work, which are designed for RF amplifiers and switches, can be used in those applications around 30GHz.

While reliability testing on the process technology is just beginning, CEA-Leti's ongoing R&D in this area will include increasing the raw output power and efficiency of its MIS-HEMT transistors, integrating its improved process modules to boost device performance and increase operation frequency toward 100+GHz, and 3D integration of GaN/Si chips on 300mm silicon wafers.

www.ieee-iedm.org
www.leti-cea.com



Scanning transmission electron microscopy cross section of the AlN/GaN MIS-HEMT and zoom on the gate foot.

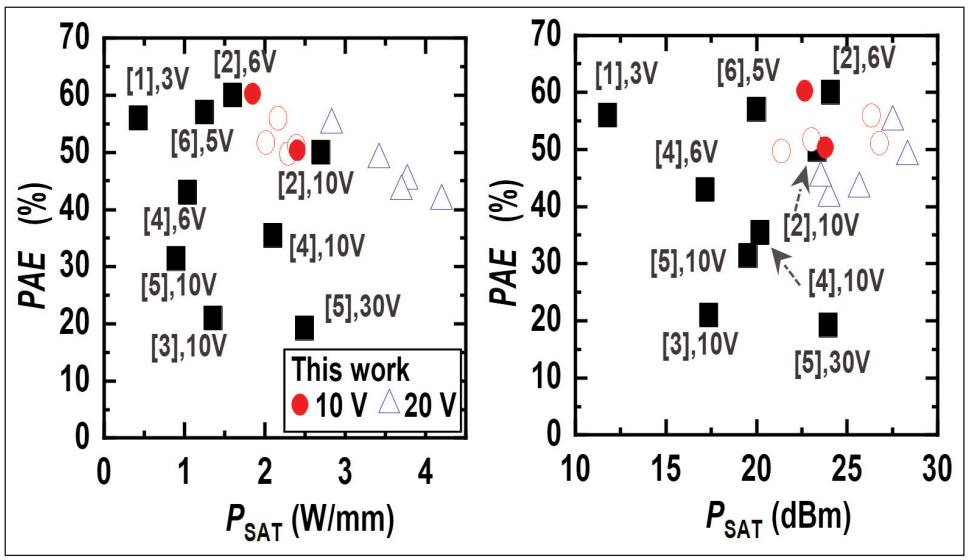
Imec demos GaN-on-Si MISHEMTs with performance suiting 5G-advanced base stations and mobile devices

At the 69th International Electron Devices Meeting (IEEE IEDM 2023) in San Francisco (9–13 December), nanoelectronics research center imec of Leuven, Belgium has presented aluminum nitride/gallium nitride (AlN/GaN) metal-insulator-semiconductor high-electron mobility transistors (MISHEMTs) on 200mm silicon with high output power and energy efficiency while operating at 28GHz. This outperforms other GaN MISHEMT device technology in terms of performance, it is claimed, while adoption of silicon substrate provides a major cost advantage for industrial manufacturing.

GaN-based (MIS)HEMTs are widely explored for 5G-advanced high-capacity wireless communication applications, the next evolutionary step in 5G technology. Due to their material properties, GaN-based devices offer superior performance over silicon CMOS devices and gallium arsenide (GaAs) HEMTs in terms of output power and energy efficiency. Industry is looking at two different RF use cases: (1) mobile devices where GaN (MIS)HEMTs are used in power amplifier circuits operating at relatively low voltages (V_{DD} below 10V); (2) base stations where V_{DD} voltages are higher (above 20V).

For the latter case, GaN-on-silicon carbide (SiC) devices offer the largest potential, but SiC substrates are expensive and small in diameter. The ability to integrate GaN HEMTs on silicon offers a tremendous cost advantage and potential for technology upscaling, but the performance of GaN-on-Si based (MIS)HEMTs lags behind.

"The challenge is in achieving a high operating frequency (derived from the f_T and f_{max} at small-signal conditions) while at the same time delivering a high output power with sufficient efficiency (derived from the devices' large-signal performance)," says imec fellow Nadine Collaert, imec's program director advanced RF.



Large-signal performance benchmarking (at 28-40GHz) for gallium nitride MISHEMTs, MOSHEMTs and AlN/GaN HEMTs integrated on a silicon substrate. The graph shows PAE versus PS_{AT} normalized with gate width (W/mm). [1] H. W. Then, IEDM, pp402-05, 2019; [2] H. W. Then, IEDM, pp230-233, 2021; [3] P. Cui, Semi. Sci. Tech., 38 035011, 2023; [4] H. Du, EDL, vol.44, no.6, pp911-14, 2023; [5] E. Carneiro, Electronics, 12(13), p2974, 2023; [6] H. W. Then, VLSI 2020.

"While most GaN devices are HEMTs, in this experimental study, we focused on GaN-on-Si MISHEMTs with AlN barriers as a crucial step towards addressing the demand for both high-power d-mode [depletion-mode] devices for infrastructure as well as low-voltage e-mode [enhancement-mode] devices required in mobile handsets," she adds. "These GaN MISHEMT devices, featuring a relaxed gate length of 100nm, demonstrate exceptional performance across various metrics. Specifically, for low-voltage (up to 10V) applications, these devices achieved a saturated output power (P_{SAT}) of 2.2W/mm (26.8dBm) and a power-added efficiency (PAE) of 55.5% at 28GHz, positioning our technology better than comparable HEMT/MISHEMTs out there. These results underscore the potential of our technology as a strong foundation for next-generation 5G applications."

Also, for base stations (20V applications), excellent large-signal performance at 28GHz is demonstrated with a P_{SAT} of 2.8W/mm (27.5dBm) and PAE of 54.8%. "Our AlN/GaN MISHEMTs are still d-mode devices," says Collaert. "But we know the path towards e-mode devices, through further device stack engineering."

Underlying the performance improvement is a comprehensive study of the impact of the thickness scaling of the AlN and Si_3N_4 layers, which are used as stop barrier layer, and also gate dielectric, respectively. Ultrathin stacks, for example, enable a high operating frequency, but come at the expense of trapping-induced current collapse and device breakdown in large-signal conditions. A broader study of on-state breakdown of GaN HEMTs, also shown at IEDM, reveals the mechanism behind these reliability issues. "These fundamental studies give us a modelling platform to further optimize the design of our GaN-based material stack for specific use cases," concludes Collaert.

www.ieee-iedm.org
www.imec.be

ASU gains $17.5m as part of $100m state funding to boost semiconductor and microelectronics development in Arizona

Expansion to create GaN manufacturing and research ecosystem

The Arizona Commerce Authority (ACA) has announced a $17.5m investment in Arizona State University (ASU) to expand Arizona's advanced semiconductor manufacturing capabilities. The expansion will enhance Arizona's fan-out wafer-level packaging R&D and workforce training capabilities and drive the creation of a gallium nitride (GaN) manufacturing and research ecosystem in the state to enable technology of the future and make it available to more companies in the industry.

ASU will allocate the funding to purchase equipment to enhance the capabilities of ASU's MacroTechnology Works (MTW) in Tempe. ASU plans to expand advanced packaging and GaN research to additional capabilities that support 6G, the Internet of Things (IoT), machine learning and more. The expansion will also include workforce development initiatives such as internships and university joint research, and next-generation GaN research & development for 6G in partnership with NXP Semiconductors N.V. in Chandler, AZ.

"The expansion of ASU's MacroTechnology Works is another important step in enhancing Arizona's semiconductor ecosystem," says Arizona Governor Katie Hobbs. "These new capabilities enable first-of-its-kind training and R&D opportunities to strengthen the state's workforce and support continued industry growth," she adds.

"Today's announcement represents another important step in ASU's commitment as a university to contribute to advancing America's domestic semiconductor manufacturing, research and development capabilities," says ASU's president Michael Crow. "Our recent creation of a Microelectronics Workforce Development Hub and our strategic focus on the university's MacroTechnology Works facility are both in place to assist with achieving the objectives outlined today and we look forward to working with the Arizona Commerce Authority and NXP to drive success at an accelerated rate," he adds.

"This new investment showcases Arizona's continued commitment to advancing our semiconductor industry," says ACA president & CEO Sandra Watson. The investment at ASU will "expand the state's semiconductor supply chain and workforce development efforts while building on strategic efforts to establish an advanced packaging ecosystem in Arizona," she adds.

"We are excited for the opportunity to collaborate with ASU, helping train and develop the engineers of the future, who could one day contribute to the development of critical communications infrastructure benefitting both the state of Arizona and US as a whole," comments Jim Norling, VP of product management, Radio Power, NXP Semiconductors. "This partnership will drive innovation in 6G, taking lab concepts through joint research to full-scale manufacturing."

The expanded capabilities at MTW in Tempe will support future growth opportunities within Arizona's semiconductor ecosystem. The ASU expansion also builds on Arizona's efforts to establish shared semiconductor research and manufacturing facilities that complement federal investments through the CHIPS and Science Act.

The ACA's investment is part of a $100m commitment announced last year to increase semiconductor and microelectronics development in the state. In July, ASU, Applied Materials Inc and the ACA announced plans to create the Materials-to-Fab (MTF) Center as a shared research, development and prototyping facility in the university's MacroTechnology Works building at ASU Research Park. The MTF Center, which is supported by a $30m investment from the ACA, will be home to Applied Materials' Center of Excellence in materials deposition technology.

In November, the University of Arizona and the ACA announced an expansion of the university's Micro/Nano Fabrication Center (MNFC) in Tucson. The MNFC is a cleanroom facility that supports manufacturing and research efforts involving semiconductors, computer chips, optical devices and quantum computing systems. The MNFC expansion, which is supported by a $35.5m investment from the ACA, will also include additional training efforts to continue growing the state's skilled workforce.

In September, the US Department of Defense announced that Arizona was one of eight regional hubs selected under the Department of Defense Microelectronics Commons program. The Southwest Advanced Prototyping (SWAP) Hub proposal was led by ASU. The SWAP Hub was awarded $39.8m to advance microelectronics R&D in the focus areas of artificial intelligence hardware, 5G/6G, and Commercial Leap Ahead Technologies. The hub will help to create a GaN and advanced packaging and test ecosystem in Arizona by offering lab-to-fab capabilities including DoD technical areas.

www.azcommerce.com
https://engineering.asu.edu/macrotechnology-works
www.asu.edu
www.nxp.com

Intel demos first 3D stacked CMOS transistors combined with backside power and direct backside contact

Silicon transistors integrated with GaN transistors on 300mm wafer

At the 69th annual IEEE International Electron Devices Meeting (IEDM 2023) in San Francisco (9–13 December), Intel of Santa Clara, CA, USA showcased first-of-a-kind advances in 3D stacked CMOS (complementary metal-oxide-semiconductor) transistors combined with backside power and direct backside contacts. The firm also reported on scaling paths for recent R&D breakthroughs for backside power delivery, such as backside contacts, and it was the first to demonstrate successful large-scale 3D monolithic integration of silicon transistors with gallium nitride (GaN) transistors on the same 300mm wafer, rather than on package.

"As we enter the Angstrom era and look beyond five nodes in four years, continued innovation is more critical than ever," Sanjay Natarajan, Intel senior VP & general manager of Components Research. "At IEDM 2023, Intel showcases its progress with research advancements that fuel Moore's Law, underscoring our ability to bring leading-edge technologies that enable further scaling and efficient power delivery for the next generation of mobile computing."

Transistor scaling and backside power are key to helping meet the exponentially increasing demand for more powerful computing, says Intel. Its Components Research group has been stacking transistors, taking backside power to the next level to enable more transistor scaling and improved performance, as well as demonstrating that transistors made of different materials can be integrated on the same wafer.

Recent process technology roadmap announcements highlighting the company's continued scaling — including PowerVia backside power, glass substrates for advanced packaging and Foveros Direct — originated in Components Research and are expected to be in production this decade.

At IEDM 2023, Components Research demonstrated new ways of putting more transistors on silicon while achieving higher performance. Researchers have identified key R&D areas necessary to continue scaling by efficiently stacking transistors. Combined with backside power and backside contacts, these present major steps forward in transistor architecture technology, Intel says. Along with improving backside power delivery and employing novel 2D channel materials, Intel is aiming to extend Moore's Law to a trillion transistors on a package by 2030.

Intel's latest transistor research presented at IEDM shows the industry-first ability to vertically stack complementary field-effect transistors (CFET) at a scaled gate pitch down to 60nm. This allows area efficiency and performance benefits by stacking transistors. It is also combined with backside power and direct backside contacts. Intel reckons that this underscores its leadership in gate-all-around (GAA) transistors and showcases its ability to innovate beyond RibbonFET.

Intel says that its technology development roadmap goes beyond five nodes in four years and identifies key R&D areas needed to continue transistor scaling with backside power delivery.

Intel claims to be first to successfully integrate silicon transistors with gallium nitride transistors on the same 300mm wafer and demonstrate that they perform well

Intel's PowerVia will be manufacturing-ready in 2024, which will be the first implementation of backside power delivery. At IEDM, Components Research identified paths to extend and scale backside power delivery beyond PowerVia, and the key process advances required to enable them. In addition, this work also highlighted the use of backside contacts and other novel vertical interconnects to enable area-efficient device stacking.

Also, Intel claims to be first to successfully integrate silicon transistors with GaN transistors on the same 300mm wafer and demonstrate that they perform well.

At IEDM 2022, Intel focused on performance enhancements and building a viable path to 300mm GaN-on-silicon wafers. This year, it is making advancements in process integration of silicon and GaN. Intel has now demonstrated a high-performance, large-scale integrated circuit solution — called DrGaN — for power delivery. Intel has demonstrated that this technology performs well and can potentially enable power delivery solutions to keep pace with the power density and efficiency demands of future computing.

Intel has also advanced its R&D in the 2D transistor space for future Moore's Law scaling. Transition-metal dichalcogenide (TMD) 2D channel materials offer a unique opportunity to scale the transistor's physical gate length below 10nm. At IEDM 2023, Intel demonstrated prototypes of high-mobility TMD transistors for both NMOS (n-channel metal oxide semiconductor) and PMOS (p-channel metal oxide semiconductor), the key components of CMOS.

Intel also presented what it claims is the first gate-all-around (GAA) 2D TMD PMOS transistor, and the first 2D PMOS transistor fabricated on a 300mm wafer.

www.ieee-iedm.org
www.intel.com

ULTRAFAST projects gain $42m in DOE funding

Wide-bandgap technologies to boost power grid efficiency & resiliency

Funded through its program ULTRAFAST ('Lasting Transformative Resiliency Advances by Faster Actuation of power Semiconductor Technologies') launched last February, the US Department of Energy (DOE) has announced $42m for 15 projects across 11 states to improve the reliability, resiliency and flexibility of the domestic power grid through the development of next-generation semiconductor technologies.

Technologies being developed would enable more effective control of grid power flow and better protection of critical infrastructure assets. Streamlining the coordinated operation of electricity supply and demand can improve operational efficiency, prevent unforeseen outages, allow faster recovery, minimize the impacts of natural disasters and climate-change-fueled extreme weather events, and reduce grid operating costs and carbon intensity. The announcement supports President Biden's Investing in America agenda to modernize the USA's power grid, accelerate the deployment of clean energy resources, and boost both energy and national security.

"Modernizing our nation's aging power grid is critical to strengthening our national and energy security, and absolutely essential to reaching President Biden's ambitious goal of a net-zero economy by 2050," says US Secretary of Energy Jennifer M. Granholm. "This new investment will support project teams across the country as they develop the innovative technologies we need to strengthen our grid security and bring reliable clean electricity to more families and businesses — all while combatting the climate crisis."

Managed by DOE's Advanced Research Projects Agency-Energy (ARPA-E), the selected projects are as follows:

- GaNify (State College, PA) will develop an optically isolated, power-integrated building block that would enable enhanced control of power electronics converters for a more efficient and reliable grid (award amount: $3,060,000);
- Georgia Institute of Technology (Atlanta, GA) will develop a novel semiconductor switching device from wide-bandgap III–nitride material to improve grid control, resilience and reliability (award: $2,700,000);
- Great Lakes Crystal Technologies (East Lansing, MI) will develop a diamond semiconductor transistor to support the control infrastructure needed for an energy grid with more distributed generation sources and more variable loads (award: $2,301,538);
- Lawrence Livermore National Laboratory (Livermore, CA) will develop an optically controlled semiconductor transistor to enable future grid control systems to accommodate higher voltage and current than state-of-the-art devices (award: $3,000,000);
- NextWatt (Hoffman Estates, IL) will develop an ultrawide-bandgap optical triggered device that addresses the need for fast protection for solid-state transformers, a promising technology for revolutionizing substations and renewable energy systems (award: $2,268,750);
- Opcondys (Manteca, CA) will develop a light-controlled grid protection device to suppress destructive, sudden transient surges on the grid such as those caused by lightning and electromagnetic pulses (award: $3,178,977);
- RTX Technology Research Center (East Hartford, CT) will develop semiconductor switching modules that are triggered by wireless radio frequency signals, reducing losses and improving control of power electronics converters for the grid and other applications (award: $2,500,000);
- Sandia National Laboratories (Albuquerque, NM) will develop a novel solid-state surge arrester that would protect the grid from very fast electromagnetic pulses that threaten the grid's reliability and performance (award: $2,560,000);
- Texas Tech University (Lubbock, TX) will develop a photoconductive semiconductor switching device from advanced ultrawide-bandgap materials that would enable improved control of the grid (award: $3,070,735);
- University of Arkansas (Fayetteville, AR) will develop a heterogeneously integrated high-power semiconductor module for applications in the electric power grid and electrified transportation (award: $2,931,177);
- University of California, Santa Barbara (Santa Barbara, CA) will develop ultrawide-bandgap switching devices that would achieve higher voltages and speeds than the state-of-the-art, enabling more sophisticated control methods for the grid (award: $3,122,356);
- University of Illinois at Urbana-Champaign (Urbana, IL) will develop optically triggered diamond semiconductor switching devices to enable revolutionary breakthroughs in electricity grid protection (award: $2,982,311);
- University of Pennsylvania (Philadelphia, PA) will develop an integrated module featuring wide-bandgap power devices with optical control and sensing to improve electric grid control, resilience and reliability (award: $2,240,309);
- University of Wisconsin-Madison (Madison, WI) will develop an optically triggered semiconductor switching device to reduce power losses and increase performance compared with existing technologies (award: $2,990,321);
- University of Tennessee, Knoxville (Knoxville, TN) will develop scalable, light-triggered semiconductor switching modules with integrated sensing for protection of the grid and other power distribution systems (award: $2,759,821).

https://arpa-e.energy.gov/technologies/programs/ultrafast

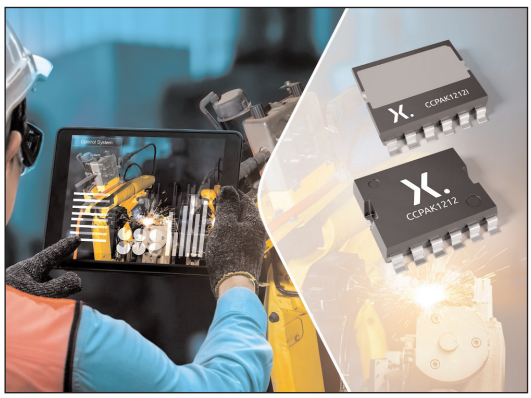
Nexperia makes available GaN FETs in compact CCPAK SMD packaging for industrial and renewable energy

Benefits of copper-clip packaging and wide-bandgap semiconductors combined

Discrete device designer and manufacturer Nexperia B.V. of Nijmegen, The Netherlands (a subsidiary of Wingtech Technology Co Ltd) says that its gallium nitride (GaN) FET devices, featuring high-voltage GaN high-electron-mobility transistor (HEMT) technology in proprietary copper-clip CCPAK surface-mount packaging, are now available to designers of industrial and renewable energy applications.

Building on two decades of expertise in supplying high-volume, high-quality copper-clip SMD packaging, Nexperia is now extending its packaging approach to GaN cascode switches in CCPAK. The GAN039-650NTB, a 33mΩ (typical) GaN FET within the CCPAK1212i top-side-cooling package, ushers in what is described as a new era of wide-bandgap semiconductors and copper-clip packaging.

The technology offers advantages for renewable energy applications such as solar and residential heat pumps. It is also suited to a wide spectrum of industrial applications such as servo drives, switched-mode power supplies (SMPS), servers and telecom.



Nexperia's CCPAK surface-mount packaging uses the firm's proven copper-clip package technology to replace internal bond wires. This reduces parasitic losses, optimizes electrical and thermal performance, and improves device reliability. For maximum flexibility in designs, the CCPAK GaN FETs are available in top- or bottom-cooled configurations to further improve heat dissipation.

The cascode configuration of the GAN039-650NTB enables it to deliver superior switching and on-state performance, with a robust gate that offers high margins against noise. This feature also simplifies application designs by eliminating the requirement for complex gate drivers and control circuitry, instead allowing them to be conveniently driven using standard silicon MOSFET drivers. Nexperia says that its GaN technology improves switching stability and helps to shrink die size by about 24%. In addition, device on-resistance $R_{DS(on)}$ is reduced to only 33mΩ (typical) at 25°C, with a high threshold voltage and low diode forward voltage.

"Nexperia recognizes that designers of industrial and renewable energy equipment need a highly robust switching solution that can provide excellent thermal efficiency when performing power conversion," says Carlos Castro, VP & general manager of Nexperia's GaN FET business. "This is why Nexperia decided to bring together the exceptional switching performance of its cascode GaN FETs with the exceptional thermal properties of its CCPAK packaging to offer customers a compelling solution."

Nexperia begins its CCPAK portfolio release with the top-cooled 33mΩ (typical), 650V GAN039-650NTB, and will follow shortly with the bottom-cooled variant, GAN039-650NBB with the same $R_{DS(on)}$.

www.nexperia.com/ccpak

Navitas holds 2023 Investor Day at opening of new HQ

Customer pipeline rises by 65% from May to $1.25bn

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA held an Opening Ceremony and 2023 Investor Day at its new headquarters in Torrance, CA on 12 December.

Torrance mayor George Chen and Dustin McDonald from the Office of the Governor of California joined Navitas' CEO & co-founder Gene Sheridan to speak and cut the ribbon, officially opening the new headquarters. About 100 Navitas staff are employed in Torrance for all aspects of GaN and SiC design, applications, test, characterization and quality plus finance, marketing and human resources. Further team growth is planned for 2024, including a $20m investment to add SiC epi-growth capability for strategic manufacturing expansion.

The investor meeting began with Sheridan's recap on a year of significant growth for Navitas, with a doubling of revenue, a $92m capital raise, four major new technology platforms and an update on Navitas' mission to 'Electrify Our World'. He then outlined a $1.3tr electrification market opportunity as GaN and SiC enable and

accelerate the transition away from fossil fuels to a carbon-neutral, full-electrified world.

Co-founder & COO/CTO Dan Kinzer then introduced technology platforms including Gen-4 GaNSense half-bridges for motor drive and mobile fast chargers, GaNSafe — claimed to be the world's most protected GaN powertrain, GaNSense Control, and a new bi-directional GaN power IC platform with up to 9x smaller chip size than legacy silicon MOSFETs or IGBTs. Sid Sundaresan, senior VP for the GeneSiC product line, added more detail on the Gen-3 Fast SiC platform.

In May, Navitas announced a qualified customer pipeline of $760m, across mobile, solar/ESS, EV/eMobility, data-center and appliance/industrial markets. At the Investor Day, David Carroll, senior VP worldwide sales, announced that the pipeline had increased by 65% to $1.25bn, including the top ten mobile OEMs and a majority of solar inverter makers. Investors also heard from Navitas customers, including Rick Liu of Accopower for EVs, Belkin's Steve Malony for mobile, Philipp Guo of VREMT for EVs, Adam Weissman of Anker for mobile, and Harron Inam of DG Matrix for EV roadside charging.

Navitas' chief financial officer Ron Shelton presented more detail on the financial results, with increased gross margin, and over $170m is cash and no debt, plus a long-term target to grow 6–10x more than the market, with 50%+ gross margins.

www.navitassemi.com

Navitas names Janet Chou executive VP, CFO & treasurer

Navitas has appointed Janet Chou as executive VP, chief financial officer & treasurer, effective upon the filing of Navitas' 2023 annual report on Form 10-K expected at the end of February.

Chou will report to president & CEO Gene Sheridan and will replace senior VP, CFO & treasurer Ron Shelton, who announced his intention to pursue other opportunities effective 15 March. Following the Form 10-K filing, Shelton will provide advice and assistance to Sheridan and transition assistance and support to Chou.

"Under Ron's financial leadership, we have executed a significant and successful capital raise, built a strong investor and analyst base, and completed three strategic acquisitions—all while delivering predictable and impressive financial results," comments Sheridan. "I am also very excited to welcome Janet Chou as our new CFO," he adds. "I am confident her deep experience in financial leadership at global, multi-billion-dollar public semiconductor leaders will be invaluable as we scale Navitas to new levels in coming years."

Chou was previously VP & CFO of global operations for Western Digital Corp, a $12bn Nasdaq-listed developer, manufacturer and provider of data storage devices and solutions. She was previously CFO of JCET Group Co Ltd, a $5bn global semiconductor firm listed on the Shanghai Stock Exchange. Before that, Chou progressed through a series of senior financial management roles at NXP Semiconductors N.V., a $13bn global semiconductor manufacturer, including VP & CFO for Greater China, and VP & CFO of the Portable & Computing business unit.

Chou is a certified public accountant and holds a bachelor's degree in accounting from the University of Texas, San Antonio, and an MBA from Santa Clara University.

Navitas and SHINRY open joint R&D power lab

Lab to speed development of EV power systems using GaNFast

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor Corp of Torrance, CA, USA and SHINRY of Shenzhen, China (a tier-1 supplier of on-board power supplies to auto-makers such as Honda, Hyundai, BYD, Geely, XPENG, and BAIC) have opened a joint R&D power laboratory to accelerate the development of new-energy vehicle (NEV) power systems enabled by Navitas' GaNFast technology.

On 16 January, SHINRY's chief operating officer Peter (Jingjun) Chen, along with Navitas' CEO Gene Sheridan and VP & general manager Charles (Yingjie) Zha plus other senior executives, attended the joint lab's opening ceremony at SHINRY headquarters.

The joint lab is planned to accelerate development projects, with GaN technology combining with system-design skills and engineering talent to enable high-power-density, light-weight, efficient designs that translate to faster charging and extended range, with faster time-to-market.

The joint lab brings together experienced engineers from Navitas and SHINRY to build efficient, collaborative R&D platforms. Navitas' own dedicated EV system Design Center in Shanghai will provide technical support. The firm will not only supply SHINRY with power devices but will also engage in system-level R&D from the initial stages of product specification and design through to test platforms and customized packaging solutions. The result should be more efficient, higher-power-density, more reliable and cost-effective power systems for NEVs.

"As early as 2012, SHINRY began applying silicon carbide (SiC) MOS, and in 2019 SHINRY initiated research on the application of GaN and has been actively seeking strategic partners," notes Chen.

"As an advanced supplier in the field, Navitas will assist in creating more advanced, energy-efficient and higher-efficiency power system products. I believe the establishment of this joint lab will comprehensively accelerate the design and market launch of SHINRY's products and further enhance the market competitiveness of SHINRY products," he adds.

"Through our joint efforts, leading GaN technologies will enter the power systems of NEVs for more end-users, contributing to the vigorous growth of the new energy industry," says Navitas' co-founder & CEO Gene Sheridan.

www.navitassemi.com

SweGaN appoints Stefan Axelsson as CFO and Anders Lundskog as R&D manager

SweGaN AB of Linköping, Sweden — which develops and manufactures custom gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers (based on a unique growth technology) for telecoms, satcoms, defense and power electronics applications — has appointed Stefan Axelsson as chief financial officer and Anders Lundskog as R&D manager. Axelsson has joined the executive management team, and Lundskog has joined in a new R&D role.

"With significant interest in SweGaN GaN-on-SiC epitaxial solutions for RF and power components, and aligned with growth projections, the company is proactive in securing resources and competence to capture a major share of the global GaN market," says CEO & co-founder Jr-Tai Chen.

The firm has previously engaged seasoned consultants for guidance in a number of fields. SweGaN reckons that adding permanent key management positions further

Stefan Axelsson and Anders-Lundskog.

positions it for fully embracing its scale-up strategy, new KPIs, investor expectations and achieving ambitious innovation goals.

Axelsson has extensive experience in corporate treasury, banking, alternative assets, and investment management – and broad industry background including SEB, Saab and Volvo.

"As SweGaN enters its next phases of growth, Stefan will provide needed expertise in financial reporting, strategic planning, cash flow management, cost control and risk management, to name a few key domains," says Chen.

"Additionally, he will furnish expert guidance during fundraising, as well as comprehensive numbers-driven decision-making to make SweGaN more resilient and competitive," he adds.

"With an impressive background in process development for GaN materials at Infineon and system engineering from Saab, Anders brings highly valuable experience to the SweGaN technical team," reckons Chen. He has a Ph.D. in Materials Science and a Master of Science (MSc) in Applied Physics and Electrical Engineering from Linköping University of Technology.

"Tapping unique experience from Saab and Infineon, Anders' objectives for the new R&D role will be to foster creativity & IT security, drive innovation research, and help SweGaN achieve and maintain a competitive edge," notes Chen. "His track-record and enthusiasm will be valuable to our team and technology endeavors," he believes.

www.swegan.se

QPT opens Crowdcube funding round, with Geoff Haynes as lead investor

Independent power electronics firm Quantum Power Transformation (QPT) of Cambridge, UK (which was founded in 2019) has opened its first funding round on Crowdcube, with Geoff Haynes, co-founder of GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications), as the lead investor. Also, the funding round is eligible under the UK Government's Enterprise Investment Scheme (EIS) for tax relief for venture capital investment.

"There is an old saying invest in what you know. GaN has been my passion for decades and my frustration as it hit the brick wall of RF and overheating issues when being driven at over 100kHz," says Haynes, who in mid-October joined QPT as an advisor. "I am really impressed with how QPT has tackled these issues to enable GaN to now be driven at much higher speeds, which are around 23 times faster than SiC [silicon carbide], and thus deliver unprecedented energy savings. I want to continue my GaN journey to realise its now unlocked capability to make more efficient power electronics that cut energy uses, so I have invested a six-figure sum in the round as its lead investor. Plus, as an advisor, I can really roll my sleeves up and take GaN to the next level," he adds.

"The UK is renowned for innovation so we wanted to provide people with the opportunity to invest in a new technology that makes electric motors more efficient," says QPT's founder & chief technology officer Rob Gwynne. "As they account for up to 45% of global energy usage, our qGaN technology's ability to cut energy wastage means that its deployment could significantly help reduce climate change. Investors are always keen on ways to help the planet, and our technology does that without downsides. Our solution is smaller, cheaper and saves more energy than rivals, according to our studies."

www.crowdcube.com/early-access/qpt

QPT appoints Rupert Baines as CEO

Appointment follows two years as lead adviser

Independent power electronics company Quantum Power Transformation (QPT) of Cambridge, UK — which was founded in 2019 and specializes in developing next-generation gallium nitride (GaN)-based motor drives — has appointed Rupert Baines as its CEO, effective from 1 April. He is a veteran of the semiconductor industry with C-level roles including CEO of UltraSoC (sold to Siemens) and chief marketing officer of Codasip.

"Rupert has been the lead adviser for QPT since January 2022 and his support has been invaluable," says founder & chief technology officer Rob Gwynne. "We are now at a very exciting stage: first prototypes, customer traction and raising funding on Crowdcube. We are looking forward to having Rupert on board to accelerate our growth," he adds.

QPT's CEO Rupert Baines.

"Up to 45% of world electricity is used in electric motors, which is increasing as we move to net zero, yet many motors are wasteful of energy," notes Baines. "QPT's qGaN technology is designed to make motors more efficient to reduce power consumption and carbon dioxide emissions so I was really proud to collect the winner's plaque for the ABB 'Power Density Start-up Challenge 2023 for Motor Drive Products'.

www.q-p-t.com

QPT wins ABB Power Density Start-up Challenge for Motor Drive Products

ABB to work with QPT's technology on projects to enhance efficiencies of drives and motors

QPT has won the ABB Power Density Start-up Challenge 2023 for Motor Drive Products. The firm says that its qGaN technology solves the issues of RF and overheating so that GaN can now be driven at the very high speeds needed to deliver major power savings in motors and drives.

"ABB has chosen QPT's technology as the one that they will work with on projects to enhance the efficiencies of their drives and motors," says founder & chief technology officer Rob Gwynne. "As motors account for around 45% of the world's electricity use, this could be a significant way to help reduce climate change."

qGaN technology

"Our qGaN technology enables drive controls or variable-frequency drives (VFDs) to be made much smaller as we achieve the best power densities and efficiencies of any current technology," claims Gwynne. "We do this by being able to hard-switch 650V GaN transistors from GaN Systems (an Infineon company) incredibly fast at only 1–2ns to slash energy losses."

Existing VFDs are invariably located away from the motor itself and then connected by copper cables that are big and heavy to cope with the high currents going through them and also waste energy in the process. "QPT's next-generation GaN technology shrinks the size of a VFD to around a twentieth of the size so that it can be integrated beside the motor," says Gwynne. "The need for big, costly filters that silicon, silicon carbide (SiC) or slow existing GaN alternatives require and preclude easy integration is also eliminated, further reducing the overall size, which further helps integration," he adds.

"Companies think that they have to move from silicon or GaN to SiC for their next-generation products, without realizing its limitations. Our qGaN technology means that they can easily leapfrog over SiC to a solution that delivers better energy savings with minimal redesign work and a roadmap for further generations of their products as we can drive GaN to ultra-high speeds for more energy savings that nothing else can achieve."

www.collaborateandcommercialize.com
www.q-p-t.com

Revasum and Asahi Diamond America collaborate on silicon carbide wafer grinding

Revasum's silicon carbide grinder combines with Asahi Diamond's abrasive technology

Semiconductor manufacturing equipment maker Revasum Inc of San Luis Obispo, CA, USA and Asahi Diamond America Inc, a provider of diamond and cubic boron nitride tools, have announced a strategic collaboration aimed at enhancing silicon carbide (SiC) wafer grinding.

Bringing together Revasum's expertise in semiconductor grinding and Asahi Diamond America's abrasive technology, the collaboration focuses on the utilization of Revasum's 7AF-HMG Silicon Carbide Grinder, which is specifically designed for the unique challenges posed by 150mm and 200mm SiC wafers.

The 7AF-HMG is distinguished by its hard-material-optimized grind engine, which quickly and precisely thins and planarizes 150mm and 200mm SiC wafers. Its advanced features and precision are said to enable highly efficient and productive processing of bare substrates and device wafers at customer facilities.

"The 7AF-HMG Silicon Carbide Grinder is a groundbreaking solution that addresses the unique challenges of silicon carbide wafers, and this cooperation will propel the industry forward by improving efficiency and performance," reckons Revasum's CEO Scott Jewler.

"Our cutting-edge grind wheels combined with Revasum's advanced tools will empower semiconductor manufacturers to achieve unprecedented precision and efficiency in silicon carbide wafer processing," believes Asahi Diamond America's president Koichi 'Ken' Kikuchi.

www.revasum.com
www.asahidiamondamerica.com

Keysight EDA strengthens design and simulation support for Tower's RF process technologies

Electro-thermal simulation in Advanced Design Systems ensures RFICs targeting Tower SiGe90 meet operating temperature specs

Keysight Technologies Inc of Santa Rosa, CA, USA has expanded the simulation capabilities in its electronic design automation (EDA) software suite to include electro-thermal simulation for the silicon germanium (SiGe) power amplifier (PA) process of specialty analog foundry Tower Semiconductor Ltd of Migdal Haemek, Israel. Together with process design kits (PDKs) for Tower radio frequency (RF) technologies for circuit and physical designs, the new electro-thermal simulation enables IC designers to achieve first-pass success.

Keysight's Advanced Design System (ADS), RFPro and RFIC Design (GoldenGate) are platforms for RF and microwave circuit design that help designers to address their most difficult challenges with advanced solutions for radio frequency integrated circuit (RFIC), electro-magnetic (EM), and electro-thermal simulation. Platform interoperability allows IC designers to access Keysight simulation technologies independent of which schematic or layout environment they use to generate the design.

Tower's silicon-based analog foundry technologies — silicon germanium (SiGe) for both high-speed and high-power and RF silicon-on-insulator (SOI) — optimized to assist chip suppliers in delivering differentiated RF front-end solutions for increasingly complex devices. Designers employ Tower's latest PDKs in developing and simulating their RFICs for various applications with Keysight EDA tools.

"Tower has been successfully collaborating with Keysight to solve the most complex RF problems for our customers. Keysight supports our RF PDKs for design and simulation in ADS with accurate electro-magnetic analysis in RFPro," says Dr Samir Chaudhry, senior director of design enablement at Tower.

"Enablement of Keysight's differentiated electro-thermal solution in ADS for Tower's SiGe PA processes is a welcome move that is already helping RF SiGe customers perform accurate thermal analyses of their designs," he adds.

"Keysight and Tower have been partnering for more than a decade to enable our mutual customer design flows with advanced RF solutions, helping them to achieve faster time-to-market," says Nilesh Kamdar, senior director and RF/Microwave portfolio manager at Keysight. "This year, our partnership achieved another milestone by providing electro-thermal simulation capability for Tower's RF SiGe processes as part of ADS. Using this new capability, customers can ensure that their ICs perform within acceptable operating temperatures prior to manufacturing."

www.towersemi.com
www.keysight.com

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IQE expecting full-year 2023 of £115m after 20% growth from first half to second half

Performance in line with guidance as diversification strategy is implemented

In a pre-close trading update for full-year 2023, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that it expects revenue to be at least £115m. This is down 31.3% on 2022's £167.5m. However, it reflects a more than 20% increase from first-half to second-half 2023, in line with previously issued guidance. IQE expects this to result in an adjusted EBITDA (earnings before interest, tax, depreciation and amortization) of at least £3m (versus £23.4m in 2022) and a net debt position of about £3m.

"Our business performance was aligned to guidance despite a challenging macro-environment," notes CEO Americo Lemos. "We returned to growth from H1 to H2 2023 and expect this positive trajectory to continue in 2024," he adds.

"Additionally, we made significant progress implementing our diversification strategy, expanding our customer engagement pipeline and securing multiple design wins in gallium nitride (GaN) power and micro-LED markets. Our strategic investment in GaN capacity in 2023 is anticipated to unlock further opportunities throughout 2024."

IQE appoints chief financial officer

Jutta Meier moves from Intel Foundry Services

IQE has appointed Jutta Meier to its board as chief financial officer, effective from 22 January.

Jutta is an experienced finance executive who has held senior positions at global semiconductor companies for over 25 years. She joins IQE from Intel Corp, where she was senior finance director at Intel Foundry Services, supporting Intel's Foundry business transformation. Previously, Jutta she was VP of finance at GlobalFoundries Inc, and she also held various positions at Advanced Micro Devices Inc (AMD).

CFO Jutta Meier.

"Her skills and experience gained within global semiconductor manufacturing will be an important asset to IQE, enabling her to drive value creation and improve margins and profitability," believes CEO Americo Lemos. "Jutta's contributions will be vital to driving IQE's growth and the continued implementation of our strategic plan," he adds.

"IQE is at the forefront of the global compound semiconductor industry and I am very excited by the market opportunities and the growth potential of the business," comments Meier.

The appointment follows an extensive global search process led by the board and CEO. The board thanks Neil Rummings for assuming the role of interim CFO during the search process.

IQE appoints VP of government affairs

Rina Pal-Goetzen formerly director of global policy at SIA

IQE has appointed Rina Pal-Goetzen to he newly created role of VP of government affairs, responsible for shaping IQE's response to global geopolitics and pursuing opportunities created by government-led initiatives worldwide, such as the US CHIPS Act, UK National Semiconductor Strategy and European Chips Act. IQE is at the core of the global supply chain and she will lead IQE's efforts to engage with regional and local governments and stakeholders to champion the firm and the broader compound semiconductor industry.

Rina has over 15 years of experience in legal, trade, IP and government affairs with specific experience in the semiconductor sector. She was previously director of global policy at the Semiconductor Industry Association (SIA), where she worked with major global chip companies, industry associations, and government agencies to promote innovation and competitiveness in the semiconductor industry. IQE reckons that her expertise will be highly valuable as it aims to grow and increase its presence internationally.

"Semiconductors are vital to the global economy and play a critical role in national security. We are witnessing supply chain regionalization and governments are responding by developing national strategies, such as the US CHIPS Act, UK National Semiconductor Strategy and European Chips Act," notes CEO Americo Lemos. "Rina's expertise in dealing with international policymakers and regulators will be highly valuable as IQE continues to engage with government agencies globally."

www.iqep.com

Raytheon qualifies IQE North Carolina

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK says that its North Carolina site has been qualified by US-based Raytheon, a business of aerospace & defense company RTX, for the manufacture of epitaxial wafers for use in advanced infrared sensing and imaging. IQE will continue to be a trusted technology partner, providing Raytheon with a secure supply of high-performance infrared photodetector epiwafers made in the USA to bolster national security and domestic supply chains. Building on a 15-year partnership, both parties will continue to collaborate on the research and development of infrared sensors, further developing capabilities for intelligence, surveillance and reconnaissance applications.

"Having received a Raytheon Premier Supplier Excellence Award, this qualification demonstrates the continued confidence that Raytheon has in IQE," says IQE's CEO Americo Lemos. "We are proud to be a strategic partner, ensuring the volume production of sensor and imaging materials made in the USA for a resilient supply chain," he adds. "We look forward to continuing our long-term partnership for years to come."

www.iqep.com

CSA Catapult and UKESF offering bursaries to students in Wales to study electronics and electrical engineering

Spark their imagination; power their future' — a project funded by Innovate UK and run by Compound Semiconductor Applications (CSA) Catapult and the UK Electronics Skills Foundation (UKESF) — is to offer 24 bursaries of £1000 to Year 13 pupils in Wales who have secured a place at university (for students from Wales who are starting their undergraduate studies in the academic year 2024/25 for a degree in Electronic Engineering, Electrical Engineering, Computer Science or Physics at any university in Wales or a UKESF partner university across the UK).

A one-off bursary of £1500 will also be awarded for personal and professional development after a student's first year of study.

The project will also provide thousands of learners across Wales, aged 15–18, with classroom resources and insights into career opportunities that are on offer across the Welsh electronics sector.

Between 2012 and 2021, the number of Welsh students studying an Electronics and Electrical Engineering (EEE) degree fell by a third, dropping from 180 to 120. Also, electrical engineers are in high demand, with opportunities to work in areas such as smartphone technologies, aerospace, robotics, artificial intelligence and electric vehicles.

Wales is also home to the world's first compound semiconductor cluster, CSconnected.

It has also established itself as one of the best places in the country to study EEE degrees, with Cardiff University recently ranked first in the UK for EEE degrees by the Guardian League Table in The Guardian University Guide 2024.

As well as financial support, the new project will deliver a selection of the UKESF's well-established and award-winning schools' initiatives, such as classroom resources, online learning, mentoring and career days to demystify electronics and encourage more learners into the industry.

The project also aims to increase the diversity of young people entering the electronics industry. The Office for Students shows that in 2022, just 17.9% of engineering, technology and computing undergraduate entrants were female, while Engineering UK reports that 11.4% of the core and related engineering workforce are from minority ethnic groups.

The project will have support from a range of stakeholders across the STEM eco-system in Wales. "Developing skills for the future in clusters across the UK is a key part of our strategy," says CSA Catapult's CEO Martin McHugh. "We are therefore delighted to partner with the UKESF on this project and to start work on increasing the number of Welsh students taking an electronics and electrical engineering degree," he adds. A career in electronics and electric engineering "presents a wealth of opportunities to be at the forefront of exciting and emerging industries such as robotics, artificial intelligence and autonomous vehicles," McHugh continues. "It is imperative that these well-paid and in-demand jobs are made visible to learners in Wales and that we do everything we can to break down barriers so that students from a wide range of backgrounds have every opportunity to pursue a career in this industry."

"As the only organization linking schools, universities, students and industry to address electronics skills, the UKESF will be an important contributor to the long-term success of the industry in Wales," says UKESF's CEO Stewart Edmondson.

"This initiative is a great example of targeted action to encourage young people into science and technology careers that will help us spur innovation in sectors like semiconductors," commented Saqib Bhatti, UK Parliamentary Under Secretary of State (Department for Science, Innovation and Technology), speaking during a visit to CSA Catapult.

www.ukesf.org

www.csa.catapult.org.uk

Veeco revises revenue guidance for Q4/23 from $155–175m to $165–175m

Initial guidance for full-year 2024 revenue of $680–740m, growing from 2023's expected $658–668m

At the 26th Annual Needham Growth Conference, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has revised its revenue guidance for fourth-quarter 2023 from $155–175m to $165–175m (up from $153.8m in Q4/2022). Revenue guidance for full year 2023 has been revised from $648–668m to $658–668m (up on 2022's $646.1m), after having previously been raised from the initial guidance of $630–670m.

Guidance for earnings per diluted share on a non-GAAP basis has also been raised, from $0.35–0.45 to $0.40–0.45 for Q4/2023. After previously having been raised from the initial $1.15–1.35 to $1.30–1.50 then $1.55–1.65, guidance for full-year 2023 EPS has been increased again, to $1.58–1.65 (up on $1.57 in 2022).

Veeco says that its initial 2024 outlook is for revenue to grow to $680–740m. Non-GAAP earnings per diluted share is expected to be $1.60–1.90.

www.veeco.com

Aixtron receives supplier award from onsemi

New G10-SiC and customer service supported rapid ramp-up and productivity increase at South Korea SiC fab

Deposition equipment maker Aixtron SE of Herzogenrath, Germany has received a supplier award from onsemi of Scottsdale, AZ, USA. With its new G10-SiC chemical vapor deposition (CVD) and customer service on-site, Aixtron is supporting the production ramp-up of onsemi's facility in Bucheon, South Korea, which was achieved in record time. With a production capacity of more than 1 million 200mm SiC wafers per year, the facility is one of the world's largest silicon carbide (SiC) fabs. At the inaugural event of the new S5 production line, Aixtron was among the suppliers receiving this award.

At the new site, onsemi operates multiple new G10-SiC systems, and both companies worked together to not only install the new tools but also achieve major productivity improvements on-site: Together, the teams have improved tool operation and optimized maintenance procedures, all enabling a major increase in uptime and wafers output. The speed of the on-site support plus the collaboration on data analysis resulted in further tool performance enhancements.

"Thanks to the close cooperation with Aixtron, we were able to improve the already very high level of productivity of the installed base," says onsemi. "The Aixtron team offered great on-site support and training and helped to optimize our operating and maintenance processes. With their mindset of only being satisfied if the tool is achieving the highest productivity, the service team really made the difference," the firm comments.

"A strong and trustworthy relationship with our customers is an essential element of our success," believes Aixtron's CEO & president Dr Felix Grawert. "To obtain a strong and sustainable market position, technology leadership always has to be matched with excellent customer support," he adds. "We have worked hard to build what is likely today the largest SiC expert and service network worldwide to support our customers in their rapid production ramp-ups."

www.onsemi.com
www.aixtron.com

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Innolume orders Riber MBE 49 system to boost GaAs quantum dot laser production capacity

Order for services & accessories to modernize existing machine and increase productivity by integrating new solutions

Riber S.A. of Bezons, France — which makes molecular beam epitaxy (MBE) systems as well as evaporation sources — says that, at the end of December, Innolume GmbH of Dortmund, Germany ordered a new MBE 49 production system (for delivery in 2024) to boost its production capacity for gallium arsenide (GaAs)-based quantum dot (QD) lasers and to support the expansion of its markets, in particular the cloud networking market.

Innolume is said to be one of few companies to produce ultra-high-performance quantum dot lasers with high reliability, low sensitivity to optical feedback and what is claimed to be unrivalled high-temperature operation.

The MBE 49 system will further strengthen the fleet of Riber machines operated by Innolume. Its acquisition is also accompanied by a major order for services and accessories to modernize an existing machine and increase its productivity by integrating new solutions offered by Riber.

www.innolume.com

Asian order for three Riber production MBE systems

GaAs pHEMT process development on two MBE 412s to be transferred to MBE 6000 for production scale-up

Riber has received an order from a "major compound semiconductor industrial customer in Asia" for three production systems: two MBE 412 systems and one MBE 6000 system (for delivery in 2024).

The acquisition of a new MBE 6000 system (following the delivery of the first two units in 2022 and 2023) will enable the customer to increase its production capacity of gallium arsenide (GaAs)-based pseudomorphic high-electron-mobility transistors (PHEMTs) for mobile communications. At the same time, the two MBE 412 systems will be dedicated to the development of advanced components, before transferring their production processes to the larger MBE 6000 machines.

The similar architecture and complementarity of the MBE 412 and MBE 6000 means that their interoperability will enable the customer to optimize its production processes for complex semiconductor heterostructures, with high-level performance, monoatomic precision and high production yields, Riber says.

www.riber.com

Busch and Pfeiffer Vacuum jointly constructing sales, systems and service center in Sisseln, Switzerland

New building to be completed in 2025

Vacuum pump and system maker Busch Vacuum Solutions of Maulburg, Germany and Pfeiffer Vacuum of Aßlar, Germany (also part of the Busch Group) are jointly constructing a new sales, systems and service center in Sisseln, Switzerland, 35km east of Basel, for completion in 2025.

The new building became necessary due to the positive business development of the Busch Group in Switzerland. "This new facility symbolizes the close relationship with our customers in Switzerland. It will be a center of innovation and state-of-the-art vacuum solutions," says Busch Vacuum Solutions' co-CEO & co-owner Sami Busch at the recent groundbreaking ceremony. "Our goal is to set new standards in efficiency and reliability, tailored to the unique requirements of the Swiss industry," he adds.

"Our new location is in an attractive business location with excellent transportation links, enabling us to reach our customers easily anywhere in Switzerland," says Christian Muser, managing director of Busch Switzerland.

The new building is being constructed on an area of almost 6100m^2 in the Grossmatt industrial estate in Sisseln in the canton Aargau. Premises for systems building, a repair workshop, storage space, and offices for sales staff and engineers will occupy a total of 3195m^2. All 34 existing staff of Busch Switzerland, which is celebrating its 50th anniversary this year, will continue to be employed in Sisseln, as will the 15 staff of Pfeiffer Vacuum Switzerland. Busch Switzerland is currently based in Magden, near Sisseln, while Pfeiffer Vacuum Switzerland is in Zurich.

www.pfeiffer-vacuum.com
www.buschvacuum.com

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Oxford Instruments supplies ALD system to UK micro-LED maker for consumer AR/VR/MR devices & smart watches

System to deposit high-K dielectric ultra-thin films for high-density, very high-brightness, low-power and high-frame-rate RGB pixel arrays

UK-based Oxford Instruments says that its atomic layer deposition (ALD) equipment has been installed at an "award-winning UK micro-LED provider" to support the latest consumer-immersive reality products and display devices. The system is used to deposit high-K dielectric ultra-thin films for high-density, very high-brightness, low-power and high-frame-rate RGB pixel arrays for consumer augmented-, virtual- and mixed-reality devices and smart watches.

The increase in demand for smaller-form-factor wearable devices, with high-definition displays, is fuelling significant growth in research for this sector. Micro-LEDs are able to deliver die pitch sizes of <10μm and therefore enable the miniaturization of consumer wearable display devices, while still maintaining high image resolution. As pitch size decreases, perimeter-to-area ratio proportionally increases, and the damage introduced during the mesa formation and isolation step becomes a performance limiting factor.

At the 14th International Conference on Nitride Semiconductors (ICNS 2023) in Fukuoka, Japan in mid-November, numerous presentations were given highlighting the benefits of plasma ALD for counteracting damage. Plasma ALD was also shown to significantly increase external quantum efficiency, with ALD described as critical to miniature light emitters.

Oxford Instruments' PlasmaPro ASP system

"Our low-damage plasma ALD technology is gaining market traction on our 200mm-capable platform," says Oxford Instruments' strategic business development director Klaas Wisniewski. "Our plasma ALD high-K passivation solution is optimized for smaller dies with smaller active areas, and was shown in some cases by our customers at ICNS to double external quantum efficiency," he adds. "Small-form-factor high-performance micro-LEDs are a critical component in head-mounted displays for virtual reality, and other advanced devices such as smart watches, and our technology is enabling some of the most desirable and advanced consumer devices."

Oxford Instruments is attending the SPIE Photonics West 2024 event in San Francisco (30 January –1 February), where it will share its latest optoelectronics processes for augmented, virtual and mixed reality and quantum, as well as data transfer applications for artificial intelligence and machine learning.

https://plasma.oxinst.com/technology/atomic-layer-deposition

k-Space hosts visit by US Congresswoman Debbie Dingell

In the week before Christmas, 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 — hosted Congresswoman Debbie Dingell, who represents Michigan's 6th Congressional District in the US House of Representatives (as well as being a member of the Energy and Commerce Committee and the Natural Resources Committee).

During a tour of k-Space engineering and production facilities led by CEO & co-founder Darryl Barlett, Dingell learned first-hand how k-Space's metrology tools support growing both the compound semiconductor and solar panel industries.

"k-Space is in growth mode and Congresswoman Dingell was able

to see exactly how we design and build our industrial and semiconductor metrology tools," says Barlett. "Seeing first-hand the various semiconductor wafer measurements our tools make, plus getting a hands-on tour of our 3D printing facility, were highlights of the tour. We are very thankful for her visit and appreciate her energy and support of small business in Michigan."

Following her tour, Dingell held a question & answer session with k-Space staff. Questions ranged from how the CHIPS and Science Act can benefit smaller Michigan-based technology companies, to developing a stronger green energy manufacturing base in Michigan, to the national security benefits of making semiconductor chips in the USA. She also spoke briefly about the 2024 election, student loans, and how tech companies can effectively partner with public research universities.

www.k-space.com

Porotech and Powerchip partner on mass producing 200mm GaN-on-Si micro-LEDs for displays

PoroGaN μLEDoS, Dynamic Pixel Tuning, GaN-on-Si technologies to be applied in PSMC's front-end wafer foundry

Fabless micro-LED company Poro Technologies Ltd (a spin off from the Cambridge Centre for Gallium Nitride at the UK's University of Cambridge that has developed porous GaN material and has an R&D center in Hsinchu, Taiwan) and Taiwan-based foundry Powerchip Semiconductor Manufacturing Corp (PSMC) have announced a strategic partnership in micro-LEDs for display applications.

This partnership aims to expedite the production of bright, high-pixel-density, small and low-cost micro-LEDs for displays with high-yield manufacturing for consumer applications. PSMC's proprietary technologies in semiconductor front-end wafer manufacturing foundry combined with Porotech's technologies in PoroGaN micro-LED-on-silicon (μLEDoS), Dynamic Pixel Tuning (DPT), GaN-on-silicon platform target the commercialization of micro-LED displays.

Mass producing Porotech's micro-LED-on-silicon for pixelation in a semiconductor environment is a step ahead in the commercialization of displays for consumer application. Powerchip's strength in front-end semiconductor foundry is also expected to contribute to this during the mass-production stage.

The micro-LED-on-silicon for semiconductor manufacturing technology is expected to capitalize on the manufacturing precision for product performance, high-volume and low-cost display applications.

"Our collaboration with PSMC signifies a momentous step forward for mass-producing the micro-LED-on-silicon technology for display applications," reckons Porotech's CEO & founder Dr Tongtong Zhu. "An exciting road lies ahead with PSMC, propelling tremendous opportunity of commercialization with our mutual partners and customers."

www.powerchip.com
www.porotech.com

Kopin and MICLEDI to collaborate on micro-LED displays for AR applications in high-brightness light conditions

MICLEDI's micro-LED technology to combine with Kopin's backplane design capabilities

Kopin Corp of Westborough, MA, USA (a provider of application-specific optical systems and micro-displays for defense, enterprise, consumer and medical products) and MICLEDI Microdisplays B.V. of Leuven, Belgium — a fabless developer of micro-LED display modules for augmented reality (AR) glasses that was spun off from nano-electronics research center IMEC in 2019 — have announced a strategic agreement to work together to design, develop and manufacture micro-LED displays to provide a more immersive and information-rich AR experience for use in high-brightness light conditions.

The program will utilize MICLEDI's unique CMOS production flow and Kopin's backplane control and driving capabilities, along with its experience in manufacturing complete display systems, to create full-color micro-LED displays integrated with an advanced CMOS technology node for high-performance defense, enterprise, consumer and medical systems.

"The demand for AR solutions, particularly for defense programs, has never been higher as users desire more immersive and information-rich experiences," says Bill Maffucci, senior VP for business development and strategy at Kopin. "MICLEDI's micro-LED technology, combined with Kopin's advanced backplane design capabilities, aims to create micro-LED displays that address the demanding needs of emerging applications without the deficiencies of current technologies," he adds.

"We are pleased with Kopin's adoption and co-development of our disruptive AR display technology in truly innovative system solutions," says MICLEDI's CEO Sean Lord. "To enable optimum micro-displays for AR, we believe MICLEDI has developed the world's first solution for micro-LED manufacturing in a 300mm CMOS line, which allows integrating both controller ASIC and emitter module on a 300mm wafer in a highly efficient, high-volume and low-cost manufacturing flow," he adds. "Unique solutions can be tailored to the particular requirements of each end-use system, making MICLEDI's micro-LEDs — manufactured in collaboration with Kopin's backplane and system integration skills — applicable to a variety of specialized AR micro-display systems."

www.ces.tech
www.kopin.com

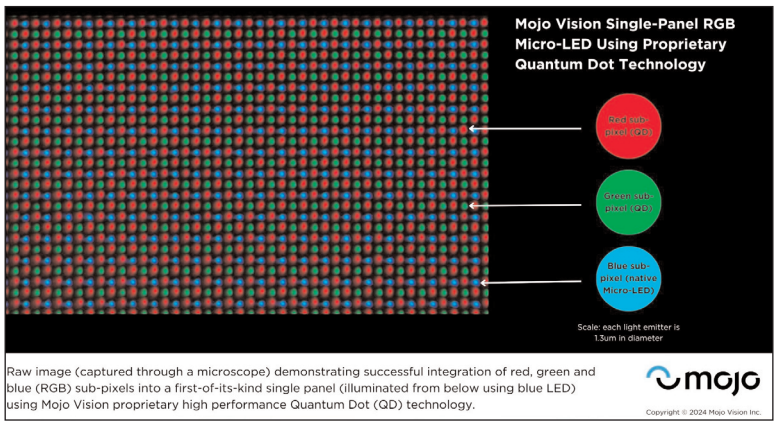
Mojo Vision integrates RGB micro-LED sub-pixels into single panel

Using proprietary quantum dots and integration processes demonstrates viability of single-panel RGB micro-LED displays

Mojo Vision Inc of Saratoga, CA, USA — which is developing and commercializing micro-LED display technology for consumer, enterprise and government applications — has integrated red, green and blue (RGB) sub-pixels into a first-of-its-kind single panel using its proprietary high performance quantum dots (QDs) and integration processes. The proof-of-concept integrates 1.3µm-diameter red and green QD-based sub-pixels adjacent to 1.3µm-diameter native blue sub-pixels, demonstrating the viability of the company's path to developing single-panel RGB micro-LED displays. The milestone is said to mark significant momentum toward scaling micro-LED technology and its use in augmented reality (AR) devices for peak performance in diverse outdoor environments.

The firm's focus on blue micro-LEDs at 200mm and 300mm wafer scale, coupled with its proprietary high-performance QD technology, leads the display industry to more scalable and commercial solutions. Existing commercially available QDs, designed for conventional displays like LCD, substantially lack the reliability under high light conditions required for AR glasses.

"Mojo Vision's proprietary process for robust QDs addresses the common industry challenge of achieving high brightness and durability when creating single-panel RGB displays," says CEO Nikhil Balram. "This process ensures the technology's reliability, coupling high image quality with efficiency and lifespan," he adds. "As companies develop wearables and smart glasses equipped with artificial intelligence (AI), micro-LEDs enable much better display resolution, brightness, contrast and dynamic range, crucial for rendering detailed images and supporting the advanced image recognition that the disruptive industry requires."



Raw image (captured through a microscope) demonstrating successful integration of red, green and blue (RGB) sub-pixels into a first-of-its-kind single panel (illuminated from below using blue LED) using Mojo Vision proprietary high performance Quantum Dot (QD) technology.

Track record of industry milestones

Previously, Mojo Vision announced a 300mm GaN-on-silicon micro-LED array wafer, marking progress toward maturing micro-LED manufacturing. The firm also demonstrated a vibrant red micro-LED micro-display using 1.3µm-diameter red QD regions on top of 1.3µm-diameter blue micro-LEDs.

"Augmented reality technology continues to progress toward the goal of seamlessly blending immersive, virtual experiences into the physical world and enabling natural interactions with digital objects," says Dr Achin Bhowmik, president of the Society for Information Display (SID). "Achieving this requires the high dynamic range, great contrast and image quality, super resolution, low power consumption, and compact form factor of micro-LED," he adds. "Mojo Vision's single-panel RGB display is a significant advancement toward realizing this promise."

Mojo Vision demonstrated its proprietary RGB single-panel micro-LED technology at the Consumer Electronics Show (CES 2024) in Las Vegas (9–12 January).

www.mojo.vision

SemiLEDs' quarterly revenue rebounds to $1.65m

Net loss cut from last quarter, but still greater than a year ago

For its fiscal first-quarter 2024 (to end-November 2023), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of $1.65m, down slightly on $1.695m a year ago but up on $1.453m last quarter.

Gross margin was 15%, down on 27% a year ago but rebounding from just 3% last quarter.

Net loss was cut from $881,000 ($0.18 per diluted share) last quarter to $598,000 ($0.12 per diluted share), although this is still greater than the $512,000 ($0.11 per diluted share) a year ago.

During the quarter, cash and cash equivalents fell from $2.572m to $2.322m.

For its fiscal second-quarter 2024 (ending 29 February), SemiLEDs expects revenue of $1.1m +/–10%. However, the quarter-to-quarter drop is partly due to the firm's office and factory in Chunan being closed for the Chinese New Year (CNY) on 3 February before resuming operations on 19 February.

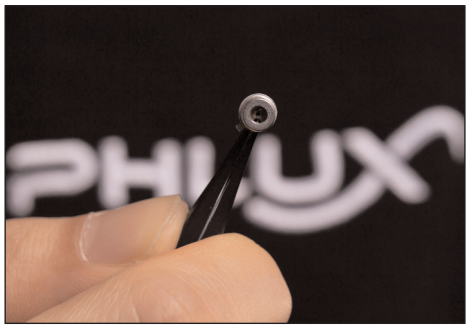
www.semileds.com

Phlux unveils Noiseless InGaAs APDs as first products

12x more sensitive IR sensors extend operating range of LiDAR, range-finders and optical fiber test equipment

Avalanche photodiode (APD) infrared sensor designer and manufacturer Phlux Technology (which was spun out of the UK's Sheffield University, with a seed funding round of £4m led by Octopus Ventures in December 2022) has announced its first products, the Aura family of 1550nm infrared (IR) devices based on the firm's Noiseless InGaAs APD technology. The sensors are claimed to be 12x more sensitive than traditional best-in-class indium gallium arsenide (InGaAs) APDs. As a result, the operating range of LiDAR, laser range-finders, and optical fiber test equipment can be extended by up to 50% with Phlux sensors, which are drop-in replacements for existing surface-mount or TO-packaged components.

In new designs, the Aura sensors can enable 12x greater LiDAR image resolution for a given laser power, up to 30% reduction in system size and weight, and up to 40% lower system costs. The size and cost reductions come from using lower-power lasers and smaller optical apertures without impacting system performance. Also, thermal management is simplified because Aura APDs operate at up to +85°C without performance degradation, which is a significantly higher temperature than traditional parts.



Phlux's Noiseless InGaAs Aura APD.

"Our Noiseless APD technology is a step-function leap in performance and provides tangible benefits for any company involved with 1550nm lasers," claims CEO Ben White. "Automotive LiDAR is an exciting application where the move from 905nm to 1550nm lasers is accelerating, not least because the latter is 'eye-safe'. But there are also huge opportunities for our products in telecommunications, laser range-finders, imaging, spectroscopy, gas sensing and optical fiber test equipment, particularly optical time-domain reflectometers," he adds.

Phlux created its Noiseless InGaAs APD technology by adding an antimony alloy to the compound semiconductor manufacturing process. The resulting sensors can be operated with APD gains of up to 120, enabling even the smallest signals above the noise floor of a connected trans-impedance amplifier (TIA) to be amplified. A further benefit of Aura APDs is their rapid overload recovery, which means that weaker secondary pulses that closely follow a large pulse can be detected.

The Aura APD 200 (200µm optical aperture) and Aura APD 80 (80µm optical aperture) sensors are available as bare die or in industry-standard SMD, chip-on-sub-mount, and TO-46 packages designed to meet MIL-STD 883.

Typical parameters for both devices are responsivity of 0.98A/W at 1550nm, spectral range of 950–1700nm, and excess noise factor of 1.86 at an avalanche gain of 40, or 1.08 at an avalanche gain of 10.

At a gain of 10, the noise equivalent power for the Aura APD 200 diode is 17fW/Hz$^{0.5}$, its capacitance is 2.4pF and its cut-off frequency is 0.7GHz. The equivalent figures for the Aura APD 80 are 11.1fW/Hz$^{0.5}$, 0.6pF, and 1.8GHz.

Both devices have a typical operating voltage of –55V to –65V and breakdown voltage of –65V, and their operating temperature range is –40°C to +85°C.

www.phluxtechnology.com/

Lynred appoints executive president and CEO

Hervé Bouaziz and Xavier Caillouet to expand IR detector range while strengthening global market competitiveness

Lynred of Grenoble, France, which designs and manufactures infrared (IR) detectors for aerospace, defense and commercial applications, has appointed Hervé Bouaziz as the firm's executive president and Xavier Caillouet as its CEO.

With more than 30 years of executive-level high-tech industrial expertise in aerospace & defense at Safran and Thales respectively, it is expected that Bouaziz and Caillouet will usher in a new business dynamic within the company. Their objective is to collectively leverage the company's technological skills and the €85m ($93.7m) Campus industrial project to increase Lynred's offering in infrared detectors, while strengthening its global market competitiveness.

As the European market leader in infrared detection, Lynred is currently leading the EU HEROIC project, a consortium of 10 European partners developing next-generation devices for defense and security. It is also designing infrared detectors for imaging satellite instruments for several European Earth observation missions, such as LSTM. Among other projects, the company is collaborating with partners to help car makers improve the reliability of collision prevention systems by detecting pedestrians or obstacles in adverse visibility conditions, particularly at night.

Bouaziz has 30 years of aerospace, defense and security experience. He joins Lynred from Europrop International, where he was CEO for four years. Previously, he worked for a decade at Safran, where he held several executive and strategic roles in electronics and defense, including his appointment in 2013 as executive VP for strategy and M&A at Safran Electronics and Defense, and in 2016 as VP for military engines programs at Safran Aircraft Engines. Prior to that, Bouaziz had a 20-year career at the French defense procurement agency DGA, where he first started as a test engineer in 1994. Subsequent promotions within the organization led to taking charge of the air-to-ground capabilities of the Mirage 2000 and Rafale in the DGA's aircraft program directorate and being named director of the Mirage 2000 N and D program. Following that, in 2005 he was appointed deputy armaments attaché at the French embassy in Washington D.C. He returned to France in 2008 and to the DGA as head of the armed forces systems division at the Defense Analysis Center. Bouaziz holds degrees from the Ecole Polytechnique (1988) and Sup'Aero (1993) engineering schools, as well as the Industrial College of the Armed Forces in the United States (2005). He also earned his air-force pilot wings in 1994.

Caillouet comes to Lynred after a 30-year career in international roles within various Thales divisions. Recently, he was VP of radiology at Thales and CEO of Trixell, a position he held for five years. Between 2013 and 2018, he served as VP of operations in airlines support for Thales Avionics, where he oversaw operations in four countries, including the USA and China. Prior to that, Caillouet managed strategy and product policy as VP of navigation and surveillance for Thales Air Systems in Europe and the USA, a position he held following his two-year role as director of projects and development. For a period of 10 years earlier in his career, Caillouet had successive managerial roles within Thales, including managing director of Thales Avionics Asia in Singapore and CFO of Thales Avionics Inc. in the USA. He holds a degree in engineering (1983) from Sup'Aero, a French institution for aerospace.

www.lynred.com

KYOCERA SLD Laser demos high-speed underwater wireless optical communications and custom GaN laser

At SPIE Photonics West 2024 (30 January–1 February), KYOCERA SLD Laser Inc (KSLD) of Goleta, near Santa Barbara, CA, USA demonstrated new LaserLight technologies including a high-speed, bidirectional link for underwater wireless optical communication (UWOC) and custom-chip GaN laser capabilities.

The high-speed, bidirectional link was powered by KSLD's GaN-based blue laser to enable UWOC. Laser LiFi is being adopted in applications including undersea and space, secure office, factories, defense and security, as well as future smart cities. Recognized with the 2023 Prism Award, KSLD's LaserLight LiFi system offers white and IR illumination with 1Gbps transmission rate bi-directionally in air to support the future of wireless connectivity. The new blue laser powered technology expands this system capability into underwater applications.

Based on the firm's GaN epitaxial growth, epitaxial layer transfer and wafer-level facet formation technologies, KSLD's custom-chip laser capabilities are being introduced to the market for customers needing specialized GaN-device-based products. During the exhibition, a selection of GaN laser products is being shown in KSLD's booth, including customized single-mode and multi-mode lasers at a variety of visible wavelengths. These new devices can enable advances in applications including quantum sensing, quantum computing, directed energy, 3D printing, optical wireless communication, biomedical, and life sciences.

In the talk 'Advances in InGaN Laser Diodes for Emerging Applications in the Visible Spectral Range', R&D process engineering manager Dr Phillip Skahan presented the latest performance of efficient, high-power lasers spanning the violet-to-green wavelength range as well as novel applications for its unique transfer technology. He also provided updates on ultra-short-cavity in-plane laser diodes and other technologies for specialty chip applications.

https://spie.org/photonics-west

KYOCERA SLD Laser unveils automotive headlight modules at CES

At the Consumer Electronics Show (CES 2024) in Las Vegas (9–12 January), KSLD unveiled Laser-based Automotive Headlight Modules and FiberLight Grille Assemblies that offer high-brightness white and infrared (IR) dual illumination for night vision and sensing for increased safety and visibility in automotive and mobility applications. The headlight assembly provides full features of low beam and high beam enabled by compact size modules with KSLD's LaserLight SMD White/IR dual-emission devices. The white light illumination provides a high-brightness and long-range light beam with a sharp cutoff, high contrast and precise patterns with minimum glare to maximize visibility. The IR illumination improves safety, with increased detection of objects such as animals, pedestrians or other hazards that would be otherwise difficult if not impossible to see using conventional lighting in foggy or dark conditions. The LaserLight Headlight Modules can be arranged in a set of four per headlight, for example two modules for low beam and two modules for high beam. The ultra-compact LaserLight Modules have a lens height of under 12.7mm, enabling flexibility for designers to adjust the configurations such as horizontal 2x2, vertical 2x2, offset layouts, and other arrangements.

The FiberLight Grille assembly offers ultra-bright white light in a thin emissive fiber only possible with laser light, enabling vehicle manufacturers to offer a strong brand signature. Applications include interior or exterior lighting, front lighting, tail lighting, in white or blue. KSLD's FiberLight demonstrator was on display at CES assembled into an automotive grille application. The FiberLight delivers white emissive fiber illumination with more than 10,000cd/m^2 and is targeted for exterior and interior lighting applications such as grilles, logos, daytime running lights (DRLs) and ambient lights. The FiberLight is said to deliver 10 times the brightness of LED solutions, producing brilliant and efficient illumination from thin, low-cost fiber optics and a remote light source.

KSLD also demonstrated a LaserLight line generator, providing a high-brightness and sharp-edge line light with capability to generate a variety of light patterns including straight, ring, square or angled lines. Applications include road projection to illuminate the line lights on a roadway in the forward direction of the vehicle to increase the visibility of moving vehicles to surrounding vehicles, cyclists or pedestrians. The application is useful in a dark roadway where traffic lane lines are not visible or difficult to see.

KSLD has been shipping its white light emitting LaserLight device for automotive high-beam boost applications since 2019 and was winner of the 2021 Prism Award for Photonics Innovation, Transportation Category. Beyond lighting, KSLD has been working on a development of gallium nitride-based laser light sources and modules for applications like LiFi, sensing and 3D printing.

www.kyocera-sldlaser.com

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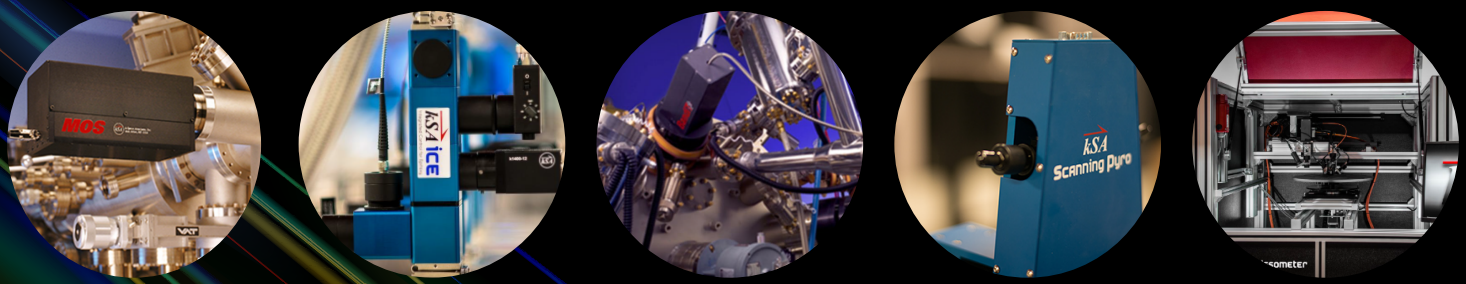

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Nichia's blue and green laser diode technology receives Scientific and Technical Award from the Academy of Motion Pictures Arts and Sciences

Nichia Corp of Tokushima, Japan — the world's largest gallium nitride (GaN)-based light-emitting diode/laser diode (LED/LD) manufacturer and inventor of high-brightness blue and white LEDs — says that its laser diode technology has been recognized for its contribution to the advancement of the motion picture industry by receiving a Scientific and Technical Awards from the Academy of Motion Picture Arts and Sciences (AMPAS).

The Academy's Scientific and Technical Awards are given to companies and engineers who have developed significant technologies that have contributed to the motion picture industry. Five engineers in Nichia's Laser Diode Development Department (Yoshitaka Nakatsu, Yoji Nagao, Tsuyoshi Hirao, Tomonori Morizumi and Kazuma Kozuru, involved in the development of the blue and green laser light sources that have been widely adopted in laser projection systems for movie theaters) have been awarded in the category of 'Technical Achievement Award' (receiving an Academy certificate).

The official Academy Awards ceremony takes place on 23 February at the Academy Museum of Motion Pictures in Los Angeles, California.

Laser projection systems have been increasingly adopted in movie theaters in recent years, since they provide ultra-high-resolution images with vivid colors, brightness and high contrast compared with conventional systems using lamp light sources. Laser light sources used in laser projection systems require extremely high quality, long-term reliability, and high luminous efficiency and wavelength control to achieve a high color gamut. Nichia says that its blue and green laser diodes meet and surpass these quality requirements and are being used throughout the industry.

www.nichia.co.jp

NUBURU wins PO from multi-national electronics firm

NUBURU Inc of Centennial, CO, USA has been awarded a purchase order from a multi-national electronics manufacturer with manufacturing capabilities across Asia, Latin America, Europe and the USA to supply a BL-250 for next-generation computers, consumer electronics and communication (3C) device manufacturing.

NUBURU says that its blue laser technology will be utilized in an R&D capacity to demonstrate the integration of its laser welding capabilities as an alternative to conventional soldering manufacturing techniques.

"By integrating our modular manufacturing solutions, we provide customers with the means for increased scalability and ability to produce more durable products," says CEO Brian Knaley. "We look forward to the continued market adoption of our BL product line, as the increasing demand for innovative capabilities and green manufacturing alternatives continues to accelerate."

Laser joining in its current state faces significant challenges rooted in energy-intensive soldering practices, resulting in inefficiencies and constraints on the precision and reliability of precise metal fabrication, notes NUBURU. By integrating its patented BL-250 product, existing manufacturing capabilities are expanded to enable new product designs, increase manufacturing throughput, enhance the overall sustainability of manufacturing, and achieving ROHS compliance by eliminating lead-based solders.

www.nuburu.net

NUBURU receives NYSE American non-compliance notice

NUBURU — which was founded in 2015 and develops and makes high-power industrial blue lasers — says that on 28 December it received a deficiency letter from the NYSE American LLC small-cap equity market indicating that it is not in compliance with the continued listing standards as set forth in Section 1003(f)(v) of the NYSE American Company Guide. Specifically, the notice informed NUBURU that NYSE American has determined that the shares of its common stock have been selling for a low price per share for a substantial period of time and, pursuant to Section 1003(f)(v) of the Company Guide, the firm's continued listing is predicated on it demonstrating sustained price improvement by 28 June.

NUBURU says that it intends to monitor the price of its common stock and consider available options, including conducting a reverse stock split, if its common stock does not trade at a consistent level likely to result in the firm regaining compliance by 28 June.

Receipt of the notice does not affect NUBURU's business, operations or reporting requirements with the US Securities and Exchange Commission (SEC).

www.nyse.com/markets/nyse-american

BluGlass completes acquisition of GaNWorks

Acquired wafer processing equipment now meeting operational benchmarks in BluGlass' Silicon Valley production facility

BluGlass Ltd of Silverwater, Australia — which develops and manufactures gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has completed its acquisition of contract manufacturer GaNWorks Foundry Inc, following the installation and validation of core GaN wafer processing equipment at its laser production fab in Silicon Valley.

Testing has confirmed that the n-side wafer metallization, wafer thinning, and bar cleave equipment is meeting GaNWorks' operational benchmarks in-house. Product validation of new GaN lasers made at BluGlass' Silicon Valley fab is also underway.

"Our acquisition of GaNWorks' specialist wafer processing equipment, manufacturing process transfer, and experienced GaN engineers will fast-track development and production cycles, and deliver significant cost savings over the long-term," believes BluGlass' CEO Jim Haden. "We have moved quickly to bring these complex processes in-house, having now completed process verification tests, and commenced validation of our first vertically integrated laser lots," he adds.

"We are already seeing the benefits of having all processes in-house under our operational control, enabling us to quickly identify additional process optimization opportunities, which are expected to significantly enhance production yield, reliability and throughput," Haden says. "With our wafer fab vertical integration completed, we are continuing to refine processes across the manufacturing supply chain to further improve laser performance, reliability and repeatability."

www.bluglass.com.au

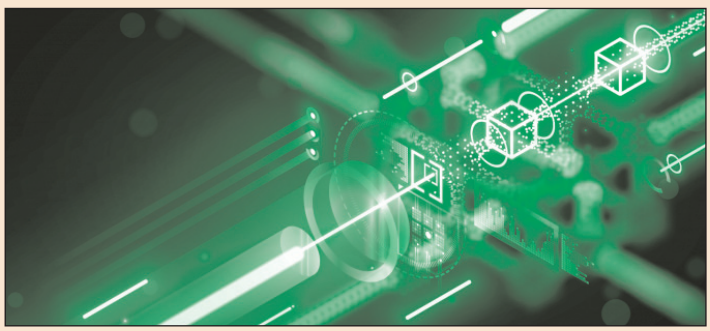
BluGlass secures first order for alpha prototype blue gallium nitride distributed feeedback lasers

Customer to use 450nm DFB prototypes for testing in the development of next-gen defence, aviation and scientific applications

BluGlass has secured its first purchase order of alpha gallium nitride (GaN) distributed feedback (DFB) lasers. The customer is a "pioneer in photonic and fiber-based laser technology" and will use BluGlass' prototype blue DFB lasers in the development of defence, aviation and scientific applications.

Quantum sensing, navigation and computing applications are driving significant demand for compact single-frequency laser light sources, such as GaN DFB lasers, says BluGlass. Single-frequency visible lasers have unique characteristics required to stimulate quantum transitions for highly promising military and commercial applications, including advanced robotics, bio-medical applications, and atomic clocks for quantum navigation, the firm adds.

In addition to quantum applications, the unique performance properties of single-wavelength



visible lasers can also enable advances in ranging and underwater communication, gas sensing, stand-off threat detection, and high-performance spectroscopy applications. GaN DFB lasers are a suitable candidate to facilitate the strict frequency, beam fidelity, narrow linewidth, and the high power and efficiency that these next-generation technologies require, BluGlass says.

BluGlass claims to be one of the first companies to develop viable DFB lasers in gallium nitride, as part of its partnership with the University of California Santa Barbara's SLEEC Consortium.

"Our first customer order of BluGlass prototype GaN DFBs reflects the significant interest in these ultra-precision lasers for quantum, defence and commercial applications," notes CEO Jim Haden. "Novel capabilities such as DFB lasers form a key pillar of our growth strategy, and we will continue to leverage our RPCVD technology to enhance BluGlass' DFB lasers, achieving advanced single-frequency performance at blue wavelengths and beyond."

BluGlass cautions that, while this order reflects a significant strategic step in its development of laser diodes and demonstrates customer need for GaN DFB lasers, the revenue for the order is immaterial.

Coherent launches VCSEL-based illumination module platform for short- and mid-range LiDAR in automotive safety and industrial robotic vision

Five-junction VCSEL technology enables up to 200W of output

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA has introduced of an illumination module platform for short- and mid-range light detection & ranging (LiDAR) in automotive safety and robotic vision in industrial applications.

The growing adoption of advanced driver assistance systems (ADAS) in vehicles and of depth sensing in industrial robots is accelerating the demand for compact and flexible LiDAR systems that perform efficiently and reliably, even in the most extreme environments. Using eight 940nm vertical-cavity surface-emitting laser (VCSEL) modules, Coherent has demonstrated a solution with several selectively addressable horizontal slices of the field of illumination (FOI). As well as offering a compact form factor and what is claimed to be excellent power conversion efficiency, the module is a much lower-cost alternative than using large addressable VCSEL arrays. Coherent has a demonstrator available for customers to explore multiple VCSEL module

positioning configurations and scanning algorithms for various depth sensing modalities and types of scenery.

"A powerful aspect of the module platform is the ability to customize an optimized solution for use cases requiring up to 30m of depth sensing in bright daylight. Our illuminators exceed 30% total power conversion efficiency and have a compact footprint, only about a third of the size of a credit card," says Dr David Ahmari, VP & general manager, Optoelectronic Devices & Modules Business. "To achieve this breakthrough in efficiency and size, we are leveraging our state-of-the-art five-junction VCSEL technology that enables each illuminator module to achieve up to 200W of output power," he adds. "Our demonstrator is available for customers to evaluate and better envision the expanded universe of applications enabled."

Users will be able to adjust the duration of the driving pulses to achieve both short- and mid-range LiDAR sensing. The FOI slices are dynamically selectable, depending on the number of VCSEL modules and the order in which they are scanned. A voltage supply of only 21V is required, which is much lower, and therefore more efficient, than existing LiDAR technology, it is reckoned.

Coherent showcased its range of products and innovations for sensing at Photonics West in San Francisco (30 January to 1 February).

www.spie.org/conferences-and-exhibitions/photonics-west
www.coherent.com/electronics/sensing-imaging-ranging

Sivers Photonics receives $860,000 follow-up orders from US Fortune 100 customer

Design optimization and supply of 50,000 lasers for optical sensing follows 30,000-device shipment at end-Q2/2023

IC and integrated module supplier Sivers Semiconductors AB of Kista, Sweden says that its subsidiary Sivers Photonics of Glasgow, Scotland, UK has received new orders and requests worth about $860,000 (SEK9m) from its first established US Fortune 100 customer, estimated to be delivered mostly during first-half 2024 (including some contingency planning that up to 25% that may be delivered later).

This work will cover design optimization and the supply of at about 50,000 semiconductor laser devices for further system testing for use in advanced optical sensing applications. This is a follow-up to the 30,000 device shipment order made at the end of second-quarter 2023. Sivers Photonics has been working with this key customer for over five years and has invested more than $17m on development.

"In 2023 we got the first, larger prototype order, and we are now adding some design changes to deliver more prototypes for further system testing," says Sivers Semiconductors' group CEO Anders Storm. "The customer is making progress in their project and is getting closer to the volume phase, which strengthens our belief in a favorable future volume phase."

www.sivers-semiconductors.com

VCSELence Torino inaugurated as VCSEL center of excellence in Italy

Characterization, modelling and design of VCSELs targeted at high-speed optical fiber data transmission links and optical sensing

As part of the IEIIT-Reunion in Turin, Italy on 20 December, VCSELence Torino was inaugurated as a center of excellence (CoE). The primary scientific and technological goals are to investigate vertical-cavity surface-emitting lasers (VCSELs) for applications in high-speed optical fiber data transmission links and optical sensing. Relying on its established technical background in VCSELs, VCSELence targets the experimental exploitation of these devices, pushing their application beyond the current limits by performing modelling of the in-laser phenomena, supported by in-house experiments, with final testing of the device in the entire system.

VCSELence Torino unites the competences of the founders Department of Electronics and Telecommunication (DET) at Politecnico di Torino), LINKS Foundations and IEIIT-CNR (Istituto di Elettronica e di Ingegneria dell' Informazione e delle Telecomunicazioni del Consiglio Nazionale delle Ricerche). These organizations collectively have expertise in optical, electrical and spectral characterization, modeling and advanced applications of semiconductor lasers, spanning all wavelengths for the optical communication bands and optical sensing. The scientific goal is to advance understanding of the dynamics of the coupled photon-carrier system in these optoelectronic emitters by combining theoretical and experimental investigations. It is expected that this will allow improved devices to be designed on-demand, exploiting their ultimate limits and going far beyond the existing state-of-the-art.

VCSELence Torino says that it is open in offering its services of modelling, design, characterization and system testing on a worldwide platform by collaborating with all technology-driven and application-oriented groups. It is expected that this will result in international research, in the spirit of collaborative opportunities with innovative companies. VCSELence Torino already relies on a wide range of European and worldwide funded projects with universities and companies, and it intends to extend these.

VCSELence is building on the existing photonics infrastructure of LINKS and Photonext (Interdepartmental Center for Applied Photonics of Politecnico di Torino) where it shares a 300m^2 lab. It aims to become a significant player in the development of knowledge and expertise in the application of semiconductor technologies, benefitting Italy's economy. The new center is also expected to play an important role in advancing quantum physics-based technology and the ability to apply it to the advantage of society.

"Our Center of Excellence will be the research building for all scientists involved in modeling, design, technology and application of these low-cost semiconductor lasers, working together on the advancing of semiconductor optics research and optoelectronics," says CNR's Dr Pierluigi Debernardi, who has 25 years of experience working on VCSELs.

www.ieiit.cnr.it

Innolume expands quantum dot laser production

Expansion to meet surging demand for O-band CW lasers and semiconductor optical amplifiers for AI-driven connectivity

Gallium arsenide (GaAs)-based quantum dot (QD) diode laser manufacturer Innolume GmbH of Dortmund, Germany has announced a substantial expansion of its production capacity to address the surging demand for O-band continuous wave (CW) lasers and semiconductor optical amplifiers (SOAs) in several markets including artificial intelligence (AI)-driven connectivity. For example, according to LightCounting Market Research, shipments of 800+Gbps optical transceivers are expected to nearly double annually over the next five years, driven by the rapid expansion of hyperscale data centers.

To meet this escalating demand and solidify its market position, Innolume has placed purchasing orders for a Riber CPS 442 laser facet passivation machine and a Riber 49 molecular beam epitaxy (MBE) system to expand its existing MBE fleet. This investment is a part of the overall on-going investment program to ramp up Innolume's manufacturing capacities.

Innolume says that its quantum dot distributed feedback (DFB) lasers are known for their high power, superior reliability, efficient operation at elevated temperatures, and ability to work with silicon photonics photonic integrated circuits (PICs) without optical isolator, making them the preferred choice for cloud networking systems navigating the complexities of next-generation connectivity.

www.innolume.com

Aeluma appoints Craig Ensley to board

Experienced executive to provide guidance on scale-up and accelerating business development

Aeluma Inc of Goleta, CA, USA, which develops optoelectronic devices for communications and sensing applications including LiDAR (light detection and ranging), has elected Craig Ensley as a new member of its board of directors.

"He brings a breadth of experience from the semiconductor industry across multiple market verticals including sensors, communications, automotive, mobile, PCs, consumer and AI," comments CEO & founder Jonathan Klamkin Ph.D. "Craig provides a deep understanding of technology, and also of strategy, customer engagement, and supply chain. We can leverage his experience driving high-growth advanced semiconductor companies, for Aeluma, where we have been establishing a foundation for rapid growth," he adds. "Craig's appointment is timely, given our recent achievement of revenue, recent wins, and our plans to begin scaling our technology for large-volume consumer markets."

Ensley, age 73, has led global semiconductor businesses in analog & DSP, MEMS & sensors, and communications (RF/wireless, optical, and wired). His prior executive leadership roles include CEO of Atomica (formerly IMT), the largest MEMS & sensors manufacturing foundry in the USA; CEO of DisplayLink, an enterprise video networking firm; president of Peregrine, a high-volume RF & wireless devices company for 3G & 4G; and senior VP at Cirrus Logic, a mixed-signal circuits company for consumer applications. Earlier in his executive career, Craig helped to build the communications semiconductor business at Rockwell International, which spun out as three public companies: Mindspeed, Jazz and Conexant.

Ensley currently serves on the boards of AI company Mentium Technologies as well as the MEMS & Sensors Industry Group. Previously he was on the boards of the Consumer Electronics Association Audio and Home Networking Divisions, and the KLRU Austin PBS Television Station. He earned a Master in Business Administration from Stanford University, and a Bachelor of Science in Applied Physics and a Bachelor of Arts in Economics, both from the University of California San Diego.

"It is impressive how far the company has come in such a short time since inception… This is a testament to Aeluma's leadership, team, and its technology," comments Ensley. "During its next stage of growth, I hope to provide the company with guidance on how to scale, how to accelerate business development activities, and how to make the most of the opportunities ahead for transformative semiconductor companies, given the strong demand for this technology."

Aeluma is working to commercialize its chip technology for a markets including automotive LiDAR, mobile, defense & aerospace, AR/VR, AI, and communications. The firm says that it has established a unique semiconductor manufacturing capability in Santa Barbara, CA. With proprietary technology that combines compound semiconductor nanomaterials with mass-market semiconductor manufacturing, Aeluma is developing products that, it reckons, could offer high-performance and low-cost solutions for emerging markets. Key to its technology is the ability to manufacture its compound semiconductor chips on silicon substrates of up to 12" in diameter, which can scale and be mass produced, potentially cutting the cost of chips dramatically.

www.aeluma.com

Ayar Labs' board gains silicon industry veterans to accelerate growth

Microchip CEO Ganesh Moorthy and tech entrepreneur Craig Barratt join board; co-founder Vladimir Stojanovic becomes CTO

Silicon photonics-based chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA says that Ganesh Moorthy, president & CEO of Microchip Technology Inc, and technology entrepreneur Craig Barratt, former CEO of Atheros and current chair of the board of Intuitive Surgical, are joining its board of directors. Also, Ayar's co-founder Vladimir Stojanovic has been named chief technology officer.

"Each will play a critical role as we move our technologies into production maturity," says CEO Mark Wade. "Their collective knowledge and experience will help us accelerate our roadmap leadership, and deliver the transformative value of optical I/O in AI systems, high-performance computing (HPC) and next-generation data-center system architectures."

Moorthy has more than 40 years of executive leadership and semiconductor industry experience. In addition to his role as president & CEO of Microchip, Moorthy serves on the board of the Semiconductor Industry Association (SIA), the Global Semiconductor Alliance (GSA), Rogers Corp, and Celanese. Previously, he held several senior leadership roles at Intel Corp.

"The work Ayar Labs is doing to make optical I/O a reality is essential to the forward progress of the entire industry," believes Moorthy. "By addressing the performance and power bottlenecks of traditional electrical-based interconnects, Ayar Labs will help unleash the full potential of everything from AI and 6G networks to disaggregated data centers and so much more," he adds. "I look forward to helping Ayar Labs expand its reach across the ecosystem as the company moves into its next phase of growth."

As CEO of Atheros, Barratt completed an IPO and ultimately sold Atheros to Qualcomm for $3.1bn. He also served as CEO of Barefoot Networks, which was acquired by Intel. In addition to his entrepreneurial career, he has held executive positions at Google, Qualcomm and Intel, and he is currently chair of the board for Intuitive, IonQ and Calysta.

"Optical I/O solves long-standing data movement challenges in computing systems. With the dramatic bandwidth and performance needs in AI systems, a new generation of foundational technologies and products are needed," says Barratt. "Ayar Labs' leadership in breakthrough optical I/O solutions enables system performance that is not possible with alternative approaches," he adds. "I look forward to leveraging my background in bringing new semiconductor technologies to market to accelerate the company's growth."

In addition to co-founding Ayar and serving as its chief architect, Stojanovic is co-founder of NanoSemi, which was acquired by MaxLinear. Most recently, he served as professor of Electrical Engineering and Computer Sciences at the University of California, Berkeley, and he was also an associate professor at MIT from 2005 to 2013. He was recently named an IEEE Fellow for his contributions to electronic–photonic design and system-on-chip integration.

These additions to Ayar's leadership team build on the firm's momentum in 2023, including technology breakthroughs and progress with customers and partners. Ayar showcased the industry's first 4Tbps optical solution, moving data from one TeraPHY optical I/O chiplet to another at 2Tbps in each direction powered by Ayar's SuperNova light source. The firm is able to achieve this data transfer at the latency and power efficiency needed for data-intensive workloads such as generative AI, machine learning and more, while also supporting novel disaggregated compute and memory architectures.

Ayar also recently demonstrated its in-package optical I/O solution integrated with Intel's Agilex FPGA technology. This new optically enabled FPGA promises 5x the existing industry bandwidth at 5x lower power and 20x lower latency, all packaged in a common PCIe card form factor.

www.ayarlabs.com

OIF unveils CEI-112G-XSR+-PAM4 Extended Extra Short Reach Implementation Agreement

Optical Internetworking Forum also releases C-CMIS IA, publishes AI network operations and 400ZR+ demo white papers, and announces next CMIS webinar

The Optical Internetworking Forum (OIF) has published a new Implementation Agreement (IA) for Common Electrical I/O (CEI) CEI-112G-XSR+-PAM4 Extended Extra Short Reach.

The CEI-112G-XSR+-PAM4 IA specifies a 112Gb/s PAM4 electrical interface for die-to-die (D2D) and die-to-optical-engine (D2OE) interconnect with bump-to-bump insertion loss up to 13dB at the Nyquist frequency and baud rate in the range 36–58Gsym/s. The intended applications encompass multiple-chip modules (MCM), co-packaged optics (CPO) and near-package optics (NPO) assemblies. It also details the requirements for the CEI-112G-XSR+-PAM4 extended extra-short-reach high-speed electrical interface with nominal baud rates between 36Gsym/s and 58Gsym/s using PAM4 modulation.

"The CEI-112G-XSR+-PAM4 IA represents a significant milestone, extending the reach of previously published XSR-class specifications at this speed range," says OIF Physical and Link Layer Working Group chair David Stauffer of Kandou Bus S.A. "This IA empowers advanced interconnectivity solutions in die-to-die and die-to-optical-engine scenarios, supporting baud rates up to 112Gb/s (58Gsym/s). These specifications have the opportunity to revolutionize multiple-chip modules, co-packaged optics and near-package optics applications, pushing the boundaries of high-speed data transmission," he adds.

"The CEI-112G-XSR+-PAM4 IA addresses a gap in the set of OIF CEI specifications to address new applications identified by the diverse membership of the OIF," says Alphawave Semi's Matt Brown, editor of the CEI-112G-XSR+-PAM4 IA.

OIF also recently released the Coherent Common Management Interface Specification (C-CMIS) IA 1.3, published an Application of Artificial Intelligence (AI) to Enhanced Network Operations technical white paper, published the ECOC 400ZR+ demo white paper and launched a series of CMIS technical webinars.

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C-CMIS IA 1.3: This Implementation Agreement extends the Common Management Interface Specification [CMIS] to allow the management of digital coherent optics (DCO) modules. Initially covering 400ZR modules, this IA supports the management of modules that have a single data path with an eight-lane host interface for a 400GBASE-R Ethernet signal and a single-lane 400G coherent media interface based on the 400ZR specification. Future extensions to accommodate other DCO modules are anticipated.

Application of Artificial Intelligence (AI) to Enhanced Network Operations Technical White Paper: This new white paper addresses the interoperability requirements for enhanced network functions that interface between transport networks and their management-control systems. It identifies various use-cases for applying AI to guide interoperability and provides insights into data requirements, processing needs, output specifications and interfaces relevant to each use case.

ECOC 400ZR+ Demo White Paper: This paper presents the methodology and results of an interoperability study of OpenZR+ MSA QSFP-DD transceivers conducted during the ECOC 2023 plugfest. Ten different transceivers were cross-connected in a matrix of transmitter-to-receiver combinations using a noise-loaded link to characterize the penalties associated with supplier interoperability. Individual transceiver performance was tested using 400GE traffic over a shortened optical line system link with a DWDM 75GHz fixed-channel grid and a separate configuration to capture the transmitter error-vector magnitude (EVM) performance. The transceiver receiver OSNR performance is compared against the transceiver transmitter EVM performance for each vendor.

CMIS Technical Webinar Series: OIF is hosting a series of free, public CMIS tutorial webinars. The next webinar 'Data Path State Machine (DPSM) and Application Advertising' will be held on 7 February. These webinars aim to equip engineers, developers and industry professionals with a comprehensive understanding of CMIS.

www.oiforum.com/wp-content/uploads/OIF-CEI-05.2.pdf

OpenZR+ MSA Group completes multi-vendor interop testing transporting 400G traffic over different routes

The OpenZR+ Multi-Source Agreement (MSA) Group has announced the results of two interoperability test events at LightRiver, showing compatibility to the OpenZR+ specification and interoperability between optical transceiver modules from different vendors in two different routers by transporting 400Gb/s traffic over various optical links. These testing events featured coherent optical transceivers from Cisco, Coherent, Fujitsu, Juniper Networks and Lumentum operating on Cisco and Juniper routers.

"The results of this multi-vendor interoperability testing validate the readiness of network operators to take advantage of 400G pluggables in order to cost-effectively scale their networks to meet growing bandwidth demands," says OpenZR+ MSA Group co-chair Tom Williams.

"Not only does interoperability enable a more robust supply chain in the industry by allowing network operators to mix and match equipment and services from different providers, but it can also accelerate the adoption of new technology," adds co-chair Atul Srivastava.

The two interop testing events were:

- Phase 1 (August 2023): Verification that optical transceiver QSFP-DD-DCO modules comply to the OpenZR+ multi-source agreement in router platforms through the OIF CMIS compliant interface in loopback mode, plus verification that optical transceiver QSFP-DD-DCO modules from different vendors interoperate over a single-span link with 75km of fiber;
- Phase 2 (September 2023): Multi-vendor interoperability and performance testing over a multi-span optical line system (OLS).

As outlined in the white paper, these two events demonstrated the following successful results:

- 400G OpenZR+ optical transceiver modules from multiple vendors operated in various routers;
- all 400G OpenZR+ optical transceiver modules transported traffic with no post-FEC bit errors at receiver OSNR of 24dB or less;
- 400G OpenZR+ optical transceiver modules from five vendors interoperated with each other;
- 400G traffic was transported over a typical DCI use case with 75km of fiber and a typical metro use case with multi-spans over 430km of fiber.

OpenZR+ was designed to focus on Ethernet traffic with support for multiple host and line interface rates in form factors that are used for high-density 400G client optics, such as QSFP-DD and OSFP. The OpenZR+ modes utilize oFEC, which was originally specified by the Open ROADM MSA for carrier applications in metro networks, and support multi-vendor interoperability, providing network operators with an operationally efficient solution for DCI, metro and long-haul applications.

www.openzrplus.org/documents

Enablence and Polar partner on transceiver chips

Enablence Technologies Inc of Ottawa, Ontario, Canada, a publicly traded company that designs and manufactures optical components, and Polar Semiconductor of Bloomington, MN, USA, a foundry manufacturer of analog and power semiconductor devices and sensors for automotive, consumer and industrial markets, are partnering to develop and manufacture optical semiconductors for transceivers.

As part of its strategic growth plan, Enablence has recently ramped up product development efforts, launching new families of coarse wavelength division multiplexing (CWDM) and dense wavelength division multiplexing (DWDM) optical devices. The firm has also made significant investments in critical tool sets, including etching, lithography and deposition process technologies, to ramp up production of its planar lightwave circuits (PLCs) to meet demand. PLCs provides a higher volume of optical integration in a smaller footprint, offering a lower cost, lower power and high-capacity advantages for systems using wavelength division multiplexing. With many new products in the development pipeline designed to address datacom, telecom, LiDAR and industrial automation growth opportunities, the collaboration with Polar provides Enablence access to high-quality, leading-edge tool sets, proven production processes and the capacity to meet new demand. For Polar, the partnership provides an opportunity to expand its footprint within the optoelectronics market, which is projected to grow substantially over the next several years.

"This partnership strengthens Polar Semiconductor's expansion into optoelectronics manufacturing, something we see as a strategic growth segment," says Polar's VP of technology development Rajesh Appat. "Our primary goal is to work closely with Enablence Technologies to help deliver best-in-class, quality optoelectronics products to the market by applying our 60-plus years of proven expertise in technology and process development."

"This partnership provides synergistic growth opportunities for both companies," reckons Enablence's CEO Todd Haugen. "It strengthens our production capabilities, provides us with new capacity, and immediately brings online critical etching, deposition and lithography processes which will help accelerate the development and release of our advanced, new optical products to the market."

https://polarsemi.com
www.enablence.com

NREL awards $1.8m in second round of contracts for Cadmium Telluride Accelerator Consortium

Funding to support development of cheap, efficient CdTe solar cells

The National Renewable Energy Laboratory (NREL), on behalf of the US Department of Energy's Solar Energy Technologies Office (SETO), has awarded $1.8m to fund seven projects to support the Cadmium Telluride Accelerator Consortium (CTAC).

Announced in August 2022, CTAC is a three-year consortium intended to accelerate the development of cadmium telluride (CdTe) technologies by lowering the cost and increasing the efficiency of these thin-film solar cells. The first round of awards for $2m was announced in June 2023.

CdTe solar cells are the second-most-common photovoltaic technology after silicon solar cells. CdTe solar cells rely on a thin film of material to absorb light and convert it into electricity. Photo by Dennis Schroeder, NREL.

NREL released the most recent request for proposal for small projects in June 2023. This second round of awardees was announced in December 2023. These projects were selected for the latest round of the consortium:

Topic area 1: High-efficiency devices

Vapor-assisted group V diffusion doping control in high-efficiency CdSeTe solar cells

CdTe photovoltaic technology has shown power conversion efficiency (PCE) of 22.3%, but it remains distant from its theoretical PCE of 31%. To address this gap and achieve 26% cell efficiency while reducing domestic CdTe module costs to 15 cents per watt by 2030, additional innovation is crucial. Group V doping has proven effective in enhancing CdTe device performance, improving both efficiency and stability. The proposed project by Arizona State University explores novel vapor-based ex-situ group V doping, diffusion doping activation strategies, surface cleaning techniques, passivated back-contact methods, and innovative device architectures. The goal is to develop higher-efficiency CdTe devices exceeding 22% by tailoring the group V vapor doping conditions to realize fine control of the incorporation and activation of the dopants.

Optimizing iodine-doped CdTe for potential n-type solar cells

Washington State University will develop CdTe homojunctions using iodine-doped n-type CdTe absorbers that are shown to have high carrier concentration and minority carrier lifetime with 100% dopant activation. The team will apply a combination of defect spectroscopy techniques, optimized surface passivation techniques, and device architecture and aim to overcome present performance limitations based on p-type absorbers.

Solution-processed buffer layers for CdTe solar modules

This work by nexTC Corp will use liquid-phase precursors to fabricate state-of-the-art buffer films that improve device performance. These films exhibit ultra-smooth surfaces. They reduce surface texture/roughness and increase transmission by limiting optical haze, providing manufacturers with pristine surfaces for device manufacturing. In this project, the team will demonstrate the efficacy of solution processing to yield high-quality front-interface buffer/emitter layer films used in the CdTe market. They will demonstrate the ability to deposit compositions of commonly used materials and explore novel material compositions that are impossible to create via typical sputter deposition. NexTC will work with CTAC members to fabricate and prototype CdTe solar devices. This approach should accelerate the transition from ideation to high-volume manufacturing.

Topic area 2: Tellurium supply

Identifying high-potential areas for tellurium extraction within existing base and precious metal supply chains

Tellurium is a key component of the manufacturing of CdTe systems required to increase the domestic renewable energy generation capacity of the USA. However, supplies of tellurium are insecure, with the USA being significantly import-reliant despite well-established large-scale domestic mining and smelting operations involving tellurium-bearing ores. This project by the University of Nevada, Reno will assess the tellurium extraction potential of existing mining supply chains, providing baseline data for the targeting of high-priority areas for enhanced tellurium extraction. This should increase sustainability and ensure secure supplies of this critical commodity for US industry.

Topic area 3: New device configurations and processes

Ultra-thin high-efficiency CdTe/MgCdTe double-heterostructure solar cells with light-trapping features

Arizona State University's program aims to develop a model system to demonstrate ultra-thin monocrystal CdTe solar cells with an efficiency potentially reaching 28% and to better understand the challenges that polycrystalline CdTe thin-film solar cells face. The impact of this model system is beyond the demonstration of solar cells with high efficiencies. It also helps the CdTe solar cell community to address several critical issues, such as the optimization of both contacts and associated interfaces, the optimal passivation of the grain boundaries, and the development of ultra-thin absorbers integrated with light-trapping features. The team will continue collaborating with NREL and other CTAC members during this proposed program to exchange scientific findings and samples, technological knowledge, and practical inventions.

Innovative high-voltage cadmium selenide (CdSe) solar cells

In this project, the Iowa State University team will investigate high-performance devices made from CdSe, a material for making top (large-bandgap) solar cells for tandem junction solar cells with Cd(Se,Te) acting as the bottom (lower-bandgap) cell of the tandem pair. Simulations show that theoretical solar conversion efficiencies approaching 40% are possible using this combination of materials. Both material systems are capable of low-cost vacuum deposition techniques. The team will make novel device structures using heterojunctions to achieve high voltage and efficiency in CdSe.

Topic area 4: Characterization, modeling and simulation

Towards automated atomic-resolution scanning transmission electron microscopy and machine learning for achieving high-efficiency Cd(Se)Te solar cell devices

The University of Illinois Chicago team will develop and utilize novel materials characterization and modeling approaches to determine the atomic-scale barriers that currently limit the conversion efficiency of polycrystalline CdTe solar cell devices to <23%. By combining advanced machine learning (ML) with state-of-the-art electron microscopy, the team will study the role that grain boundaries, hetero-interfaces and defects have on the carrier lifetime and durability of the Cd(Se)Te materials. 4D scanning transmission electron microscopy, energy-dispersive x-ray spectroscopy, and electron energy-loss spectroscopy will be used to quantify local atomic and electronic structures of Cd(Se)Te bulk, interfaces and defects. ML approaches to autonomous anomaly detection will be developed to increase the field of view and sensitivity of existing electron microscopy methods. Insights resulting from this project should enable the development of CdSeTe-based devices with efficiencies exceeding 25%.

www.nrel.gov/pv/cadmium-telluride-photovoltaics-accelerator-consortium-solicitation.html

First Solar acquires facility for use as distribution center to serve expanding Ohio manufacturing footprint

1.2 million square-foot facility could also serve as light-scale manufacturing location

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has acquired a 1.2 million square-foot facility in Troy Township, Ohio. Formerly known as Peloton Output Park, the facility is expected to be repurposed into a new distribution center serving First Solar's Ohio manufacturing footprint, which comprises three manufacturing facilities with a combined annual nameplate capacity of about 6GW at the end of 2023.

"As we prepare to expand our Ohio capacity by almost a gigawatt this year, there's a need for our logistics and distribution capabilities to scale to match manufacturing growth," says chief supply chain officer Mike Koralewski. "We intend to use this facility to ensure the efficient and timely shipping of modules to our customers, repurposing it into a dedicated distribution hub for the largest solar manufacturing footprint in the Western Hemisphere. We expect that this approach will allow us to streamline logistics operations, while reducing operating costs and contributing to our cost-reduction roadmap," he adds. "In the long term, the flexible space that the facility affords us could also serve as a light-scale satellite manufacturing location with the potential to support our factories and R&D center in Ohio."

In addition to expanding its Ohio footprint to over 7GW of annual nameplate capacity this year, First Solar expects to invest over $2bn in new manufacturing facilities in Alabama and Louisiana. The firm expects to have 14GW of fully vertically integrated US solar manufacturing capacity by 2026. Additionally, First Solar is investing up to $370m in a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

www.firstsolar.com

First Solar inaugurates $700m, 3.3GW PV module manufacturing plant in India

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA says that its new facility in Tamil Nadu, India, the country's first fully vertically integrated solar manufacturing plant, has been inaugurated by Dr T R B Rajaa (Minister for Industries, Promotions & Commerce of the Government of Tamil Nadu) in a ceremony attended by Eric Garcetti (the US Ambassador to India) and Scott Nathan, CEO of the US International Development Finance Corporation (DFC).

"We are pleased that First Solar chose Tamil Nadu for this landmark investment, solidifying our state's position as India's hub for manufacturing," said Rajaa. "This factory sets a high bar for sustainability and advanced manufacturing and has created high-value jobs as a result of its presence in our state, all while supporting India's ambition to become self-sufficient in solar technology."

The facility, which has an annual nameplate capacity of 3.3GW and directly employs about 1000 people, produces First Solar's Series 7 modules, which were developed at the firm's R&D centers in the USA and optimized for the Indian market. First Solar claims to be unique among the world's largest solar manufacturers for being the only US-headquartered company. Its tellurium-based semiconductor material, which allows it to avoid dependence on Chinese crystalline silicon supply chains, is the second most common photovoltaic technology available.

"One month ago in Dubai, COP28 participants issued a bold call for the world to transition away from fossil fuels, to achieve net-zero emissions by 2050," said Garcetti at the inauguration ceremony. "This First Solar production facility will help advance our global transition to cleaner, greener energy, and stands as a shining example of what can be achieved when the United States and India work together — across government and private sectors — to achieve lasting climate action."

Representing an investment of about $700m, which includes $500m in previously announced DFC financing, the facility is First Solar's sixth operational factory and expands the firm's global manufacturing footprint to four countries, including the USA, Malaysia and Vietnam.

"The United States is leveraging American innovation and technology to diversify critical energy supply chains around the world and drive economic growth in India. That's good for the United States and it's good for India," says DFC's CEO Scott Nathan. "This $500m in financing reflects the increasing strength of our partnership with India — DFC's largest market and a like-minded partner with a dynamic private sector."

Since the start of this decade, First Solar has embarked on a $4.1bn manufacturing expansion strategy that has seen it grow from about 6GW operational in 2020 to over 16GW global nameplate capacity at the end of 2023. In addition to its India facility, the firm also commissioned its third US factory, located in Ohio, in 2023. It is further growing its footprint in the USA with a 0.9GW expansion of its Ohio manufacturing complex and new factories in the states of Alabama and Louisiana, which are each expected to add 3.5GW of annual nameplate capacity, once commissioned and ramped. The firm expects to have 25GW of global annual nameplate capacity by 2026.

The United States is leveraging American innovation and technology to diversify critical energy supply chains around the world and drive economic growth in India

"The inauguration of this landmark manufacturing facility and the launch of commercial shipments to customers in India is a crucial milestone in our journey to long-term and sustainable growth," says First Solar's CEO Mark Widmar. "The speed with which we were able to build and commission this facility is a testament to the policies of India's Federal and the Tamil Nadu state governments," he adds.

"We are proud of our associates who worked tirelessly to replicate and adapt our advanced solar manufacturing template for India," Widmar continues. "Thanks to their work, our newest facility doesn't just set standards for our global manufacturing footprint, but for our industry."

Located in an area of high baseline water stress, the factory is believed to be the world's first net-zero water withdrawal solar manufacturing facility. Designed to minimize its impact on local water resources, it will rely entirely on tertiary treated reverse osmosis water from the city's sewage treatment plant and have zero wastewater discharge. Also, the factory is home to India's first solar PV recycling plant. First Solar pioneered high-value solar recycling, which provides closed-loop semiconductor recovery for use in new modules, while also recovering other materials including aluminium, glass and laminates.

The Series 7 module produced by the new facility is claimed to be the industry's most eco-efficient, with a carbon and water footprint that is about four times lower than crystalline silicon solar panels produced in China. The firm's sustainable manufacturing approach uses 50% less energy and only a third of the water than an equivalent polysilicon module production facility would require, it is reckoned.

www.firstsolar.com

Cleantech Solar to procure 150MW of India-made Series 7 modules to power First Solar India manufacturing facility

Cleantech to supply 7.3GWh to new 3.3GW solar manufacturing facility in Tamil Nadu

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has entered into a 15-year, captive power purchase agreement (PPA) with Singapore-headquartered Cleantech Solar, a provider of renewable energy solutions to corporations in India and Southeast Asia. Cleantech Solar will construct 150MW of solar and 16.8MW of wind-generating assets in Tamil Nadu, India, supplying about 7.3 gigawatt-hours (GWh) of electricity to First Solar's new 3.3GW vertically integrated solar manufacturing facility, also located in Tamil Nadu.

Minister for Industries, Promotions and Commerce of the Government of Tamil Nadu, Dr T R B Rajaa, the US Ambassador to India Eric Garcetti, and Scott Nathan, CEO of the US International Development Finance Corporation (DFC) inaugurated First Solar's new module manufacturing facility in India.

When fully commissioned by third-quarter 2024, the solar and wind generation assets are expected to provide up to 70% of the facility's anticipated electricity needs, displacing almost 7000 kilotons of CO_2 emissions over the duration of the PPA. Furthermore, Cleantech Solar has agreed to procure 150MW of India-made Series 7 panels from First Solar, utilizing the modules to power the solar PV component of the PPA. The modules are expected to be delivered in first-half 2024.

"Our new manufacturing facility in Tamil Nadu sets a high benchmark for responsible and sustainable vertically integrated solar manufacturing, not just in India, but globally," reckons Sujoy Ghosh, VP & managing director, First Solar India. "By powering our operations with clean, renewably generated electricity, we are working to further reduce our environmental footprint, which is already the lowest in the industry," he claims.

First Solar's Tamil Nadu plant, located in an area of high baseline water stress, is believed to be the world's first net-zero water withdrawal solar manufacturing facility. Designed to minimize its impact on local water resources, it will rely entirely on tertiary treated reverse osmosis water from the city's sewage treatment plant and have zero wastewater discharge. Additionally, the factory is home to India's first PV solar recycling plant. First Solar claims that it pioneered high-value solar recycling, which provides closed-loop semiconductor recovery for use in new modules, while also recovering other materials including aluminium, glass and laminates.

"This collaboration extends beyond powering First Solar's flagship manufacturing facility in India; it involves leveraging their advanced, ultra-low-carbon thin-film solar panels to energize our solar assets," says Cleantech's CEO Sachin Jain. "Cleantech has a substantial presence in the state of Tamil Nadu within the renewable energy sector, particularly in wind and solar. Our state-of-the-art solar and wind energy parks in the region play a pivotal role in delivering clean and cost-competitive power to our esteemed clients, including First Solar," he adds.

"This collaboration enables our partners' efforts to diversify their energy sources, integrate renewable energy into their operations, and achieve a higher degree of stability and sustainability in their power supply," Jain continues. "This partnership exemplifies our commitment to advancing sustainable energy solutions and reinforces our position as a key player in the renewable energy landscape."

The agreement is believed to be one of the largest intra-state PPAs in India, and the projects being developed across Cleantech Solar's renewable energy parks in Tamil Nadu are already providing solar, wind and hybrid energy solutions to its corporate customers. With this latest agreement, Cleantech Solar's total portfolio size in Tamil Nadu is now nearly 500MW across operations and construction stages, and includes solar, wind and hybrid power projects.

www.cleantechsolar.com
www.firstsolar.com

Nickel nanoparticle lift to p-GaN-free deep-UV LEDs

Lower contact resistance and higher light extraction give cooler-running chips and longer-life performance.

Hebei University of Technology and Advanced Ultraviolet Optoelectronics Company Ltd in China have reported the use of self-assembled nickel (Ni) nanoparticles to improve the performance of deep ultraviolet (DUV, wavelength less than 300nm) light-emitting diodes (LEDs) that do not contain DUV-absorbing gallium nitride (GaN) [Tong Jia et al, IEEE Transactions on Electron Devices, vol.70, issue 12 (December 2023), p6410–6414].

DUV LEDs are being developed for a wide range of applications such as disinfection, air/water purification, indoor plant growth, and phototherapy. Presently, DUV is mostly generated using mercury lamps, which are bulky, have low efficiency and lifetime, and release poisonous vapor when broken. It is hoped that successful LED development will address each of these drawbacks. The present efficiency for AlGaN DUV LEDs is less than 20% at 280nm wavelength.

P-type GaN is often used as a hole injector into DUV LEDs constructed otherwise from aluminium gallium nitride (AlGaN) alloys. The alternative of using p-AlGaN contacts suffers from lower hole injection efficiency, but are more transparent to DUV. Such p-GaN-free DUV LEDs have been achieved, and ways to improve the various efficiencies that make up the overall energy efficiency have begun to be explored extensively.

The Hebei researchers' device structure with Ni nanoparticles (Device Ni) improves the contact resistance between the metal and AlGaN on the p-side of the LED, and also improves the light-extraction efficiency by reducing the total internal reflection arising from the high refractive index contrast between the AlGaN and other materials of the LED and air. Both these factors reduce the chip temperature, adding to the improvement in performance.

The team explains: "We think that two factors contribute to the lower chip temperature of Device Ni. First, the nanoparticle array causes more photons to be scattered out of the device. Hence, fewer photons are absorbed by the device and, thus, less heat is generated. Second, as has been previously discussed, the presence of Ni nanoparticles reduces ohmic contact resistance in Device Ni, thereby decreasing heat production under identical current conditions, which results in an improved self-heating effect."

The material for the DUV LEDs was grown using metal-organic chemical vapor deposition (MOCVD) on c-plane sapphire (Figure 1). The researchers processed the material into two device types: a reference, and a device enhanced with Ni nanoparticles (Figure 2).

The first fabrications steps, common to both devices, were to etch mesas with inductively coupled plasma, and then to deposit and anneal titanium/aluminium/titanium/gold (Ti/Al/Ti/Au) for the n-electrode.

The reference device was completed by depositing and annealing nickel/gold/nickel/gold (Ni/Au/Ni/Au) for the p-electrode, and then evaporating a thick aluminium layer for the contact pads.

Contact	p-$Al_{0.43}Ga_{0.57}N$	175nm
EBL	p-$Al_{0.6}Ga_{0.4}N$	20nm
MQW	5×($Al_{0.45}Ga_{0.55}N$/$Al_{0.56}Ga_{0.44}N$)	5×(3nm/12nm)
Electron injection	n-$Al_{0.6}Ga_{0.4}N$	1μm
Nucleation	AlN	2μm
Substrate	Sappire	

Figure 1. MOCVD epitaxy structure for DUV LEDs.

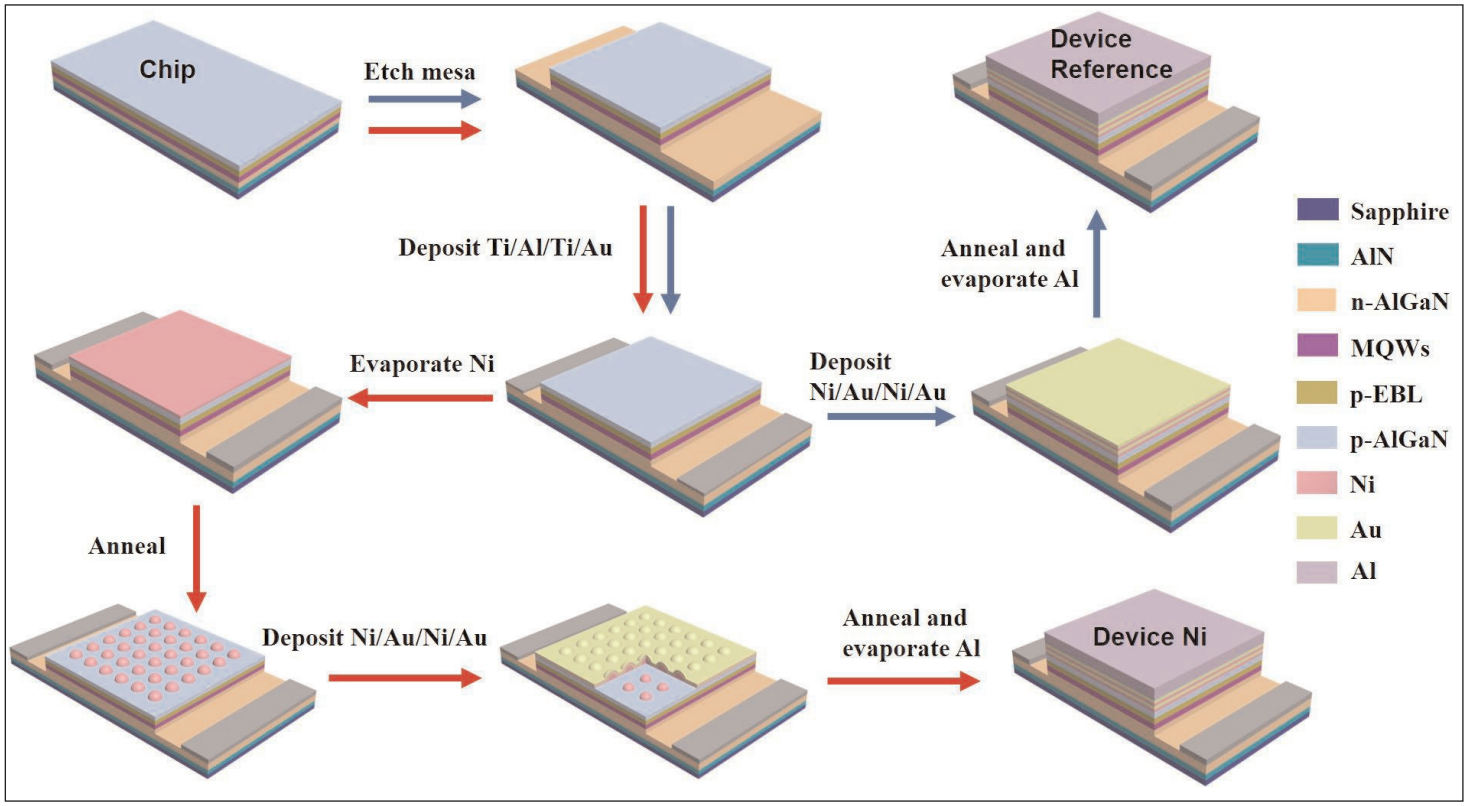

Figure 2. Process flowcharts for Ni nanoparticle device and reference.

The Ni device process preceded these final steps by first depositing 2nm Ni, followed by 2 minutes annealing in nitrogen at 600°C, forming Ni nanoparticles. According to atomic force microscopy (AFM), the nanoparticles were on average 75nm high and 300nm in diameter with around 50% fill factor.

After these processes the sapphire substrate was thinned down to 250μm with a view to chip singulation and encapsulation processing.

In electrical testing the researchers found that the Ni nanoparticle layer reduced the contact resistance between the p-AlGaN and NiAu electrode, enabling higher current injection into the device for a given forward voltage: 6V for 100mA, compared with 7V for the reference device to achieve the same injection current.

The researchers suggest that one effect of the Ni nanoparticles is to relieve thermal stress so that the subsequent Ni layer does not form clusters. Without

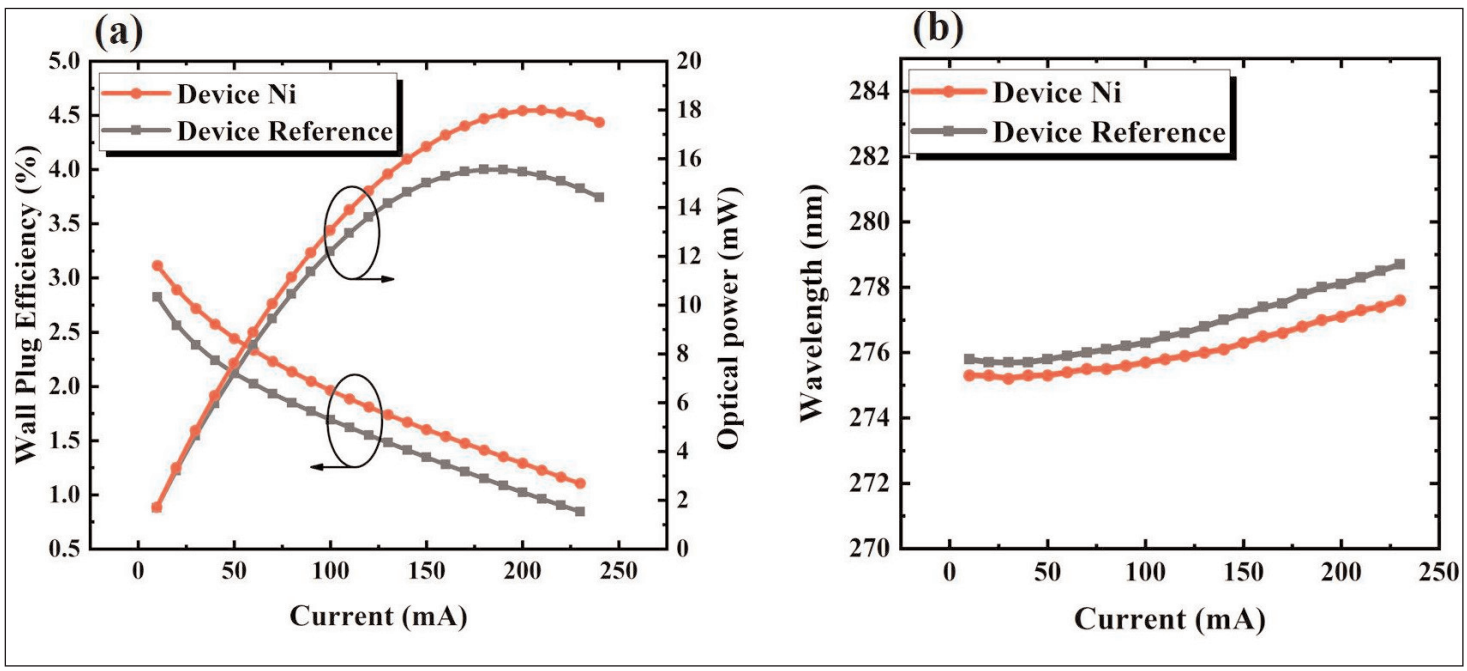

Figure 3. (a) Optical power and wall-plug efficiency (WPE) versus injection current for Ni and reference devices. (b) Peak wavelength versus injection current.

the nanoparticles, the first Ni layer forms clusters during annealing, exposing parts of the overlying Au film, which then makes contact with the p-AlGaN.

The researchers comment: "It is difficult for Au/p-AlGaN interface to form ohmic contact. We infer that when Ni nanoparticles are embedded between NiAu/p-AlGaN, the thermal stress can be effectively relaxed. As a result, the Ni layer of NiAu on the Ni nanoparticles will remain intact and not transfer into clusters. Thus, the p-AlGaN is still fully covered with a Ni film after annealing, which facilitates superior p-type ohmic contact for Device Ni."

The light output power reached 18mW at 200mA injection for the DUV LED with Ni nanoparticles, compared with 15.6mW for the reference device (Figure 3). The team comments: "Despite the fact that Ni has a high absorption rate for DUV light, Ni nanoparticles can also serve as scattering centers, leading to an improvement in optical power."

Both devices suffer from 'roll-over' from increasing to decreasing light output power with increasing current injection. The researchers attribute this to self-heating, which degrades the internal quantum efficiency (IQE). The peak in output power occurs at a higher current in the Ni nanoparticle LED, indicating a reduced self-heating effect compared to the reference. Further indications of reduced self-heating was a reduced wavelength red-shift with increasing current, and a shorter wavelength for a given current, compared with the reference. At 200mA, the wall-plug efficiency (WPE) for the Ni device was 1.3%, compared with 1% for the reference.

The researchers also performed two-dimensional finite-difference time-domain (2D FDTD) simulations of the Ni and reference device structures, which suggested that the light extraction efficiency would increase if the Ni nanoparticle diameter were reduced to 120nm with a 600nm period, reducing the fill factor.

The team also reports lifetime studies up to 170 hours. The Ni device showed a slower deterioration in light output power. The reduced self-heating results in a lower chip temperature and hence longer life performance. ■

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Stacking p-down green LEDs using tunnel junctions

Reducing injection current is shown to enhance wall-plug efficiency.

Ohio State University and Lumileds LLC in the USA, report on dual-junction p-down green light-emitting diodes (LEDs) [Sheikh Ifatur Rahman et al, Jpn. J. Appl. Phys., vol62, p110904, 2023].

By connecting stacked active LED regions with tunnel junctions, the researchers reduced the injection current needed for a desired light output power. A reduced injection current allows the devices to operate in a region with higher external quantum efficiency (EQE), avoiding the efficiency droop typically seen at higher currents.

Efficiency droop becomes particularly severe in longer-wavelength green LEDs, creating a 'green gap' for efficient light-emission capabilities for lighting, display and laser applications. With further development, it should be possible to stack more than two LED active regions.

Further, the use of the p-down structure should avoid efficiency sapping effects of the charge polarization field arising from contrasting ionicity of the chemical bonds in the different layer materials that comprise the devices.

The researchers explain: "In conventional metal-polar (+c oriented) LEDs, where the p-doped layer is on top of the n-doped region, the polarization dipole within the InGaN quantum well opposes the depletion field, and high electrostatic carrier injection barriers are formed on both sides of the well. These barriers block electron and hole injection into the active region, and therefore could cause degradation in the electrical efficiency of the diode. In the p-down case, the polarization dipoles are in the same direction as the depletion field and, therefore, the electrostatic barriers to electron and hole injection at the edge of the quantum wells are reduced."

In the p-down format the charge polarization field is reversed relative to the device structure. Of course, the conventional structure is conventional due to a number of difficulties in realizing the p-down structure, particularly in activating the buried p-type layers.

Activation usually consists of thermally annealing the magnesium-doped gallium nitride (GaN) to drive out hydrogen, which passivates the p-doping effect of Mg. When p-GaN is the top layer, most of the hydrogen escapes from the top surface. In buried p-GaN, the only route is through the sidewalls, making activation more tricky.

More problems arise from the thermal budget. High-temperature processing can affect doping profiles and degrade the light-emitting indium gallium nitride (InGaN) quantum wells (QWs).

The epitaxial material for the p-down LED with two active regions was grown using metal-organic chemical vapor deposition (MOCVD) on n-GaN/sapphire templates (Figure 1). The active light-emitting regions

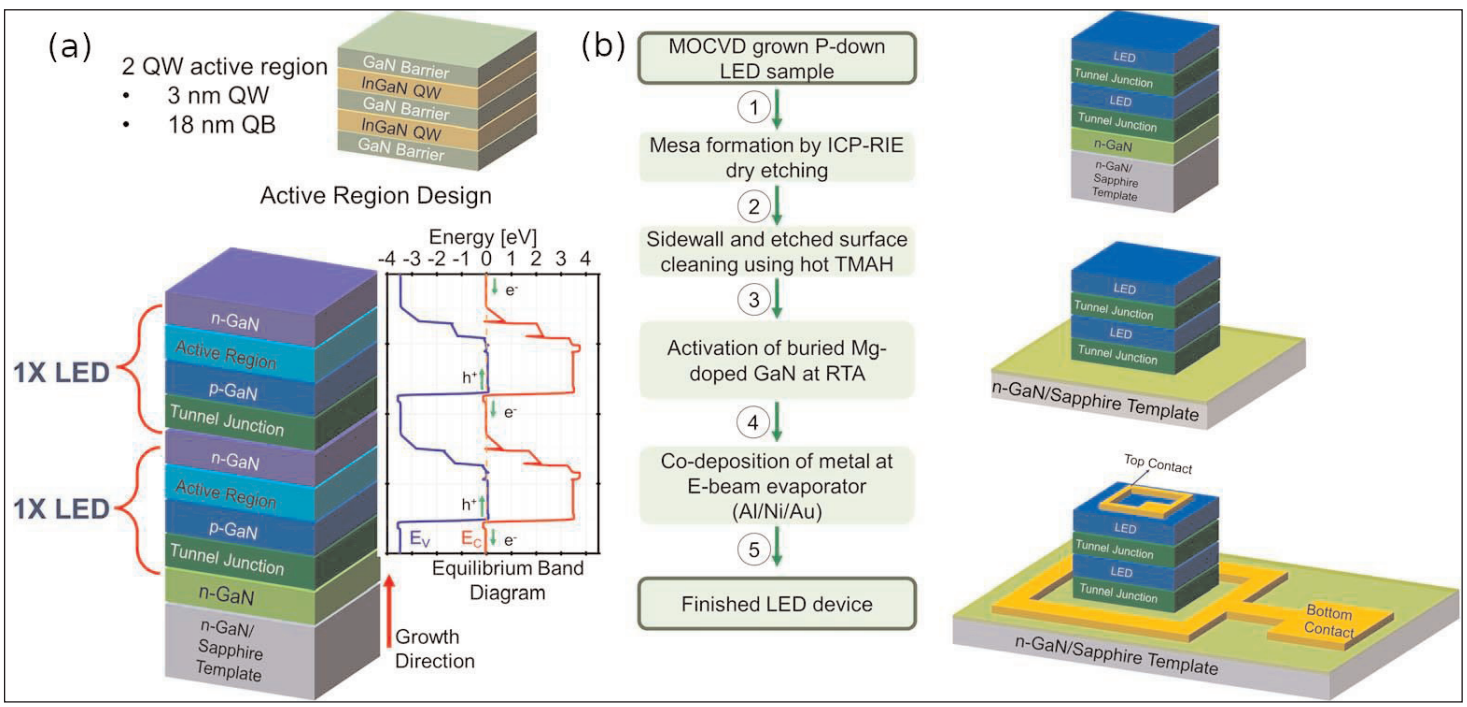

Figure 1. (a) Epitaxial structure of dual-active-region p-down LED with active region design and corresponding equilibrium band diagram. (b) Process flow for single-junction and dual-junction p-down LEDs.

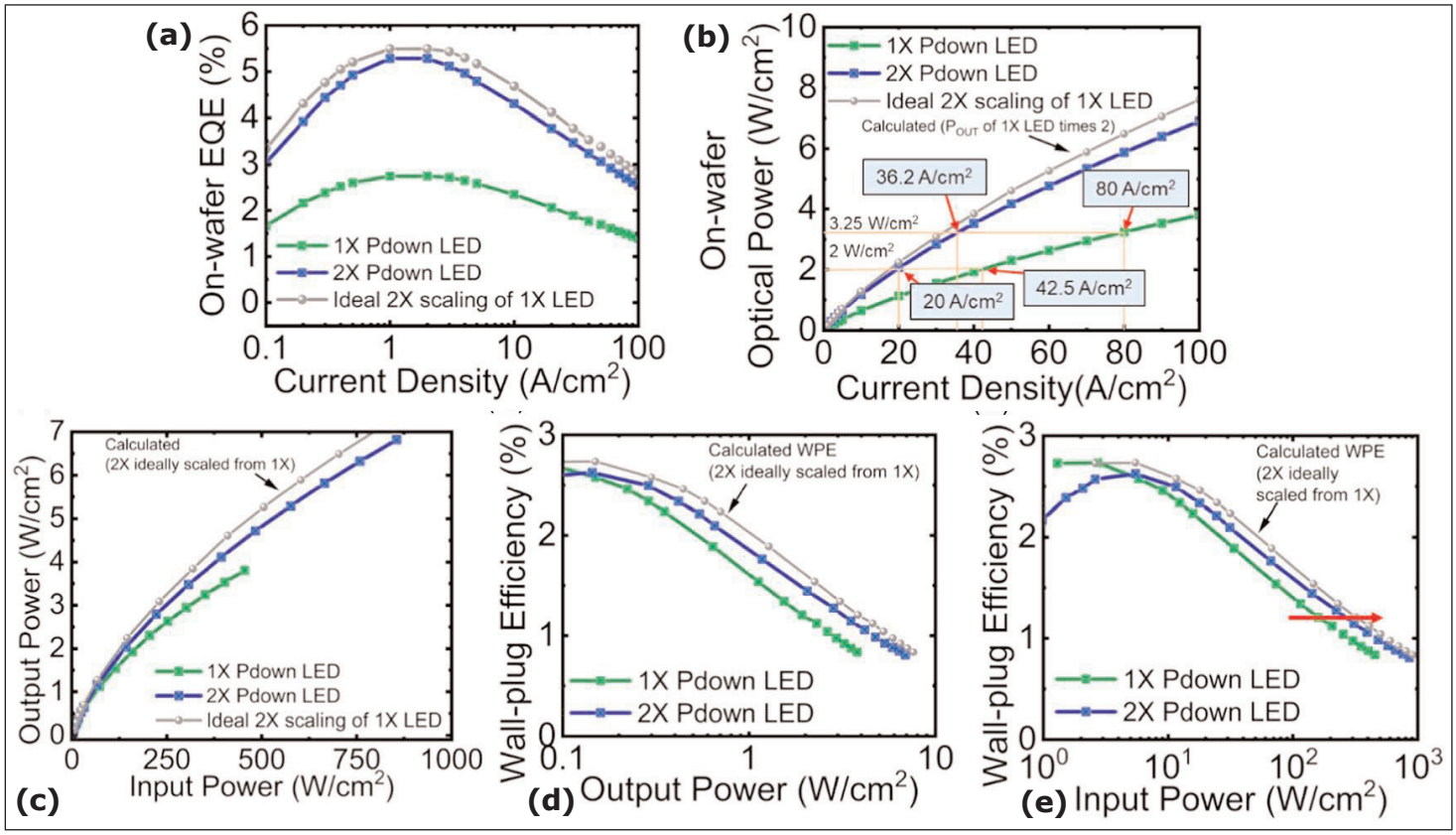

Figure 2. (a) On-wafer measured EQE for single-junction and dual-junction devices. (b) Optical power. (c) Electrical input power and output optical power. (d), (e) Calculated wall-plug efficiency with corresponding output power and input power.

contained two InGaN QWs separated by GaN quantum barriers (QBs). The tunnel junctions consisted of heavily-doped p/n layers. The bottom junction enables uniform current spreading across the device in the more electrically conductive n^{++}-type layer.

The material was fabricated into LEDs, using direct-write optical lithography, inductively coupled plasma reactive-ion etch (ICP-RIE), rapid thermal annealing (RTA), and electron-beam (E-beam) evaporation. The ICP-RIE was used for mesa isolation, while the RTA activated the buried p-GaN layers. The E-beam evaporated contact metals were aluminium/nickel/gold (Al/Ni/Au) on n-GaN. The devices were not optimized for light extraction — for example, the metal contact was not designed with a view to high reflectivity. The devices measured 100μmx100μm.

The forward voltages at 20A/cm^2 were 3.6V and 7.1V for single- and dual-LED devices, respectively. The 3.6V/junction excess voltage is relative to the ~2.3eV photon energy. The researchers comment: "We attribute the excess voltage in each single p-down LED+TJ structure to the tunnel junction — MOCVD-grown tunnel junctions in the n^{++}/p^{++}configuration have high voltage drop due to challenges associated with achieving high Mg doping density in the top p-region while ensuring that the active region does not degrade due to the Mg doping tail. The estimated tunnel voltage drop in these devices is still the lowest voltage demonstrated for any MOCVD-grown reversed-polarization tunnel junction-based green LED."

The peak emission wavelengths varied in the range 543–517nm for current densities in the range 0.1–100A/cm^2, respectively. The EQEs at 1A/cm^2 injection reached 2.75% and 5.3% for the single- and dual-junction LED, respectively (Figure 2). At 100A/cm^2 the corresponding EQEs were reduced to 1.4 and 2.5%.

The team comments: "While the scaling of EQE is not exactly 2x, the significant improvement of the EQE value both at low and high current densities highlights the benefits of cascading multiple active regions to tackle pronounced efficiency droop in long-wavelength emitters. Several factors such as the increased thermal budget and Mg memory effects can impact the optical characteristics of multi-active-region LEDs and cause non-ideal EQE scaling."

For 2W/cm^2 optical output power density, the single-junction LED required a 42.5A/cm^2 injection, while the dual-junction device only needed 20A/cm^2. The researchers calculate the single- and dual-LED wall-plug efficiencies (WPEs) at 2W/cm^2 output to be 1.17% and 1.40%.

At 3.25W/cm^2 output, the corresponding current densities were 80A/cm^2 and 36.2A/cm^2. The lower injection currents for the dual-junction device enabled it to operated in a more efficient region for producing light. ■

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Author: Mike Cooke

Full-color active-matrix micro-LED micro-displays

Flip-chip-bonded micro-LED arrays feature 391 pixels per inch (ppi) density and "decent" color gamut.

Hong Kong University of Science and Technology in China reports progress in fabricating prototype full-color active-matrix micro-LED micro-displays with 391 pixels per inch (ppi) density and "decent" color gamut [Longheng Qi et al, Light: Science & Applications, v12, p258 2023].

The 200x80-resolution device consisted of indium gallium nitride (InGaN, blue/green) and aluminium gallium indium phosphide (AlGaInP, red) micro-LED arrays flip-chip bonded to a silicon (Si) complementary metal oxide semiconductor (CMOS) backplane.

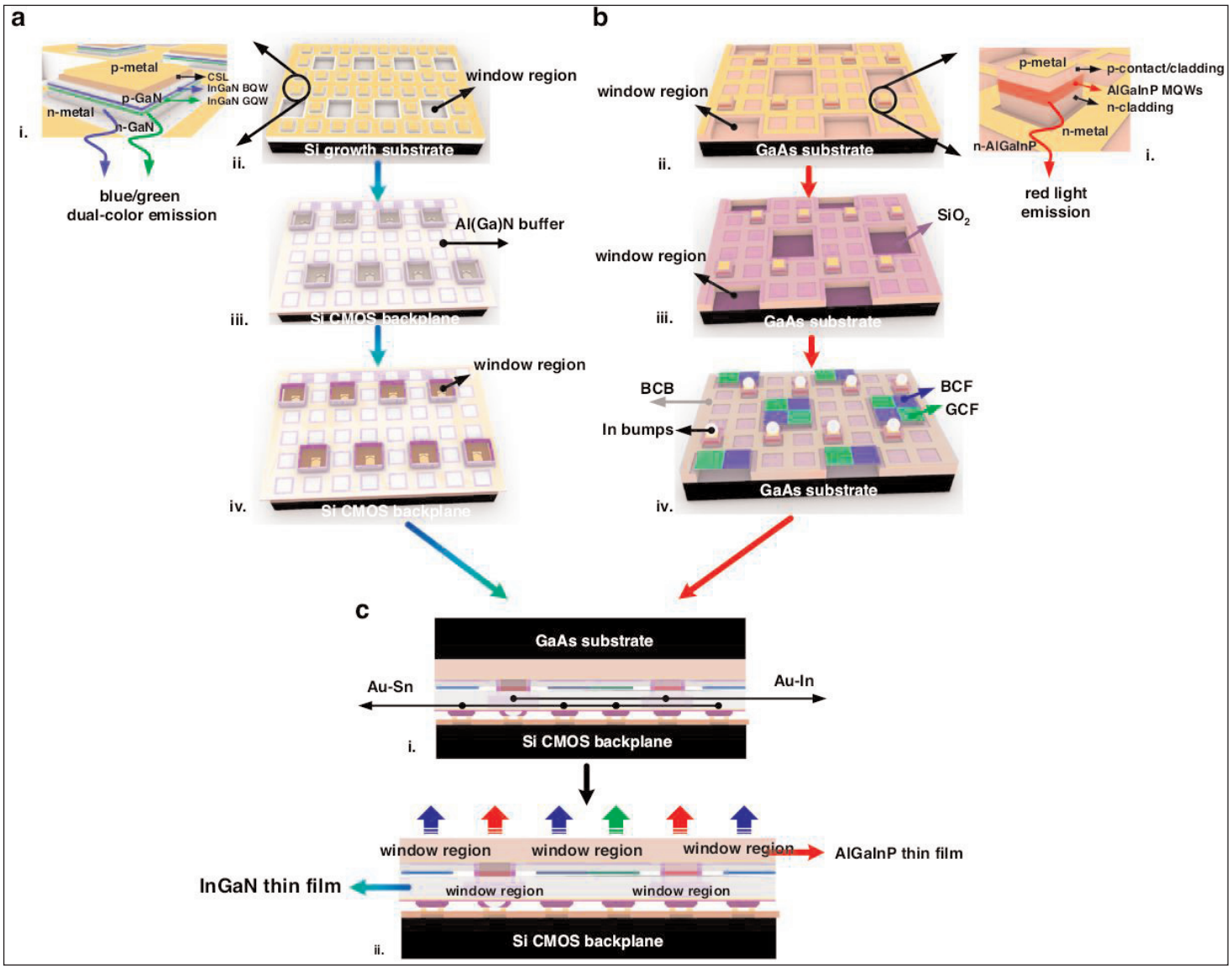

Figure 1. Process flow. (a) Fabrication of InGaN blue/green dual-color micro-LED display: (i) subpixel; (ii) window regions and p, n metallization; (iii) Au–Sn flip-chip bonding to CMOS backplane; (iv) Al(Ga)N buffer etchback. (b) Fabrication of AlGaInP red micro-LED array: (i) subpixel; (ii) window regions and p, n metallization; (iii) SiO_2 passivation and contact holes; (iv) BCB polymer etchback, reflow of indium micro-bumps and blue/green color filter patterned. (c) Heterogeneous integration: (i) Au–In flip-chip bonding of InGaN and AlGaInP display arrays; (ii) GaAs substrate removal.

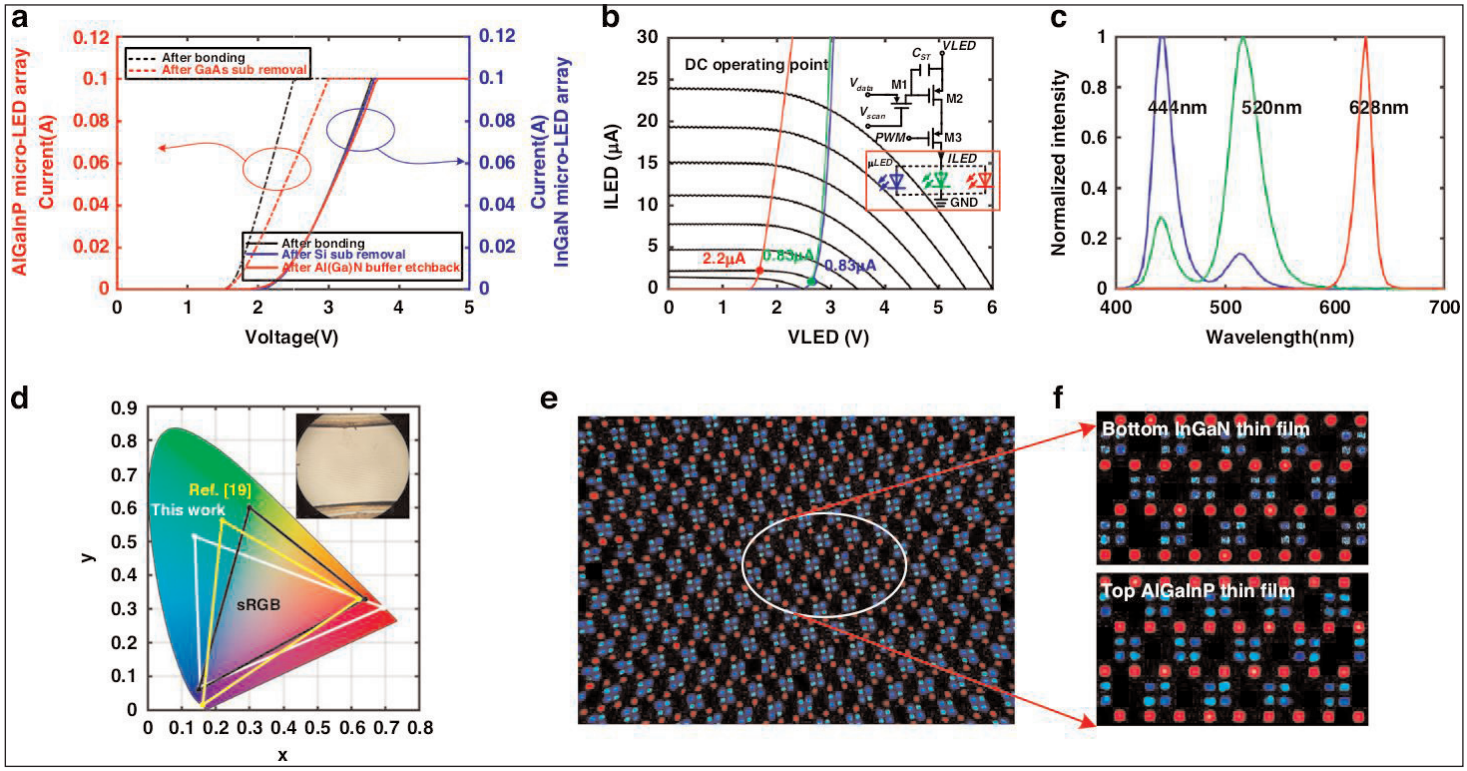

Figure 2. (a) Current–voltage (I–V) curves of InGaN dual-color micro-LED array and AlGaInP red micro-LED array during integration. (b) Pixel driver output curves and I–V curves of micro-LED subpixels. (c) Elecroluminescence spectrum of full-color display at 3.2V, aiming at current injections of 0.83μA and 2.2μA for the blue/green and red subpixels, respectively. (d) Color gamut in CIE 1931 chromaticity diagram (Inset: as-fabricated double-layer thin-film full-color display). (e) Inspection of all RGB subpixels turned on. (f) Zoomed-in photos at different focal planes.

Such micro-display formats are being developed for augmented-reality/mixed-reality (AR/MR) application.

The researchers comment: "The performance of the current prototype is limited by the yet-to-be-optimized GaN-on-Si dual-wavelength LED epiwafers and the CMOS driver". A further concern is yields, "primarily determined by the integration step of the monolithic AlGaInP red micro-LED array."

The 200x80 (0.55-inch diagonal) full-color (RGB) displays were constructed from flip-chip bonding of InGaN blue/green and AlGaInP red micro-LED arrays (Figure 1). The dual-color InGaN devices generated their light from multiple quantum wells (MQWs) consisting of three bottom blue wells, a single green well, and two top blue wells. The InGaN LED structure was grown on a 4-inch silicon substrate.

The InGaN blue/green array of 15μmx15μm subpixels was flip-chip bonded to a backplane with electronics consisting of three-transistor–one-capacitor (3T1C) pixel drivers. The solder bumps were tin/gold (Sn/Au). The silicon growth substrate was removed.

The AlGaInP red array was grown on gallium arsenide (GaAs) substrate. Window regions measuring 50μmx50μm were etched in the structure so that, when the chip was flipped onto the InGaN/backplane assembly, blue/green light could transmit out of the device. Patterned blue (BCF) and green (GCF) color filters were applied in the windows to create blue and green subpixels.

After bonding with indium solder bumps, the GaAs growth substrate was removed. An epoxy underfill process was used to support the fragile AlGaInP thin film, avoiding cracking and improving its mechanical strength. Curing the epoxy further enabled a crack-free robust AlGaInP thin film.

The researchers comment: "The Au–In bonding of the red micro-LED array has a lower soldering temperature (180°C) than the Au–Sn bonding (220°C) so that it will not damage the as-fabricated InGaN dual-color display structures."

The color balance of the blue/green InGaN pixels was controllable by the injection current density: pure green below 0.12A/cm^2 with the blue peak becoming dominant beyond 0.37A/cm^2. In terms of voltage, the switch point was at 2.60V. The full-widths at half maximum (FWHMs) were 20nm and 33nm for the blue and green peaks, respectively. The corresponding peak wavelengths were around 444 and 520nm.

The narrower bandgap of the green wells explains how the emissions begin from them. "With the increase of carrier injection, more carriers fill and recombine both in the top blue and green QWs so that the blue peak gradually occurs and increases together with the green peak," the team adds.

Tests on the red AlGaInP showed a drive current of 3μA at 1.70V. The peak wavelength was at 628nm with current injection in the range 0.14–1.74A/cm^2. The FWHM was around 18nm.

When integrated into the full-color format, the InGaN section maintained its performance, but the AlGaInP array did suffer from resistance degradation after the GaAs substrate removal (Figure 2). The researchers suggest that possibly "the current conduction path in the array is limited in the several-microns-thick n-AlGaInP layer after removal of the thick conductive GaAs substrate."

The researchers report: "Compared with our previously reported work using the QDs-photoresist color conversion method [the Ref. 19 referred to in Figure 2], this heterogeneously integrated full-color display presents better red emission, with less ideal blue and green color performance."

The brightness of the individual subpixels was controlled using pulse-width modulation (PWM), allowing different colors to be rendered. ■

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Laser-assisted separation for freestanding GaN

Reducing the contact area between sapphire and GaN results in spontaneous release during cooling after growth.

Osaka University in Japan has reported on a laser-assisted separation (LAS) technique for freestanding gallium nitride (GaN) grown by the sodium-flux technique from a seed layer on sapphire [Kazuma Hamada et al, Jpn. J. Appl. Phys., v62, p125503, 2023].

Creating freestanding and bulk GaN is seen as important for producing a wider range of GaN optical and power capabilities, using the material's wide bandgap, high breakdown field, and high thermal conductivity.

The LAS consisted of decomposing parts of the GaN seed by laser irradiation through the sapphire substrate before the main GaN crystal growth process. Sapphire is transparent to deep ultraviolet light, while GaN is highly absorbing.

The team comments: "Since this technique reduces the contact area between the sapphire and GaN, separation occurs spontaneously during the cooling process after growth. We found an appropriate LAS processing pattern for separation and successfully obtained freestanding GaN crystal without cracks."

The researchers further applied the LAS technique to multi-point seed (MPS) crystal growth, enabling crystal GaN thicker than usual with MPS without LAS preparation.

The GaN/sapphire seed substrates were grown using metal-organic chemical vapor deposition (MOCVD). The interface between the GaN and sapphire was patterned by LAS decomposition of the GaN (Figure 1): a reference without LAS, and a simple and more complex patterning resulted in three test samples.

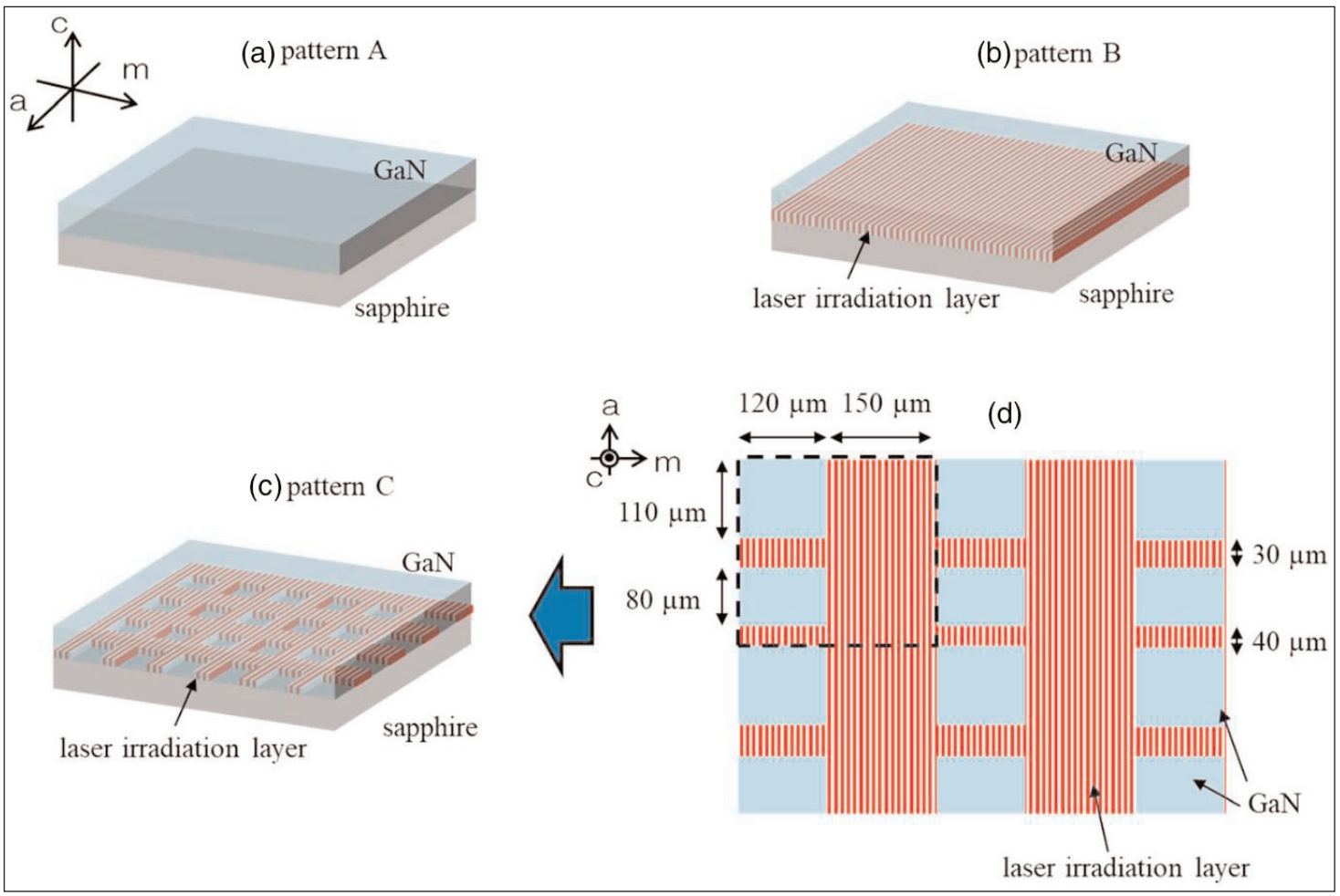

Figure 1. Schematic of seed crystals. (a) Pattern A: c-plane GaN/sapphire grown by MOCVD without LAS, (b) Pattern B: LAS over entire surface. (c) Pattern C: partial LAS. (d) Detail of pattern C.

The crystal growth consisted of placing the samples in a 19mm-diameter alumina crucible. The crucible was inserted into a glovebox with Ga, Na and carbon in an argon atmosphere. The box was evacuated and then nitrogen was introduced at 1MPa pressure. The temperature was increased to 870°C and the nitrogen pressure to 4MPa. The growth was carried out for 24 hours, resulting in a GaN layer about 500μm thick.

The unpatterned seed (sample A) resulted in cracked materials, both the GaN and sapphire. For the simple LAS patterned sample B, the GaN was uncracked, but the sapphire substrate did crack. The more complex partial LAS pattern of sample C resulted in both parts, sapphire and GaN, being uncracked. Further, only sample C gave separated freestanding GaN.

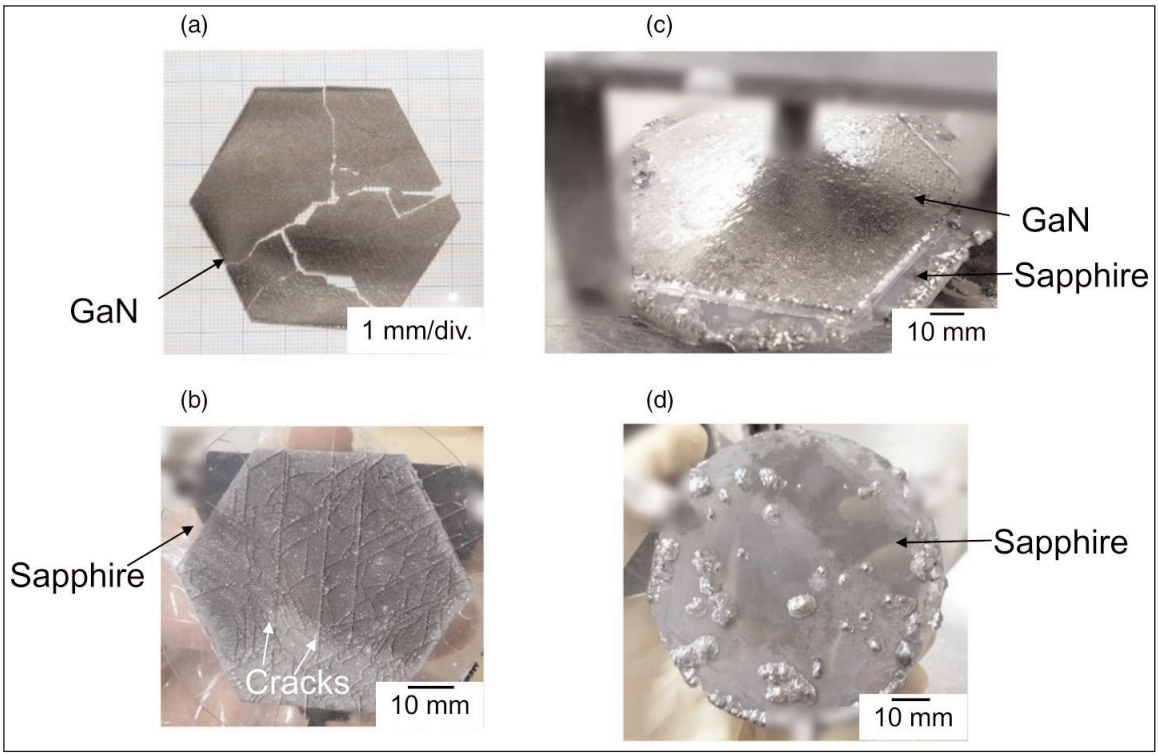

Figure 2. Optical images of grown crystal (a) on MPS substrate viewed from GaN surface and (b) viewed from sapphire surface; (c) grown crystal on LAS-MPS substrate viewed from GaN surface and (d) from sapphire surface.

X-ray analysis of diffraction peak shifts was used to assess the radius of curvatures of the samples (Table c). The sample C was much flatter, as indicated by the much larger radii of curvature.

The researchers comment: "In general, it is known that a GaN/sapphire substrate curves in a convex shape because sapphire has a larger thermal expansion coefficient than GaN. The presence of a convex shape in the grown crystal indicates that it is still under stress from the sapphire during the cooling process. In particular, the crystal grown on seed with pattern B had the same curvature as the crystal grown on unprocessed GaN/sapphire and also had cracks, suggesting that this pattern does not promote separation. In addition, we observed that it was easier to separate GaN with pattern C, where a part of the GaN was completely decomposed with the lattice pattern, compared to pattern B, where laser irradiation did not immediately separate GaN over the entire surface."

Working on the theory that the curvature was affected by the effective contact area between GaN and sapphire, the researchers tried reducing the area by using a higher LAS laser intensity on samples with the simple pattern B. Unfortunately, the seed layer separated from the sapphire before a crystal growth process could be applied. Hence, the researchers favor an LAS process using sample pattern C, in which part of the GaN is completely decomposed in a lattice pattern.

Table 1. Radii of curvature of GaN crystal grown on seed crystal with pattern A, pattern B, and pattern C along the a-axis and m-axis.

Axis	Pattern A	Pattern B	Pattern C
a-	0.93m	0.94m	16.4m
m-	1.23m	0.86m	9.25m

Cathodoluminescence (electron-beam excitation) was used to assess the dislocation density in the grown GaN, giving a value around $10^6/cm^2$ for all the samples. This compares with the higher value for the GaN seed layer of $10^8/cm^2$, a value typical for MOCVD.

The team combined the LAS method with MPS, where the seed layer consisted of 250μm-diameter circular GaN point-seed regions in a hexagonal array, separated by 550μm. Without LAS, the MPS method resulted in cracked GaN and sapphire material when the growth reached 600μm (Figure 2). Using a LAS substrate with MPS regions, the cracking was eliminated.

The researchers comment: "The contact area between GaN and sapphire was reduced to the smallest achieved thus far, significantly reducing the tensile stress from the sapphire. The threading dislocation density was found to be comparable to that of conventional MPS substrates, indicating no deterioration." ■

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Author: Mike Cooke

Record frequency AlGaN-channel transistors

Cornell University has reported 67GHz unit-gain cut-off frequency and 166GHz maximum oscillation frequency.

Cornell University in the USA claims a record high speed for any aluminium gallium nitride (AlGaN)-channel transistor from an AlN/AlGaN/AlN quantum well (QW) high-electron-mobility transistor (HEMT) structure [Eungkyun Kim et al, Appl. Phys. Express, v16, p11100, 2023].

The Cornell team reports unit-gain cut-off (f_T) and maximum oscillation (f_{max}) frequency values of 67GHz and 166GHz, respectively. The team comments: "This translates to the geometric mean of f_T and f_{max} exceeding 105GHz, breaking the 100GHz barrier for the first time for AlGaN-channel HEMTs."

The researchers attribute the high speed to a low contact resistance and aggressively scaled gate length and source-to-drain distance, overcoming somewhat the impact of the higher sheet resistance of AlGaN from alloy scattering. The shorter gate length ensures that the carriers under the gate are velocity-saturated, and reducing the source-to-drain distance decreases access resistance.

The wider bandgap of AlGaN over existing GaN-channel HEMTs should result in higher breakdown voltages, and indeed rapid progress is being made for long AlGaN-channel transistors aimed at relatively low-frequency power-switching application. Combined with higher frequency performance, AlGaN HEMTs have the potential to deliver higher-power-density systems.

The material for the AlN/$Al_{0.25}Ga_{0.75}$N/AlN QW HEMTs was grown by plasma-assisted molecular beam epitaxy on semi-insulating silicon carbide (6H-SiC) substrate. The AlGaN well was 24nm, surrounded by AlN barriers consisting of 1μm buffer and 15nm top layers. Hall measurements gave electron charge density and mobility values of $3.05x10^{13}/cm^2$ and $45cm^2/V\text{-}s$ in the two-dimensional electron gas (2DEG) channel.

The material was fabricated into HEMTs with T-gate and silicon nitride (SiN) passivation (Figure 1). Electron-beam lithography was used to define the

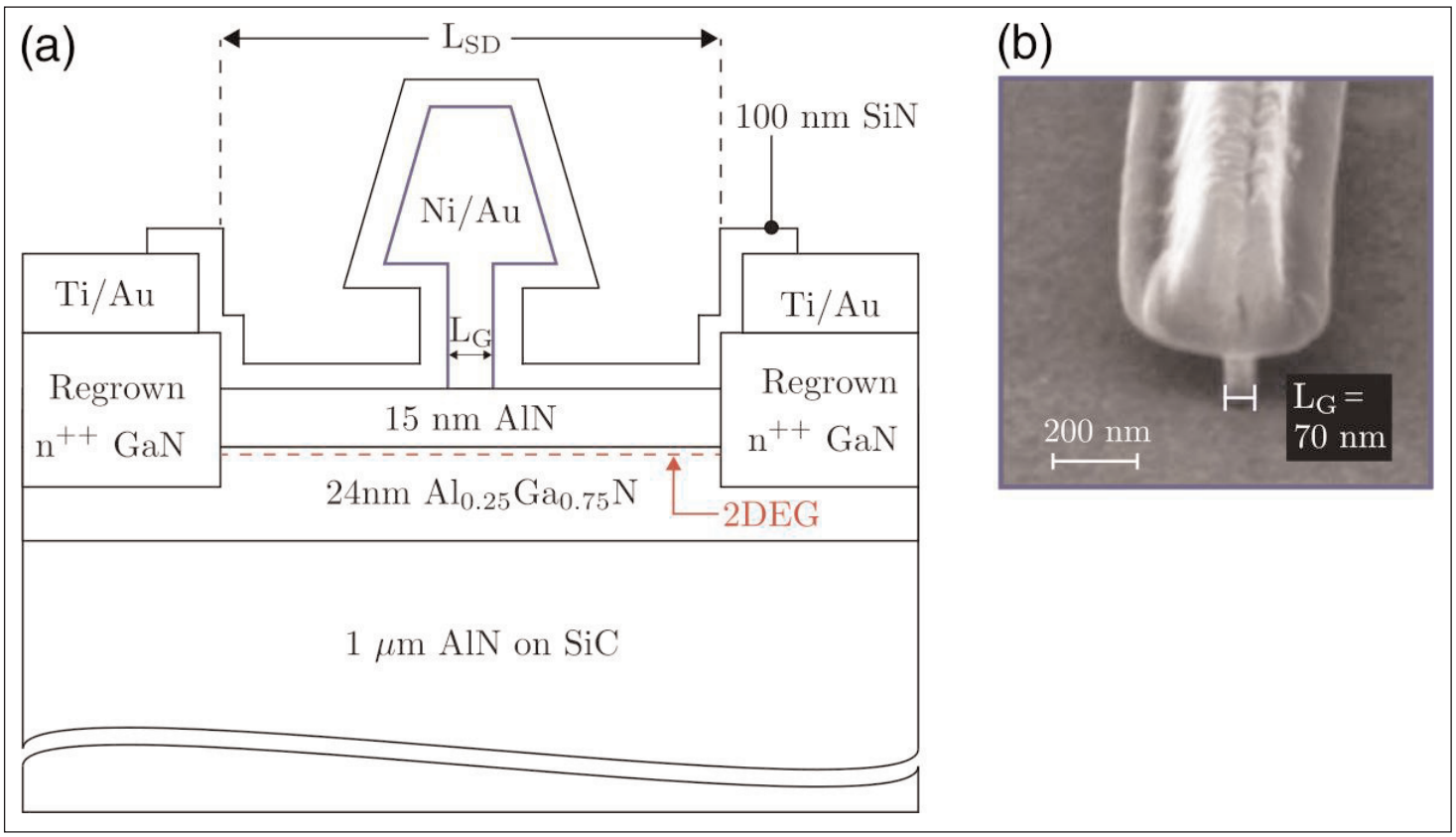

Figure 1. (a) Cross-sectional scheme of AlN/AlGaN/AlN HEMTs with T-shaped gate. (b) Scanning electron microscope (SEM) image of 70nm gate.

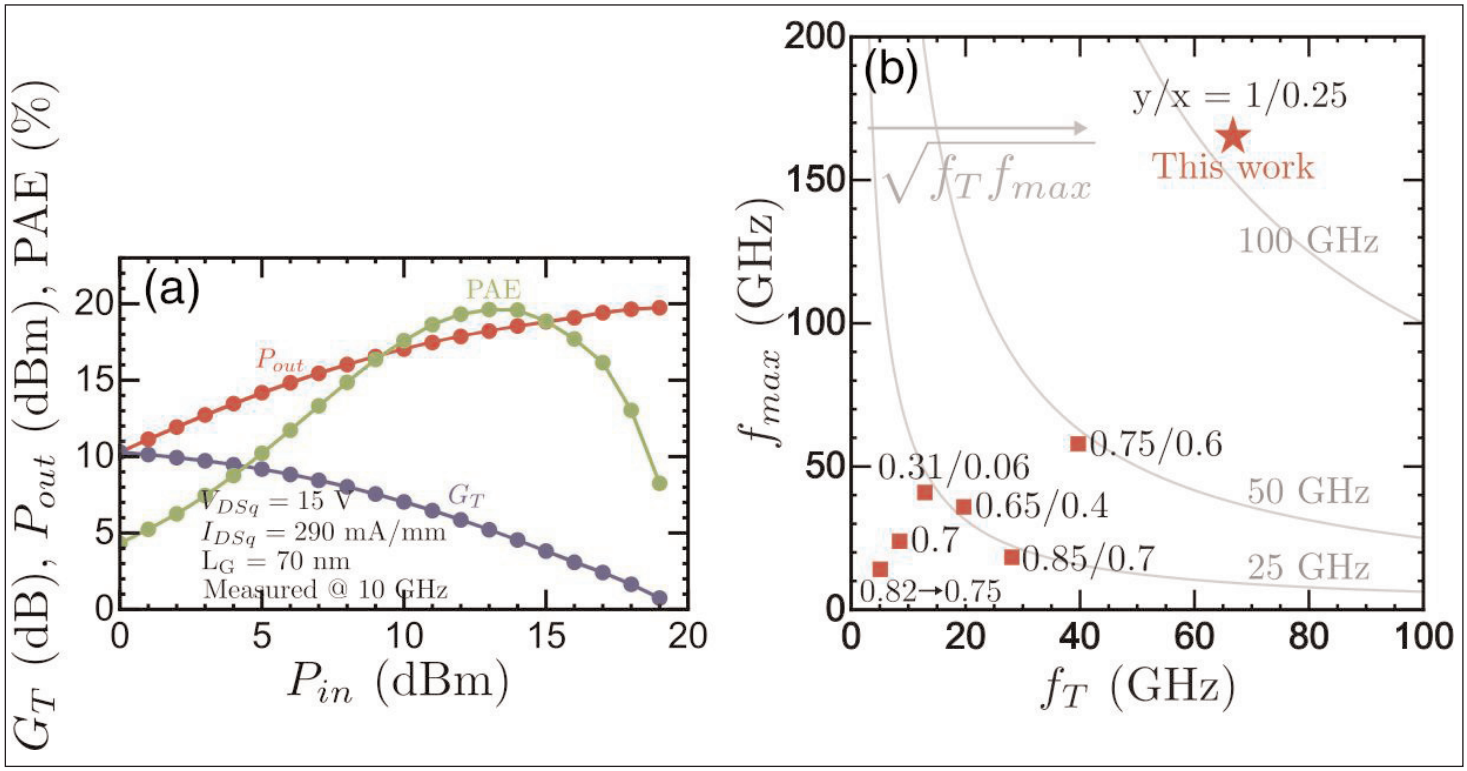

Figure 2. (a) RF power sweep at 10GHz at V_{DSq}/V_{GSq} = 15/−3V. (b) Benchmark comparing f_T/f_{max} of AlGaN-channel HEMTs reported in literature and Cornell's latest work. y/x indicates the aluminium composition in the top barrier/channel layer ($Al_yGa_{1-y}N/Al_xGa_{1-x}N$).

gate region. The passivation was designed to improve dispersion control of the device.

The gate consisted of 10nm nickel Schottky contact and 300nm gold, positioned mid-way between the source and drain. The gate length (L_G) and width were 70nm and 2x25μm, respectively. The source–drain spacing (L_{SD}) was 600nm.

The team reports: "The regrown n^+ GaN non-alloyed ohmic contacts exhibited R_c = 0.23Ω-mm, which is the lowest contact resistance to 2DEG among all AlGaN-channel HEMTs reported in the literature."

At 5V drain bias the device demonstrated 106 on/off current ratio and 0.11S/mm peak transconductance. The drain current density reached 0.9A/mm at 2V gate potential. The on-resistance (R_{on}) was 6.5Ω-mm.

The relatively thick AlN top barrier was thought to result in short-channel effects (SCEs), such as an output conductance higher than the Cornell group's previous AlN/GaN/AlN QW HEMTs. The researchers believe these effects could be reduced by thinning the barrier, bringing the gate closer to the channel for improved electrostatic control.

Pulsed (500ns, 1kHz) operation showed current collapse/dispersion around 10%. The researchers comment: "The possible sources of current dispersion include the surface states and a formation of a two-dimensional hole gas or a filling of hole traps located near the valence band edge at the bottom GaN/AlN interface with a net negative polarization charge. To suppress RF dispersion in future devices, a proper control of surface states with an in-situ passivation layer and a Si-δ doping in the AlN back barrier to compensate positive charges may be necessary."

Radio frequency measurements between 100MHz and 40GHz were used to calculate the f_T and f_{max} frequency values.

The three-terminal breakdown was measured by subjecting the device to increasing drain bias (V_{DS}) with the −10V gate potential below threshold, putting the device into its off state. Breakdown was considered to be when the off-current density exceeded 1mA/mm. The highest breakdown 59V was achieved in a device with 260nm gate–drain distance, giving an average breakdown field of more than 2MV/cm. However, on average 260nm L_{GD} devices showed lower V_{BD} values, reaching below 30V. Tests on a number of devices with 260nm, 370nm and 450nm L_{GD} all had average breakdown fields greater than 1MV/cm. The good breakdown behavior offers potential for extremely high-power operation in RF applications with proper control of current-collapse-related dispersion.

The power capability was assessed using a Maury load-pull system at 10GHz (Figure 2). The power-added efficiency (PAE) and power density reached 20% and 2W/mm, respectively. The power gain (G_T) was 5.2dB at 20% PAE. The researchers see the limitation on PAE and power output as being related to surface or bulk trap states. ■

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Author: Mike Cooke

More players exhibiting a common IP strategy for power & RF GaN technologies

KnowMade surveys the GaN electronics patent landscape in 2023.

In a new GaN electronics intellectual property (IP) report released by technology intelligence and IP strategy consulting company KnowMade, the patent landscapes for both the power GaN and RF GaN electronics sectors have been analyzed to describe the global IP competition across the whole supply chains and the local ecosystems emerging to support the industrialization of GaN technologies.

More players exhibiting a common IP strategy for power GaN and RF GaN technologies

In addition to power GaN and RF GaN patents, KnowMade's GaN Electronics IP report considers the impact of generic GaN electronics patents, applicable to both power and RF applications, on the global IP competition (Figure 1).

For example, some companies such as United Microelectronics Corp (UMC) don't limit the application scope in most of their GaN electronics inventions, showing a common IP strategy for both RF and power markets. Also, well-established power GaN market players, such as Infineon Technologies and Innoscience, own a large number of generic GaN electronics patents that could be leveraged for RF applications in the next few years.

Power GaN patent landscape: a focus on national and regional ecosystems

Inventive activity used to be dominated by Japanese players (2001–2015) until Chinese players took over the IP leadership in 2016. As a result, Japanese and Chinese players have produced more than 70% of all power GaN inventions collectively (Figure 2). Such

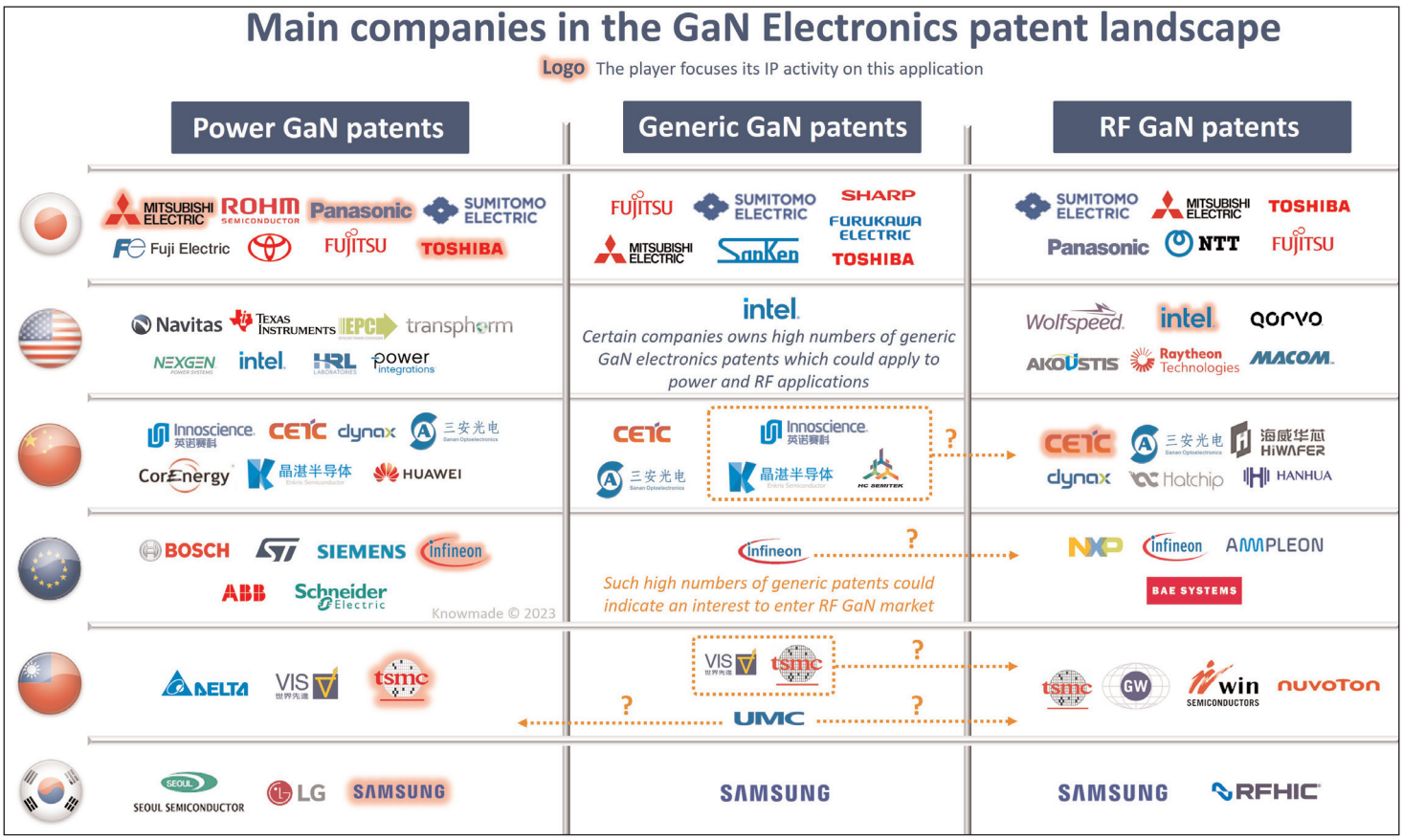

Figure 1: Main companies in the GaN electronics patent landscape.

intensive patenting activities are eclipsing important IP trends occurring in other regions (USA, Europe, etc). KnowMade's GaN Electronics report unveils such IP trends, providing separate analyses of the regional ecosystems in the power GaN patent landscape.

The GaN Electronics Patent Landscape report points out that most of the historical Japanese IP players are focusing on monetizing their power GaN IP portfolios (Sharp, Furukawa Electric, NTT, Fujitsu). Few of them are still actively filing patent applications to consolidate their IP position, apart from Fujitsu and Panasonic, in different parts of the supply chain. However, new Japanese IP leaders such as ROHM and Sumitomo Chemical are now aiming to turn their IP leadership into market leadership.

Taiwanese players are rising in the power GaN IP landscape, with most of the main Taiwanese foundries ramping up their activities across the power GaN supply chain, following TSMC's lead. The Taiwanese IP activities highlight a reinforcement of the domestic supply chain for power GaN technology, with major players actively filing patents in the upstream supply chain (e.g. GlobalWafers) and accelerating their patent filings in the downstream supply chain (e.g. Delta Electronics). In addition, several newcomers have recently entered the power GaN IP landscape in Taiwan.

The US-China trade war adds a new dimension to power GaN IP competition, urging players to adapt their strategy with a view to securing the development of their power GaN activities internationally. In this context, several Chinese players such as Innoscience and Huawei are expanding their IP activities worldwide, looking to compete in the US and European markets.

Most of the main US market players don't have complete IP coverage of the power GaN supply chain. Instead, US players leverage IP and manufacturing partnerships and/or existing IP and know-how developed for other power semiconductor technologies (silicon, silicon carbide). According to their own patenting activities, the main US market players are consolidating their own IP position in Asia and Europe, to support the development of their market activities outside the USA.

Infineon is the main vertically integrated innovator in the power GaN IP landscape, with a global IP strategy that aims to cover the main important regions for power electronics. Since 2015, Infineon has successfully leveraged multiple acquisitions (GaN Systems, International Rectifier) and IP partnerships (Panasonic) with a view to accelerating its strategy in the power GaN market. In Europe, major research organizations (CEA, imec, Fraunhofer) are driving the establishment of a domestic supply chain, leading to the establishment of new startup companies, and to the emergence of more vertically integrated innovators such as STMicroelectronics.

RF GaN patent landscape: a look into the IP strategies of key players across the supply chain

The GaN Electronics Patent Landscape report highlights different views from RF GaN market players about what innovation will be critical to protect in order to impact the future RF GaN supply chain (Figure 3). For example, several incumbent players in the RF GaN market seem to consider wafer and epiwafer IP as less critical, while others, such as Sumitomo Electric, Raytheon and Mitsubishi Electric, are still competing in

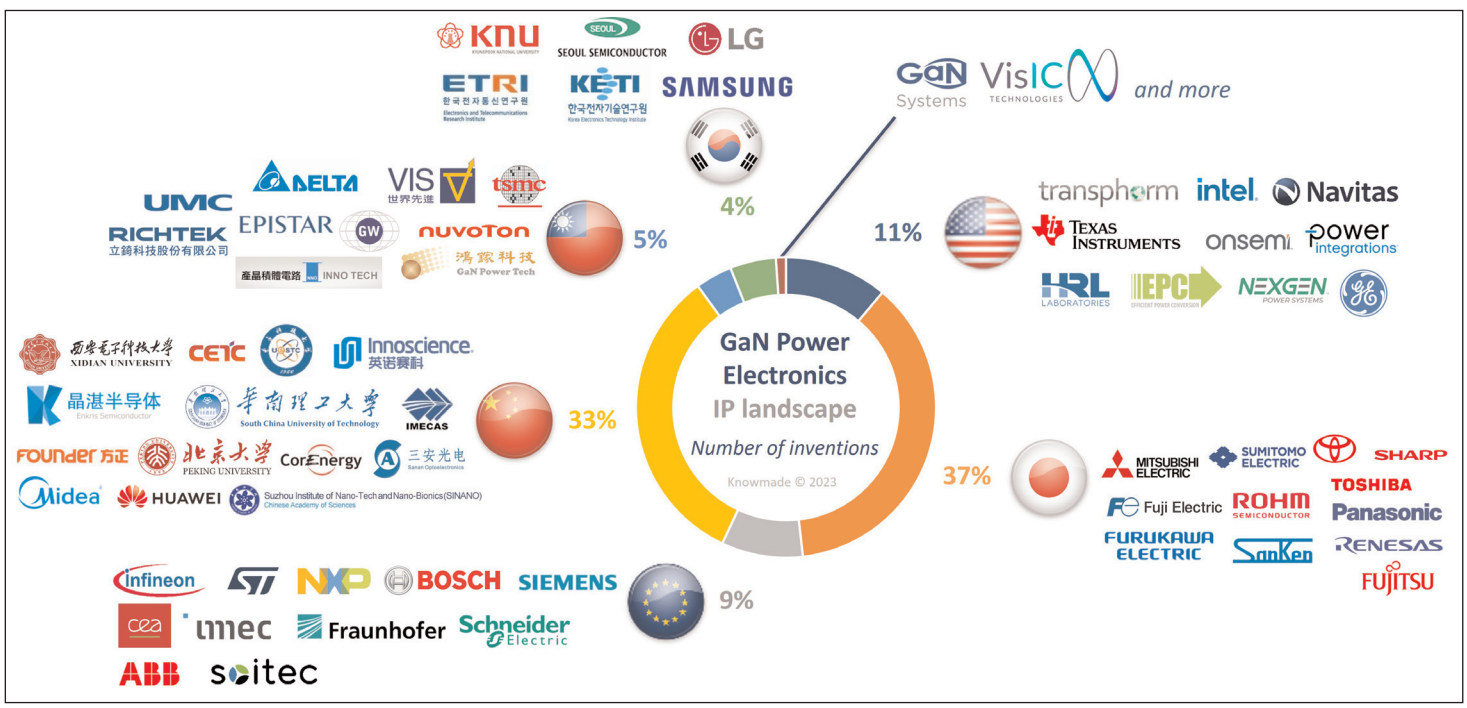

Figure 2: Main players in the power GaN patent landscape, split by country.

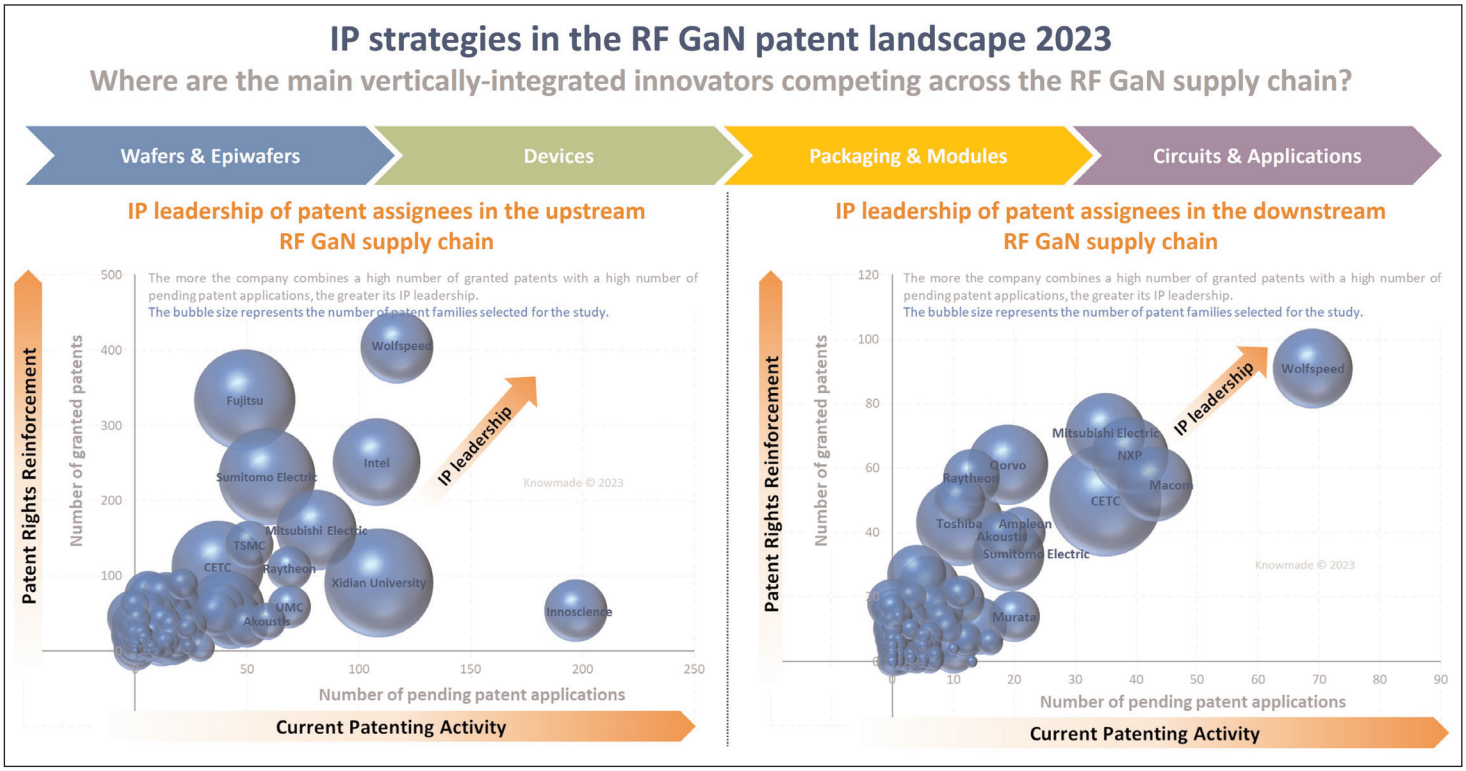

Figure 3: IP leadership of patent assignees in the upstream part (wafers, epiwafers, devices) and the downstream part (packaging, modules, circuits, applications) of the RF GaN supply chain.

this IP space. Most vertically integrated players identified in the report are still focusing on the IP related to RF GaN devices. In this regard, NXP stands out as it soon shifted its focus to the downstream supply chain. It was followed by most of the main RF GaN market players, who are now consolidating their IP position in packaging, modules, circuits and applications.

In recent years, Wolfspeed has taken over the IP leadership across the whole RF GaN supply chain, except for wafers and epiwafers (Figure 3). Just like Wolfspeed, MACOM has been actively filing patents across the RF GaN supply chain. Yet, unlike Wolfspeed, MACOM's IP activity did not translate into global IP leadership. With the acquisition of Wolfspeed's RF business, MACOM is expected to catch up with the competition in the global RF GaN IP landscape. Interestingly, this acquisition virtually positions MACOM as an indisputable IP leader for circuits and applications. Another stand-out player emerging in the RF GaN patent landscape is Mitsubishi Electric: it is currently the only vertically integrated innovator that is still competing across the whole RF GaN supply chain.

In contrast with the power GaN patent landscape, US players have established complete IP coverage of the RF GaN supply chain, and this IP ecosystem has been reinforced by many start-up companies actively filing patent applications in different part of the supply chain during the last decade (Akoustis, Akash Systems, Eridan, Finwave, etc). The analysis of their IP strategies shows that US companies are now expanding their patenting activities outside their national territory, especially in Europe, China and Taiwan, to support their international ambitions in the growing RF GaN market.

In the wafer and epiwafer IP space, the competition is now taking multiple and different directions: GaN-on-Si (IQE, Shin Etsu), GaN-on-diamond (RFHIC, Akash Systems), GaN-on-engineered substrates (Soitec, Qromis, Shin Etsu), GaN-on-AlN (Fujitsu), in addition to the mainstream GaN-on-SiC platform (Sumitomo Electric, Sumitomo Chemical). Regarding the GaN-on-Si platform, the GaN Electronics IP report highlights a reduction in patent filings from most well-established IP players. In this context, Intel continues to lead the competition in the RF GaN-on-Si IP landscape, especially for RF GaN-on-Si devices. Aside from Intel, MACOM and TSMC are the main established IP players still actively filing patent applications for RF GaN-on-Si technology. Interestingly, the other Taiwanese foundries are following TSMC's lead. What's more, many power GaN IP players were seen to file RF GaN patent applications lately (Innoscience, Infineon, ST), indicating the development of RF GaN devices with a view to entering the RF telecom market with GaN-on-Si and/or other unconventional platforms such as engineered substrates (Qromis-VIS) or semi-insulating SiC on conductive SiC substrates (ROHM). ■

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Raleigh, NC, USA
Tel: +1 919 789 8880
Fax: +1 919 789 8881
www.kymatech.com

MARUWA CO LTD
3-83, Minamihonjigahara-cho,
Owariasahi, Aichi 488-0044, Japan
Tel: +81 572 52 2317
www.maruwa-g.com/e/products/ceramic

sp3 Diamond Technologies
2220 Martin Avenue,
Santa Clara, CA 95050, USA
Tel: +1 877 773 9940
Fax: +1 408 492 0633
www.sp3inc.com

Sumitomo Electric Semiconductor Materials Inc
7230 NW Evergreen Parkway,
Hillsboro, OR 97124, USA
Tel: +1 503 693 3100 x207
Fax: +1 503 693 8275
www.sesmi.com

The Fox Group Inc
200 Voyageur Drive, Montreal,
Quebec H9R 6A8, Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

III/V-Reclaim
Wald 10, 84568 Pleiskirchen,
Germany
Tel: +49 8728 911 093
Fax: +49 8728 911 156
www.35reclaim.de

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

Wafer Technology Ltd
34 Maryland Road, Tongwell,
Milton Keynes, Bucks, MK15 8HJ, UK
Tel: +44 (0)1908 210444
Fax: +44 (0)1908 210443
www.wafertech.co.uk
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www.waferworld.com

4 Epiwafer foundry

Albemarle Cambridge Chemical Ltd
Unit 5 Chesterton Mills,
French's Road, Cambridge CB4 3NP,
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.camchem.co.uk

Intelligent Epitaxy Technology Inc
1250 E Collins Blvd,
Richardson, TX 75081-2401,
USA
Tel: +1 972 234 0068
Fax: +1 972 234 0069
www.intelliepi.com

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

Soitec
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Chemin des Franques, 38190
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Tel: +33 (0)4 76 92 75 000
www.soitec.com

The Fox Group Inc
200 Voyageur Drive, Montreal,
Quebec H9R 6A8, Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

5 Deposition materials

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

Matheson Tri-Gas
6775 Central Avenue,
Newark, CA 94560, USA
Tel: +1 510 793 2559
Fax: +1 510 790 6241
www.mathesontrigas.com

Nouryon Functional Chemicals B.V.
Zutphenseweg 10, 7418 AJ
Deventer,
The Netherlands
Tel. +31 652 478554
https://hpmo.nouryon.com

Praxair Electronics
542 Route 303,
Orangeburg, NY 10962,
USA
Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

Vital Thin Film Materials (Guangdong) Co Ltd (Vital Materials subsidiary)
18G, 18th Floor, Shenzhen Free
Trade Centre, No.111 Taizi Road,
Nanshan District,
Shenzhen, Guangdong, China 518067
Tel: (+86) 0755-21651348
sales@vitaltfm.com

www.vitaltfm.com
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

6 Deposition equipment

AIXTRON SE
Dornkaulstr. 2,
52134 Herzogenrath,
Germany
Tel: +49 2407 9030 0
Fax: +49 2407 9030 40
www.aixtron.com

ETC (LPE subsidiary)
Via Falzarego, 820021 Baranzate (Mi),
Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

FHR Anlagenbau Gmbh
(Vital Materials subsidiary)
Am Hügel 2, D-01458
Ottendorf-Okrilla,
Germany
Tel: +49 35205 520-0
E-mail: sales@fhr.de
E-mail: sales@vitalchem.com
www.fhr.biz
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

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Via Falzarego, 8
20021 Baranzate (Mi), Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

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

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

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95873 Bezons Cedex,
France
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Fax: +33 (0) 1 39 47 45 62
www.riber.com

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

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
Livermore, CA 94551,
USA
Tel: +1 925 245 5817
Fax: +1 925 449-4096
www.temescal.net

Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797,
USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

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

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

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Fax: +44 (0) 1389 879 042
www.logitech.uk.com

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

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Fax: +1 408 734 0961
www.samcointl.com

SPTS Technology Ltd
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Wales, UK
Tel: +44 (0)1633 414000
Fax: +44 (0)1633 414141
www.spts.com

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

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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

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6600 Reutte,
Austria
Tel: +43 5672 600 2422
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 GmbH
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Ismaning, 85737,
Germany
Tel: +49 89 96 24000
Fax: +49 89 96 2400122
www.csclean.com

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Fax: +44 (0)1278 420666
www.iemtec.com

Vacuum Barrier Corporation
4 Barton Lane,
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Fax: +1 781 933 9428
www.vacuumbarrier.com

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

11 Process monitoring and control

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

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

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

LayTec AG
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www.vacuumbarrier.com

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

12 Inspection equipment

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

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

13 Characterization equipment

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

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

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

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

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

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

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Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

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

18 Chip foundry

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

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

19 Facility equipment

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

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

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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
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2700 Augustine Drive, Suite 110,
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Fax: +1-408-748-0111
Contact Person: Cathy W. Hung
www.tecdia.com

24 Resources

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www.alshuktz.com

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

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

event calendar

If you would like your event listed in *Semiconductor Today*'s Event Calendar, then please e-mail all details to the Editor at mark@semiconductor-today.com

31 January – 2 February 2024
SEMICON Korea 2024
COEX, Seoul, South Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org/en

18–22 February 2024
2024 IEEE International Solid- State Circuits Conference (ISSCC 2024)
San Francisco, CA USA
E-mail: Issccinfo@yesevents.com
www.isscc.org

25-29 February 2024
IEEE Applied Power Electronics Conference (APEC 2024)
Long Beach Convention & Entertainment Center, Long Beach, CA, USA
E-mail: apec@apec-conf.org
https://apec-conf.org

11–13 March 2024
German Microwave Conference (GeMiC 2024)
Mercator Conference Center, Duisburg, Germany
E-mail: info@gemic2024.org
www.gemic2024.org

20–22 March 2024
SEMICON China 2024
Shanghai New International Expo Centre (SNIEC), Shanghai, China
E-mail: semichina@semi.org
www.semiconchina.org/en

20–22 March 2024
China Semiconductor Technology International Conference (CSTIC) 2024, in conjunction with SEMICON China 2024
Shanghai New International Expo Centre (SNIEC), Shanghai, China
E-mail: cstic@semichina.org
www.semiconchina.org/en/5

24–28 March 2024
Optical Fiber Communication Conference and Exposition (OFC 2024)
San Diego Convention Center, San Diego, CA, USA
E-mail: ofc@mcievents.com
www.ofcconference.org

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

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

advertisers' index

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

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

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

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

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

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

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

Microwave Week

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

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

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

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

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

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

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

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

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