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Developments in micro-LEDs for display applications

EPC to use Vanguard's 8" GaN foundry • Phlux gains £4m
MICLEDI forms US subsidiary • Scantinel raises €10m

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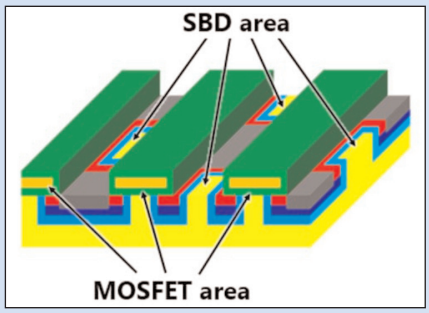

p12 Schematic of Toshiba's MOSFETs with newly developed check pattern embedded SBD-SiC MOSFET.

p13 ROHM has partnered with China's BASiC Semiconductor on SiC power devices for automotive applications.

p44 Midsummer's new CIGS thin-film solar panel factory in Bari, Italy.

Cover image: Taiwan's ITRI has introduced the High Resolution Full-Color Micro-LED Display for AR Glasses for next-generation augmented reality display products in metaverse applications, involving heterogeneous integration of μLED, CMOS and quantum dot color conversion layers. **p32**

editorial

Effectiveness of state intervention

On 16 November the UK Government issued a Final Order, under the National Security and Investment Act 2021, requiring that Netherlands-based Nexperia (a subsidiary of China's Wingtech Technology) sells at least 86% of what is now Nexperia Newport Ltd (NNL), after it in July 2021 bought the UK's largest chip maker Newport Wafer Fab (NWF) in South Wales.

Since then, as part of its semiconductor strategy, the UK announced that it is commissioning a research project to "look into the feasibility of new national initiatives with the aim of bringing the nation's industry together to tackle shared challenges and help businesses scale up" (see page 8). The aim of the strategy is to build on the UK's strengths in chip design, compound semiconductors and advanced technologies, in order to "unlock the potential of British microchip businesses, support jobs and skills to grow the UK's domestic industry and ensure a reliable supply of semiconductors".

However, the UK Government's semiconductor strategy is far from being formed. Compared with funding of $52bn through the US Government's CHIPS Act and €43bn through the European Union's 'European Chips Act' — both intended to bolster and develop domestic manufacturing and supply chains to counter the challenge posed by China – the question arises over whether the UK Government's intervention is too little, too late.

In any case, such protectionism may backfire through (1) barring and even revoking (in the case of Newport Wafer Fab) foreign investment from China; (2) restricting exports of semiconductor manufacturing equipment to China; and (3) accelerating China's efforts to develop its own supply chain.

For example, the Netherlands Government has been pressured to restrict exports to China by ASML, the sole supplier of extreme ultraviolet (EUV) lithography systems, which are essential for manufacturing integrated circuits with critical dimensions below 7nm. ASML was already reluctantly embargoed by Trump-era US Export Administration Regulations in December 2020 from exporting specifically to China's largest IC foundry (and the world's fifth largest) Semiconductor Manufacturing International Corp (SMIC).

TrendForce forecasts that, by 2025, China will account for 27% of global 12-inch-equivalent semiconductor production capacity overall, but just 1% of 7nm-and-below capacity specifically.

However, in mid-November, China's Huawei filed a patent application with the State Intellectual Property Office for an EUV lithography scanner and its core components, which would enable Chinese semiconductor manufacturing at the sub-7nm scale. While filing a patent does not equate to China developing the corresponding practical capability any time soon, it does suggest an acceleration of intent.

Also, there is a precedent. While Chinese firm Fujian Grand Chip Investment's acquisition of Germany-based metal-organic chemical vapor deposition system maker Aixtron was blocked by the Committee on Foreign Investment in the United States (CFIUS) in 2016, Chinese suppliers including AMEC have developed domestic manufacturing of MOCVD systems, and Chinese LED makers have gained a dominant share of the market for gallium nitride (GaN)-based blue LEDs, which have become a commodity (driving Aixtron to focus on more high-value market sectors).

So, it remains to be seen how effective the latest US-led restrictions on China's semiconductor industry can be, and whether other country's governments even remain aligned with them, given the financial impact on enterprises such as ASML.

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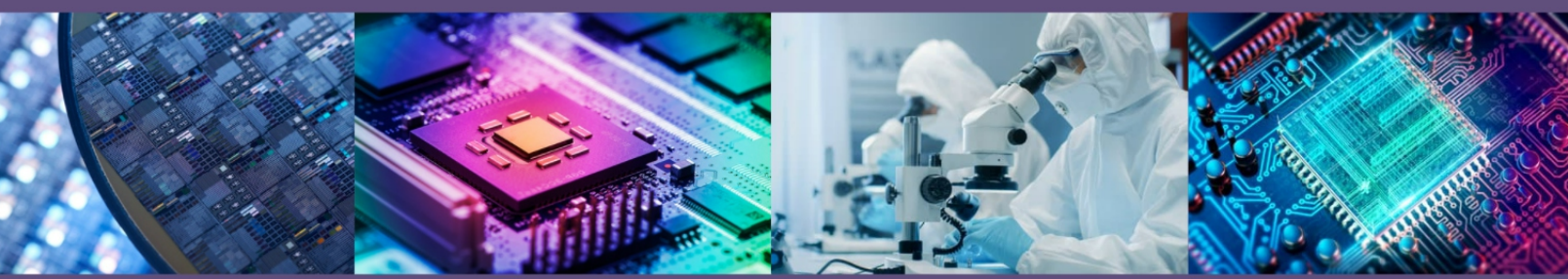

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Edge-emitting laser market growing at 13% CAGR to $7.4bn in 2027

EEL industry is highly fragmented and diversified, with each application addressed by specific supply/value chain

The market for edge-emitting lasers (EELs) is growing at a compound annual growth rate (CAGR) of 13% from $3.5bn in 2021 to $7.4bn in 2027, reckons Yole Intelligence (part of Yole Group) in its report 'Edge Emitting Lasers – Technology and Market Trends 2022'.

The semiconductor laser landscape, and especially edge-emitting lasers, is highly fragmented and diversified, as laser technologies are now ubiquitous in many traditional as well as emerging applications. Edge-emitting lasers are implemented in a wide variety of types, including diode lasers, fiber lasers, diode-pumped solid-state lasers (DPSSLs) and optically pumped semiconductor lasers (OPSLs). Traditional applications cover industrial, telecommunications, scientific, and consumer markets. Specifically, these span optical communications, material processing, displays, automotive lighting, medical dermatology, surgery, and 3D sensing in light detection & ranging (LiDAR). Also, the many niche applications include military & aerospace markets and spectroscopic analysis for the life science market.

"Growth continues to be driven by optical communication, such as optical modules and amplifiers for datacom and telecom, as well as 3D sensing applications," notes Martin Vallo Ph.D., senior analyst, Photonics (who specializes in optical communication and semiconductor lasers within the Photonics and Sensing division).

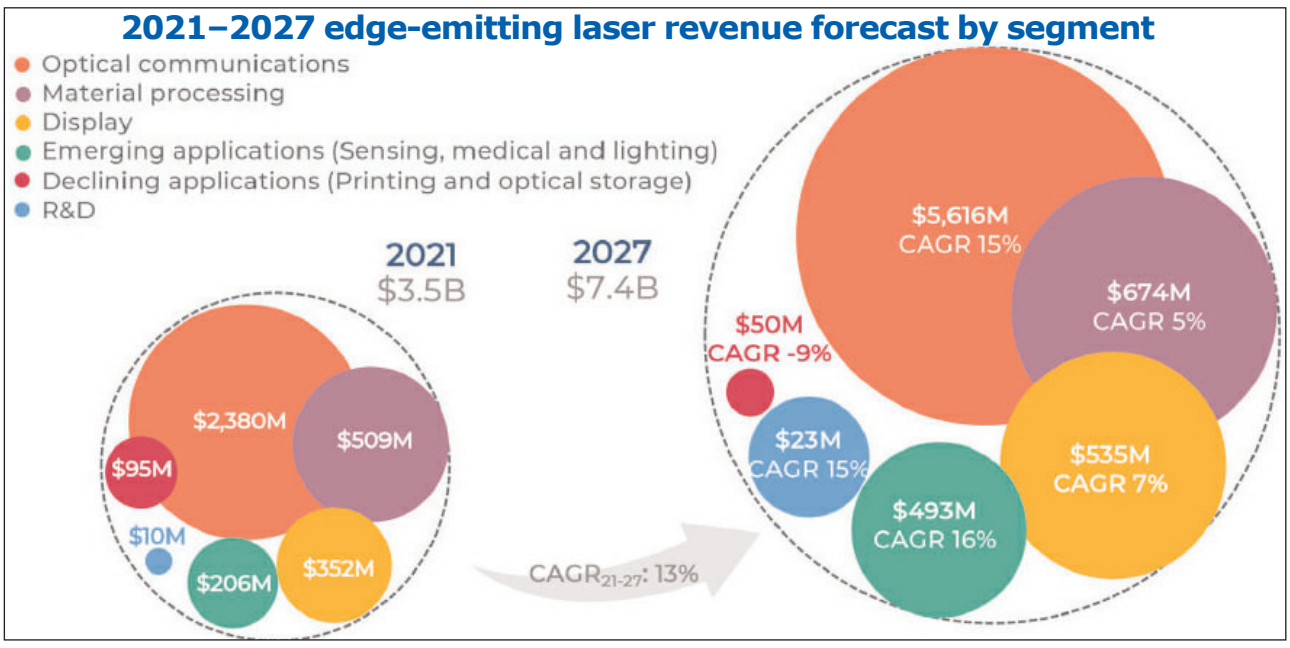
Each application is addressed by a specific supply/value chain, as a variety of edge-emitting laser device designs have been developed:

- **Chip**: Fabry–Perot (FP) is the most common edge-emitting laser design in current use. Other designs, such as distributed Bragg reflectors (DBRs), external cavity lasers (ECL), distributed feedback (DFB) lasers, quantum cascade lasers (QCLs) and broad-area laser diodes (BALDs), have been developed to improve critical parameters that make them suitable for specific applications.
- **Packaging**: There is also a wide range of package types, including TO (transistor outline), pigtailed butterfly, C-mount, D-mount, high heat load, and direct chip on sub-mount, depending on the application.

In parallel, for integrators, many questions arise, notes Yole. What is the correct laser device for an application? Which parameters are most important? Laser technology is essentially an interaction of light and matter, so new applications are still emerging for sensing, material processing, and life sciences.

Applications define device specifications, and integrators must consider several technical parameters, including wavelength, power output, spectral resolution, light beam quality, and optical intensity. Understanding application requirements and evaluating laser parameters is, therefore, key to making the right investment decisions. This is even more important as edge-emitting laser prices vary widely depending on design and technical parameters.

www.yolegroup.com/product/eel-2022



Smartphone production in Q3 down 11% year-on-year

According to TrendForce, global smartphone production totaled about 289 million units in Q3/2022, down 0.9% quarter-on-quarter and 11% year-on-year. The market saw extremely weak demand as the 'iron law' of positive growth in the third quarter was broken after being in effect for years. The contraction of production during this year's peak season was due mainly to smartphone brands giving priority to the consumption of channel inventory for whole devices and maintaining a fairly conservative production plan for Q3/2022. Moreover, they had kept lowering their production targets due to strong global economic headwinds.

Of the major smartphone brands in Q3, Samsung produced about 64.2 million units, up just 3.9% quarter-on-quarter, as it has scaled back production since Q2/2022 and maintains a conservative outlook on the future market situation. Due to persistent inventory pressure, Samsung is expected to again post a quarter-on-quarter decline for Q4. Regarding product development, Samsung has been the leader in foldable smartphones. This year, the global market share of foldable smartphones is estimated to reach 1.1% and, within this segment, Samsung is expected to hold a share of almost 90%. For 2023, the global market share of foldable smartphones is forecasted to climb to 1.5%, with Samsung retaining a share of almost 80% in the segment.

Apple posted 50.8 million units in iPhone production in Q3/2022, showing a stable growth trend. Apple had benefited from the reallocation of the demand that was originally going to Huawei's smartphones as well as the optimal pricing for the new iPhone models. Furthermore, the third quarter is usually the production ramp-up period as Apple intends to push sales of the new iPhone models to their peak in the fourth quarter. Following the release of the iPhone 14 series, much of the demand for the new iPhone models has been tilted towards the Pro subseries. Accordingly, Apple has also adjusted the share distribution of the different new models in iPhone production.

However, Foxconn's EMS base in the Chinese city of Zhengzhou has recently experienced a drop in capacity utilization rate due to a local COVID-19 outbreak. Since the base is also Apple's main site for manufacturing the iPhone Pro models, this incident will impact total iPhone production in Q4/2022.

The ranking of the top five global smartphone brands by production for Q3/2022 is rounded out by Xiaomi, OPPO and Vivo at third, fourth and fifth, respectively. Xiaomi encompasses its sub-brands Redmi, POCO and Black Shark; OPPO includes Realme and OnePlus; and Vivo also takes account of iQoo. Among them, only Xiaomi maintained about the same device production volume compared with the previous quarter, whereas the other two recorded a quarter-on-quarter drop. All of them have been constrained in raising production during the second half of this year due to the pressure to correct excess inventory. They also have to deal with COVID-19 lockdowns in the home market and the recent deceleration of India's economic growth. Moving into Q4/2022, these three Chinese brands are expected to post mostly flat growth in device production.

Looking further ahead, Xiaomi, OPPO and Vivo will face significant challenges, says TrendForce. First, China, as their home and primary market, is already highly saturated. The enforcement of the zero-COVID policy by the Chinese government has further caused a freeze in domestic demand during the recent period. At the same time, Honor has emerged to pose a direct threat in the competition for domestic market share. To maintain growth, Xiaomi, OPPO and Vivo will have to concentrate on overseas expansion while retaining their domestic market shares.

Chinese smartphone brands developing their own chips

To maintain a loyal group of customers and provide effective market positioning for their high-end device models, Samsung, Apple and Huawei have been self-developing chips such as mobile systems-on-a-chip (SOCs). Also, because these brands have generated additional value with in-house components, the other major Chinese brands now also have teams dedicated to chip design.

Xiaomi has developed the mobile SoC Pengpai S1, the image processing chip Pengpai C1, and the 120W fast-charging chip Pengpai P1. OPPO has unveiled a discrete image signal processor (ISP) MariSilicon X and will introduce an in-house application processor (AP) in Q1/2024. Vivo has launched the V1 and V2 chipsets as solutions for optimizing the image processing algorithm of the smartphone camera. TrendForce believes that, while Chinese brands are using in-house chips to raise their profiles, their more important aim is to strengthen the domestic supply chain as China and the USA are now locked in an escalating geopolitical competition.

In Q4/2022, the results from the recent promotional events related to China's Singles' Day reveal that smartphone brands have not been particularly effective in spurring device sales by lowering prices. Consumer confidence has been hit by various economic headwinds. TrendForce estimates that global smartphone production will total about 316 million units for Q4, (quarter-on-quarter growth of 9.3%). A year-on-year comparison will still show a decline.

TrendForce says the smartphone market started to show signs of weakening in Q3/2021. It has since recorded six straight quarters of year-on-year decline in device production. Demand will return when the correction of channel inventory is mostly completed, but this will occur no earlier than Q2/2023.

www.trendforce.com

Project to explore ideas to build on UK's strengths in design, compound semiconductors and advanced technologies

Study to consider how to grow chip design start-ups and testing facilities and bring together industry, customers and government to address shared challenges

A new national institution could be established as part of plans to boost the infrastructure underpinning the UK's industry through the government's upcoming semiconductor strategy. The strategy will aim to "unlock the potential of British microchip businesses, support jobs and skills to grow the UK's domestic industry and ensure a reliable supply of semiconductors".

As part of the semiconductor strategy, the UK Government's Department for Digital, Culture, Media and Sport (DCMS) is commissioning a research project to look into the feasibility of new national initiatives with the aim of bringing the nation's industry together to tackle shared challenges and help businesses scale up.

With an available budget of £700,000–900,000, the project will look at whether better access to prototyping and manufacturing facilities for chip firms is needed to tackle barriers to innovation and grow the industry. It will also cover opportunities to make specialist software tools more available for start-ups and ways to develop cutting-edge packaging processes.

UK semiconductor industry revenue has grown by 95% between 2012 and 2021. The UK has established a number of major industry strengths, including in chip design, research and compound semiconductors.

"In the UK we are leading the world in areas including design and research," reckons Digital Secretary Michelle Donelan MP. "We want to build on these successes and keep our semiconductor sector on the cutting edge," she adds. "This study will help us meet our ambition and could lead to a new national institution and greater research facilities."

The study will consider how to improve infrastructure in five key areas: industry coordination, silicon prototyping, open-access manufacturing for compound semiconductors, advanced packaging and intellectual property.

The results will inform how the government could deliver on some of the ambitions set out in the forthcoming semiconductor strategy, which will be published "as soon as possible" and is not dependent on the completion of the feasibility study.

The UK Government says that the proposed initiative is one of many options under consideration and does not represent the full breadth of the strategy.

The study will set out the delivery model that a national initiative could take to have the most positive impact on the industry, including whether or not the different infrastructure capabilities are centralized in one organization.

www.contractsfinder.service.gov.uk/notice/4d7f363a-2f0a-4fb1-b2df-a61f77397942

Guerrilla RF secures $580,000 LNA purchase order from electric vehicle maker

Designed for automotive satellite radio multi-stage LNAs, signal boosters and GPS applications, shipments due in March–November

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — a provider of radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has received a purchase order for ultra-low-noise amplifiers (LNAs) from what it says is one of the world's leading electric automobile manufacturers.

The shipments are expected to commence in March 2023 and continue through November, generating revenue of about $580,000 during that period. The ultra-low-noise amplifiers are designed for automotive satellite radio multi-stage LNAs, signal boosters, and GPS applications.

"Securing a purchase order with a top-tier electric automobile manufacturer is a testament to our ability to deliver a quality product at a competitive price," says CEO & founder Ryan Pratt. "This order is the result of a design-win process where we successfully achieved all of the specs required by this customer," he adds. "Our focus on investing in R&D is paying off, as we are adding new innovative solutions to our portfolio of products. We expect our new products will drive strong sales growth."

http://guerrilla-rf.com

Fraunhofer IAF launches BEACON project as part of ESA's ARTES program

W-band receive front-end module for satcoms based on metamorphic HEMT low-noise MMICs

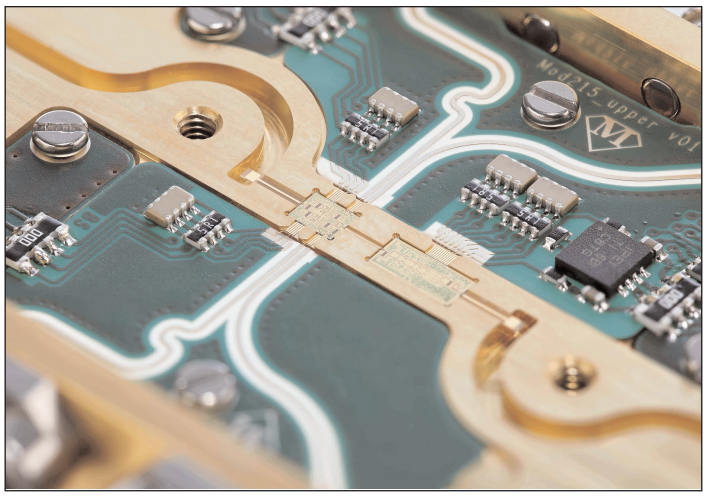
Due to limited bandwidth, it is becoming increasingly difficult to meet the growing need for higher data rates in satellite systems with very high data throughput. Using higher frequencies can help to meet this increasing demand.

The W-band (75–110GHz) is well suited for satellite communication applications: Not only does it offer high data throughput when used at high altitudes and in space but it is also likely to significantly increase system capacity, reduce the number of gateway earth stations, and thus reduce overall system costs. However, there has been a lack of suitable technology and hardware for applications in the W-band frequency range to date.

The Fraunhofer Institute for Applied Solid State Physics IAF, together with RPG Radiometer Physics GmbH, has hence launched the project 'BEACON — W-band Integrated Active Receive Front-End', realized as part of the European Space Agency (ESA) ARTES (Advanced Research in Telecommunications Systems) Advanced Technology Program. The project partners are developing an integrated active W-band receive front-end module with an operating frequency of 81–86GHz that is lower in noise than any previous W-band amplifier module, enabling extremely high data rates or long-distance data transmission through space with low power consumption.

Minimal noise at high data throughput

The receive module is based on Fraunhofer IAF's extremely low-noise monolithic microwave integrated circuit (MMIC) technology. "Fraunhofer IAF has done tremendous development work in the mHEMT [metamorphic high-electron-mobility transistor] process over the past years and has acquired a core competence in developing amplifiers with the lowest noise worldwide," says project coordinator and researcher Dr Philipp Neininger. "Based on this, the project aims to reduce the noise figure to below 3.5dB and thus significantly improve the state of the art."



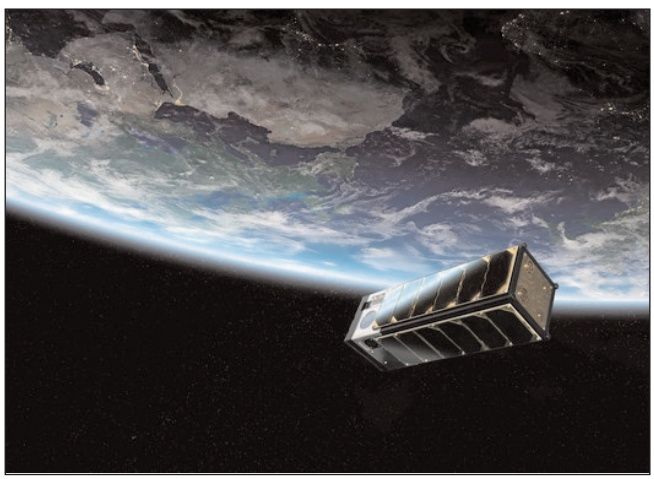
Close-up of a similar receive module showing the integration of different components. © Fraunhofer IAF.

In addition, the receive module is designed to isolate left-hand from right-hand circular polarization and amplify them with two separate channels (LHCP and RHCP), which serves to effectively double data throughput.

A major challenge in the BEACON project is the novel arrangement of components on the very small module area. The new approach involves integrating a large number of functions within a very small footprint: These include the polarizer, waveguide transitions to two individual amplifiers, two coaxial output connectors and the associated DC circuitry. "The combination of these features — extremely low noise, two different polarizations and an innovative array — brings an enormous technological advance in the field of W-band components," Neininger says.

W-band data transmission from space already tested

Only last year, satellite signals in the W-band frequency range were received from space for the first time. The W-Cube nanosatellite began its journey to polar orbit aboard a Falcon 9 rocket in summer 2021 and has since been transmitting satellite signals to Earth at 75GHz from an altitude of 500km. For this mission, Fraunhofer IAF had already developed the transmitter module of the satellite as well as the receive module of the corresponding ground station.



The W-band receive module is intended to enable low-noise data transmission in satellite communications in the future — such as in the W-Cube nanosatellite pictured. © Fraunhofer IAF.

www.iaf.fraunhofer.de

ST to qualify Soitec's silicon carbide substrate technology over next 18 months

Adoption of SmartSiC targeted for 200mm substrate manufacturing

STMicroelectronics of Geneva, Switzerland and engineered substrate manufacturer Soitec of Bernin, near Grenoble, France have announced the next stage of their cooperation on silicon carbide (SiC) substrates, with the qualification of Soitec's SiC substrate technology by ST planned over the next 18 months. The goal is the adoption by ST of Soitec's SmartSiC technology for its future 200mm substrate manufacturing, feeding its device and module manufacturing business, with volume production expected in the midterm.

SmartSiC is a proprietary Soitec technology that uses Soitec's proprietary SmartCut technology to split a thin layer of a high-quality SiC donor wafer and bond it on top of a low-resistivity handle polySiC wafer. The engineered substrate then improves device performance and manufacturing yields. The prime-quality SiC donor wafer can be reused multiple times, significantly reducing the overall energy consumption required to produce it.

In comparison with silicon, silicon carbide's intrinsic properties provide superior performance and efficiency, allowing more efficient power conversion, lighter and more compact designs, and overall system-design cost savings — all key parameters and factors in high-growth power applications such as electric mobility and industrial processes. Transitioning from 150mm to 200mm wafers will enable a substantial capacity increase, with almost twice the useful area for manufacturing integrated circuits, delivering 1.8–1.9 times as many working chips per wafer.

"The transition to 200mm SiC wafers will bring substantial advantages to our automotive and industrial customers as they accelerate the transition toward electrification of their systems and products. It is important in driving economies of scale as product volumes ramp," says Marco Monti, president Automotive and Discrete Group, STMicroelectronics. "We have chosen a vertically integrated model to maximize our know-how across the full manufacturing chain, from high-quality substrates to large-scale front- and back-end production. The goal of the technology cooperation with Soitec is to continue to improve our manufacturing yields and quality," he adds.

"The automotive industry is facing major disruption with the advent of electric vehicles. Our cutting-edge SmartSiC technology, which adapts our unique SmartCut process to silicon carbide semiconductors, will play a key role in accelerating their adoption," believes Soitec's chief operating officer Bernard Aspar. "The combination of Soitec's SmartSiC substrates with STMicroelectronics' industry-leading silicon carbide technology and expertise is a game-changer for automotive chip manufacturing that will set new standards."

www.soitec.com
www.st.com

Wolfspeed extends silicon carbide wafer supply agreement with power device maker

$225m expanded supply deal supports steepening demand for SiC

Wolfspeed Inc of Durham, NC, USA has expanded an existing multi-year, long-term silicon carbide wafer supply agreement, now worth about $225m, with what it describe as a leading power device company. The expanded agreement calls for Wolfspeed to supply 150mm silicon carbide bare and epitaxial wafers.

"This agreement further strengthens our long-time cooperation with a best-in-class power semiconductor manufacturer," says Dr Cengiz Balkas, senior VP & general manager of Materials for Wolfspeed. "This well-established partnership, paired with our most recent announcement of a multi-billion-dollar materials expansion in North Carolina, is a huge step forward in our mission of transitioning the industry from silicon to SiC."

The expansion of Wolfspeed's SiC materials footprint (announced in early September) will improve the firm's ability to supply wafers to existing and potential customers — a critical part of the larger wide-bandgap semiconductor supply chain.

The adoption of SiC-based power solutions is rapidly growing across multiple markets, including industrial and automotive. 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, device makers are interested in securing access to high-quality silicon carbide substrates to support their customers, says Wolfspeed.

The supply agreement enables silicon carbide applications in broad markets such as renewable energy and storage, electric vehicles, charging infrastructure, industrial power supplies, traction and variable speed drives.

www.wolfspeed.com

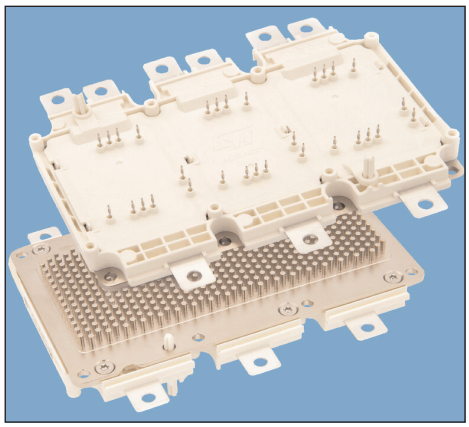
ST boosts EV performance and driving range with new silicon carbide power modules

Hyundai chooses ACEPACK DRIVE power modules for E-GMP electric vehicle platform

STMicroelectronics of Geneva, Switzerland has released new high-power silicon carbide (SiC) modules for electric vehicles (EVs) that boost performance and driving range. In production now, the ACEPACK DRIVE modules have been selected for Hyundai's E-GMP electric vehicle platform (which is shared by the Kia EV6 and several models).

Five new SiC MOSFET-based power modules provide flexible choices for vehicle makers, covering a selection of power ratings and support for operating voltages commonly used in EV traction applications. Housed in ST's ACEPACK DRIVE package optimized for traction applications, the power modules are said to be reliable (due to sintering technology), robust, and easy for manufacturers to integrate into EV drives. Internally, the main power semiconductors are ST's third-generation (Gen3) STPOWER SiC MOSFETs, which combine what are claimed to be industry-leading figure of merit ($R_{DS(ON)}$ x die area) with very low switching energy and super performance in synchronous rectification.

"ST silicon carbide solutions are enabling major automotive OEMs to set the pace of electrification when developing future generations of EVs," says Marco Monti, president of ST's Automotive and Discrete Group. "Our third-generation SiC technology ensures the greatest power density and energy efficiency, resulting in superior vehicle performance, range and charge time."



ST's ACEPACK DRIVE module.

Hyundai Motor Company has chosen ST's ACEPACK DRIVE SiC-MOSFET Gen3-based power modules for its current-generation EV platform, called E-GMP. In particular, the modules will power the Kia EV6. "ST's SiC MOSFET-based power modules are the right choice for our traction inverters, enabling longer range," says Sang-Cheol Shin, Inverter Engineering Design Team at Hyundai Motor Group. "The cooperation between our two companies has realized a significant step towards more sustainable electric vehicles, leveraging ST's continuous technological investment to be the leading semiconductor actor in the electrification revolution."

ST has already supplied STPOWER SiC devices for more than three million mass-produced passenger cars worldwide. With the recently announced fully integrated SiC substrate manufacturing facility in Catania, expected to start production in 2023, ST is moving quickly to support the rapid market transition towards e-mobility.

ST's 1200V ADP280120W3, ADP360120W3 and ADP480120W3(-L) modules are already in full production. The 750V ACEPACK DRIVE ADP46075W3 and ADP61075W3 will be in full production by March 2023. They enable a plug-and-play solution for traction inverters, compatible with direct liquid cooling, and featuring a pin-fin array for efficient heat dissipation. Specified up to a maximum junction temperature of 175°C, they provide long-lasting and reliable press-fit connections and dice sintered to substrate to ensure extended lifetime in automotive applications. ST will extend the product portfolio to include insulated-gate bipolar transistor (IGBT)- and diode-based ACEPACK DRIVE versions.

The modules feature active metal brazed (AMB) substrate technology, known for excellent thermal efficiency and mechanical strength, mounting a dedicated NTC (negative temperature coefficient thermistor) for each substrate. They are also available with a choice of welded or screw-fit busbar, giving flexibility to address different mounting requirements. A long-busbar option further extends the flexibility by allowing the choice of a Hall sensor to monitor the motor current.

www.st.com

Toshiba develops SiC MOSFET with check-pattern embedded Schottky barrier diodes

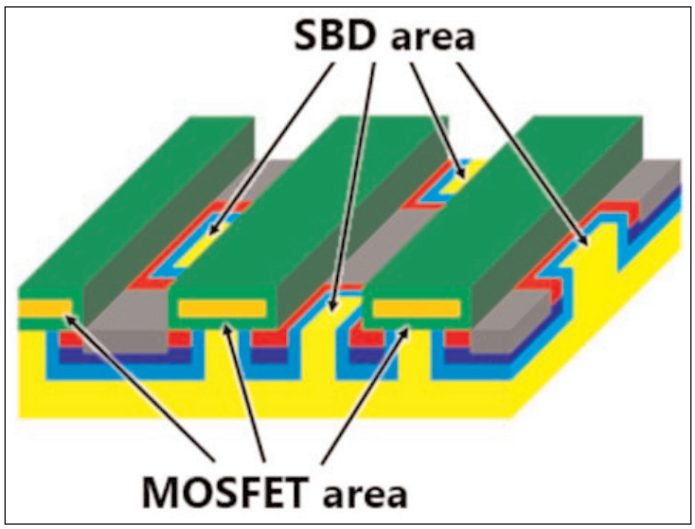
Check rather than striped design enables both low on-resistance and high reliability

At the 68th annual IEEE International Electron Devices Meeting (IEDM 2022) in San Francisco (3–7 December), Japan-based Toshiba Electronic Devices & Storage Corp (TDSC) — spun off from Toshiba Corp in 2017 — reported the development of a silicon carbide (SiC) metal–oxide–semiconductor field-effect transistor (MOSFET) that arranges embedded Schottky barrier diodes (SBD) in a check pattern (check-pattern embedded SBD) to realize both low on-resistance and high reliability. Toshiba has confirmed that the design secures an approximately 20% reduction in on-resistance ($R_{on}A$) against its existing SiC MOSFET, with no loss of reliability.

Silicon carbide is widely seen as the next-generation material for power devices, as it delivers higher voltages and lower losses than silicon. While use of SiC is now largely limited to inverters for trains, wider application is on the horizon, in areas including vehicle electrification and the miniaturization of industrial equipment. However, a problem that must first be overcome is that bipolar conduction in the body diode during reverse operation of SiC MOSFETs is harmful because it degrades on-resistance.

Toshiba Electronic Devices & Storage Corp developed a device structure that embeds SBDs into the MOSFET to inactivate body diodes, but it found that replacing the MOSFET channel with an embedded SBD lowers channel density and increases $R_{on}A$. This trade-off has now been resolved with a new embedded SBD structure, and Toshiba has confirmed that it dramatically improves performance characteristics.

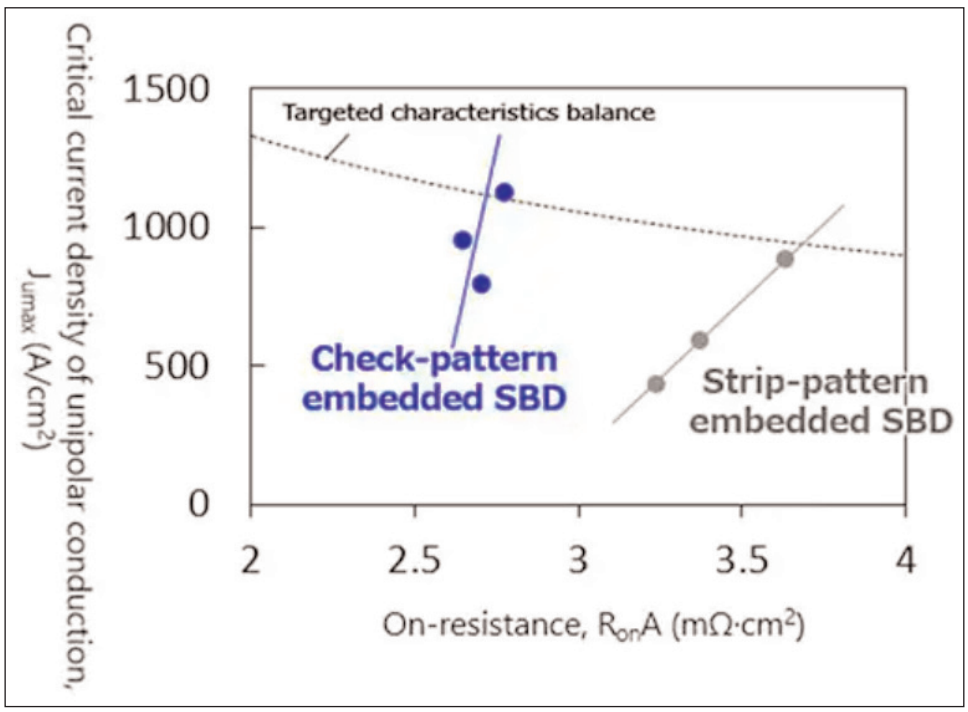
Toshiba has improved both conduction loss in its SBD-embedded SiC MOSFET and achieved good diode conductivity, by deploying a check-pattern SBD distribution. Evaluation of the on-side current characteristics of 1.2kV-class-SBD-embedded MOSFETs with the optimized design confirmed that using the check design to position the embedded-SBDs close to the body diodes effectively limits bipolar conduction of the parasitic diodes, while the unipolar current limit of reverse conduction is double that realized by the existing striped SBD pattern design for the same SBD area consumption. $R_{on}A$ was found to be about 20% lower, at 2.7mΩ.cm^2.



Schematic diagram of MOSFETs with newly developed check pattern embedded SBD-SiC MOSFET.

This confirmed improvement in the trade-off is essential if SiC MOSFETs are to be used in inverters for motor-drive applications. Toshiba is continuing to carry out evaluations toward improving dynamic characteristics and reliability, and to develop attractive, high-performance power semiconductors that contribute to carbon neutrality.

www.ieee-iedm.org
www.toshiba.semicon-storage.com



Trade-off of characteristics of 1.2kV-class SiC MOSFET.

ROHM and BASiC partner on SiC power devices for automotive applications

More efficient and reliable SiC power module for new energy vehicles

In a signing ceremony at its headquarters in Kyoto, Japan-based power semiconductor device maker ROHM Co Ltd has entered into a strategic partnership agreement with China's Shenzhen BASiC Semiconductor Ltd on silicon carbide (SiC) power devices for automotive applications.

BASiC has shipped more than 20 million SiC power devices to over 600 customers worldwide for applications including electric vehicles (EVs), solar power generation, energy storage systems, telecom power supplies, servers, charging stations, and consumer electronics.

The two firms aim to leverage their respective strengths to innovate and improve the performance of SiC power devices and develop higher-performing, more efficient and reliable SiC solutions for new energy vehicles.

BASiC's general manager Weiwei He (right) and ROHM's president & CEO Isao Matsumoto (left) at the signing.

The first step involves supplying onboard power modules that leverage the combined technologies to several major automakers for use in electric vehicle powertrains. Also, going forward, both ROHM and BASiC aim to contribute to technological innovation in the automotive sector by accelerating the development of power solutions centered on SiC.

"Amid the undergoing technological revolution of new energy vehicles, the emergence of SiC power devices stands out as the key to improving electric drive efficiency," notes BASiC's general manager Weiwei He. "BASiC Semiconductor's early involvement in the automotive SiC power module business has led to breakthroughs in both product and market development," he adds. "We are honored to work with ROHM, an internationally renowned semiconductor manufacturer, to develop high-performance, high-reliability automotive SiC power devices that meet customer needs and contribute to innovation in electric vehicle technology while reducing CO_2 emissions."

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

Semikron Danfoss secure long-term agreement to supply SiC modules for Dana's inverters

Semikron Danfoss of Nuremberg and Flensburg, Germany has announced a long-term agreement to supply silicon carbide (SiC) modules for use in the TM4 silicon carbide inverters of Dana Inc, a tier-1 manufacturer of propulsion solutions to power vehicles and mobile machines.

Semikron Danfoss' eMPack platform is optimized for SiC technology, and the fully sintered 'Direct Pressed Die' (DPD) technology (which allows for extremely compact, scalable and reliable inverters) is said to be one of the crucial factors that clinched the deal between Dana and Semikron Danfoss.

"Our modular design, capable of utilizing SiC devices from multiple chip sources, is the ideal module platform for Dana's broad inverter portfolio," says Siegbert Haumann, senior VP, Semikron Danfoss Automotive Division.

Targeted for use across the light-vehicle, commercial-vehicle and off-highway mobility markets, Dana's silicon carbide inverter designs can enable higher system efficiency and power density in a compact package for medium- and high-voltage inverter applications, resulting in the potential for increased range.

"This long-term supply agreement with Semikron Danfoss gives us a strong strategic advantage as we expand the use of silicon carbide technology and support our customers with innovative, efficient and powerful solutions," says Dana's chief technology officer Christophe Dominiak.

"The eMobility market is accelerating at a staggering pace," notes Semikron Danfoss' CEO Claus Petersen. "Combined with a major technology shift from silicon to silicon carbide, it creates an extremely dynamic market environment where close communication and fast decision making is essential. This is best executed in a close cooperation between two strong partners," he adds.

The eMobility market is expected to remain one of the fastest-growing markets for power semiconductors in the years ahead. According to business intelligence and strategy research company BIS Research, the number of hybrid and electric vehicles will continue to grow by 23% a year until 2029.

www.semikron-danfoss.com

Finwave joins MITRE Engenuity's Semiconductor Alliance

Access to high-volume fabs and lithography to bring 3DGaN FinFET technology to production in USA

Finwave Semiconductor Inc of Waltham, MA, USA has joined MITRE Engenuity's Semiconductor Alliance. Finwave says that it has answered the group's call for industry participation to help establish a US-wide approach to protect IP in advanced microelectronics R&D, manufacturing and supply chain resilience.

Led by MITRE Engenuity (a subsidiary of MITRE, a tech foundation for public good), the Semiconductor Alliance was developed from working groups in 2021, and its principles were published in a white paper 'American Innovation, American Growth' summarizing the Alliance's whole-of-nation call to action for a fair and objective National Semiconductor Technology Center (NSTC).

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

Finwave says that it brings to the Alliance a combination of university research, technology patents and industry professionals with company-building experience. The Semiconductor Alliance has been tasked with addressing semiconductor supply chain issues and ensuring that American IT innovation leads to American growth, and that these initiatives align closely with Finwave's goal to make disruptive 3DGaN FinFET IC technology readily available.

GaN semiconductors are currently manufactured almost exclusively outside the USA. Working with the Semiconductor Alliance, Finwave aims to change that by stimulating IC manufacturing in the USA. Finwave champions the building of new fabs, as well as the expansion of existing fabs, to boost American semiconductor research, development and production.

"Our plan calls for radical collaboration to secure semiconductor technology innovation, manufacturing leadership, and supply chain resilience," says MITRE Engenuity's chief technologist Raj Jammy Ph.D., executive director of the Semiconductor Alliance. "Finwave's plans to increase the economic competitiveness of its innovative GaN technology are exactly the type of forward-thinking ideas we need to revitalize US semiconductor leadership."

Seeking to address the many challenges related to 5G, Finwave's 3DGaN FinFET technology combines what is claimed to be best-in-class power amplification efficiency with high-volume manufacturing to overcome the performance and cost limitations that have together stymied widespread adoption of millimeter-wave (mmWave), says Finwave. The firm says that it significantly improves linearity, output power and efficiency in 5G mmWave systems, while greatly reducing costs for carriers. By leveraging high-volume 8-inch silicon CMOS fabs for producing 3DGaN chips, Finwave's devices benefit from both the cost model and scalability of silicon technology.

"Semiconductor innovation is the key to making critical advances in things like 5G, artificial intelligence (AI), the Internet of Things and other technologies that benefit society and are shaping the future," says CEO Bin Lu. "In joining the Alliance's growing membership, Finwave will have access to high-volume fabs and the lithography requirements necessary to bring our technology to volume production – and unlock the promise of 5G."

www.finwavesemi.com
www.mitre-engenuity.org

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CGD and IFP Energies nouvelles sign automotive inverter development deal

French public research and training organization to use ICeGaN GaN HEMTs

Fabless semiconductor company Cambridge GaN Devices Ltd (CGD) has signed an agreement with IFP Energies nouvelles (IFPEN) — a French public research and training organization in the fields of energy, transport and the environment — to develop an automotive inverter using GaN devices.

Spun out of the University of Cambridge Department of Engineering's Electrical Power and Energy Conversion group in 2016 by Dr Giorgia Longobardi and professor Florin Udrea, CGD designs, develops and commercializes power transistors and ICs that use GaN-on-silicon substrates.

"Technological innovation is central to all IFPEN's activities. Therefore we are particularly excited that IFPEN has chosen CGD's ICeGaN GaN HEMTs [high-electron-mobility transistors] in this new automotive inverter design," says co-founder & CEO Longobardi. "IFPEN also shares CGD's belief that close partnerships with key players are essential to the success of any project," she adds.

"This partnership with CGD is a key element for our future activities in power electronics for e-mobility, specifically for the next generation of inverters where a technological step is required to reduce size and increase power density levels while challenging the cost," says Gaëtan Monnier, director of IFPEN's Mobility business unit. "We count on the cooperation with this young and dynamic, extremely innovative company to address the ambitious challenges critical to the future of e-mobility industries."

The partnership combines two highly complementary areas of expertise. IFPEN is said to understand the automotive market and its performance targets, and possess a strong position in inverter and software development, with in-depth knowledge of the algorithms and equipment required. CGD's GaN technology has resulted in what is claimed to be the industry's first easy-to-use and scalable 650V GaN HEMT family. The firm's ICeGaN H1 series devices are single-chip enhancement-mode HEMTs that can be driven like a MOSFET, without the need for special gate drivers, complex and lossy driving circuits, negative voltage supply requirements or additional clamping components. ICeGaN HEMTs require no cascode structure, no complex multi-chip configurations, and no thermally complex integrated solutions. Instead, they comprise a single-chip solution with embedded proprietary logic, which enables coupling with standard gate drivers or controllers. Devices are said to be extremely reliable, suiting demanding application environments (as found in the automotive market).

www.ifpenergiesnouvelles.com
www.camgandevices.com/p/technology

Richardson to distribute Gallium Semiconductor's RF GaN products globally

Distributor expands RF & microwave portfolio

Richardson Electronics Ltd of LaFox, IL, USA (a global provider of engineered solutions, RF & microwave and power electronics products) has announced a global distribution agreement with Singapore-based Gallium Semiconductor, which supplies RF gallium nitride (GaN) solutions for 5G mobile communication networks as well as aerospace & defense, and industrial, scientific & medical applications. The agreement aligns with both companies' commitments to providing high-performing, high-efficiency RF GaN products.

Gallium Semiconductor's product range includes:

- bare known good die GaN-on-SiC high-electron-mobility transistors (HEMTs);
- unmatched GaN transistors in plastic and air-cavity ceramic packages;
- pre-matched GaN transistors in air-cavity plastic packages;
- dual-path GaN amplifiers for 5G communications infrastructure.

"Gallium Semi's portfolio of GaN products offer exceptional performance for RF power applications," comments Greg Peloquin, executive VP at Richardson Electronics' Power & Microwave Technologies group.

"Richardson Electronics is well known in the industry as the foremost distributor for RF & microwave products," comments Gallium Semi's CEO Rohan Houlden. "Their broad customer base and high touch support teams in key markets make them a strategic partner to expand the reach of our products," Houlden concludes.

www.galliumsemi.com
www.rellpower.com

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Transphorm opens GaN application lab in Shenzhen

Greater China as new location increases regional capabilities for APAC power electronics customers

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has opened a new office in Shenzhen, China, which is fully operational and already serving the firm's broad customer base in China.

As a wholly foreign-owned enterprise (WFOE), the site will house staff responsible for enhancing local customer support, sales and marketing efforts. It will also serve as an application lab for regional customers developing GaN-based power systems as well as global R&D efforts. The office will be overseen by Kenny Yim, Transphorm's current VP of Asia sales, as he also assumes the role of general manager, China. He will be supported by Chun Hung Ho, head of applications, Asia, and a seven-year-veteran of Transphorm.

"China, Hong Kong and Southeast Asia house several dynamic industries re-imagining power electronics through high-performance GaN. Shenzhen also stands as a major electronics technology hub within China," says Yim. "Establishing a formal presence in the city is critical to our growth strategy as our customers look to leverage the region's power electronics innovation. Having an application lab there allows us to easily tap into the near-shore engineering talent pool while better supporting customers at their own local design centers," he adds.

Transphorm's GaN device portfolio addresses the power spectrum from 45W to 10kW+, so the firm supplies to product manufacturers operating in the broadest range of markets, from adapters and computing to broad industrial and automotive. Recently announced customer products — 65W power adapters and a medical energy storage device — were designed and manufactured in the APAC region, emphasizing the importance of Transphorm expanding its capabilities there.

"The power GaN market is expected to reach US$2bn by 2027, according to research firm Yole Intelligence. The demand for our GaN products and resources is rising in tandem," says Tushar Dhayagude, VP worldwide sales. "We're committed to helping our customers achieve their goals and understand that this commitment calls for dedicated field support. With that in mind, Shenzhen proved to be the optimal place to open our formal Transphorm APAC facility."

Yim has more than 25 years of experience in the semiconductor industry, including more than a decade working for Transphorm heading up sales in the APAC region. He and his Asia team are credited with helping Transphorm develop customer relationships in markets such as power adapters, data centers, gaming, blockchain computing, and renewable energy. Yim previously held sales positions with global semiconductor companies Cree Inc (now Wolfspeed) and International Rectifier prior to its acquisition by Infineon.

"Kenny's contributions over the past ten years at Transphorm have been instrumental in our overall customer adoption to date," comments co-founder & president Primit Parikh. "His efforts in Asia, China in particular, have enabled us to pioneer the adoption of gallium nitride across the power spectrum from low power to high power, including in key patented solutions such as the totem-pole PFC and a variety of other power topologies."

www.transphormusa.com

EPC to use Vanguard's 8-inch gallium nitride foundry from early 2023

Multi-year agreement to expand EPC's manufacturing capacity

In a multi-year agreement, Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA is to use the 8-inch (200mm) wafer fabrication capabilities of specialty IC foundry service provider Vanguard International Semiconductor Corp (VIS) of Hsinchu Science Park, Taiwan, significantly increasing manufacturing capacities for its gallium nitride on silicon (GaN-on-Si)-based power transistors and integrated circuits. Manufacturing will begin in early 2023.

The products manufactured at VIS (an automotive IATF 16949 certified foundry) will meet the growing demand for GaN power devices in data centers, electric vehicles, solar inverters, robotics, and space systems.

"VIS' leading specialty IC manufacturing expertise, combined with EPC's product design capability and outstanding figure of merit (FOM) of GaN, will deliver greater energy efficiency for more eco-friendly high-performance computing and electric vehicle applications," comments VIS' chief operating officer John Wei.

www.vis.com.tw/en
www.epc-co.com

Transphorm releases new GaN FET reliability ratings, now segmented into low and high power levels

Transphorm has announced the latest reliability ratings for its GaN power FETs.

Reliability is measured by failures in time (FIT), which considers the number of devices reported by customers to have failed in the field when used in applications. To date, the firm's total product portfolio has achieved an average <0.1 FIT rate based on more than 85 billion hours of field operation. This rating stands as one of the industry's best and only reported broad power spectrum reliability rating of any GaN power solution available, it is claimed.

Transphorm says that it built its GaN platform with reliability in mind, understanding its importance when the wide-bandgap technology first hit the market: even though GaN boasted higher performance than silicon-based transistors, customers would not opt to switch to the then-new technology if the devices failed in real-world use. In 2019, Transphorm was the first GaN manufacturer to publish a complete validation data set backing its reliability claims. Since then, the firm regularly shares its GaN reliability to help potential customers make informed decisions when choosing semiconductor suppliers. Transphorm last reported its FIT rate to be <0.3 in first-quarter 2022.

This year, Transphorm has taken its reliability data and segmented it into two categories:

- low power: GaN devices used in applications with power levels ≤500W;
- high power: GaN devices used in applications >500W.

When looking at device performance by power-level type, Transphorm's GaN FETs yield the following reliability ratings that are notably similar to those of silicon-based power devices:

- low power: 0.06 FIT;
- high power: 0.19 FIT.

"Our high-voltage GaN devices are designed into the broadest range of applications covering the widest power spectrum, from 45W to 4kW today with the potential to reach 10+kW as GaN is adopted into new markets. This shows the immense versatility of our technology," says Philip Zuk, senior VP of business development & marketing. "However, we realized that reporting just a singular reliability rating that lumps all application types together may not be as useful to customers. We felt it necessary to help them access more nuanced data that would apply to their specific design requirements. Hence, the breakdown between low and high power."

www.transphormusa.com

Cardiff and CSA Catapult develop AI method to optimize wide-bandgap power electronic converters

Artificial neural networks aid selection of appropriate design for desired efficiency and power density

A new and more efficient way of modeling and designing power electronic converters using artificial intelligence (AI) has been created by a team at Cardiff University and the Compound Semiconductor Applications (CSA) Catapult (headquartered in Newport, South Wales). CSA Catapult's Power Electronics laboratory enables innovation through comprehensive modeling, characterization, integration and validation facilities for power converters with higher efficiency and reliability with reduced size, weight and system cost. Working strategically with academic partners like Cardiff University, CSA Catapult bridges the gap between research and application development.

Existing methods of designing power converters largely rely on complex mathematical models that significantly increase the computational time and complexity of the design process. The new method has reduced design times for technology by up to 78% compared with traditional approaches and was used to create a device with an efficiency of over 98% (IEEE Open Journal of Power Electronics and IEEE Transactions on Power Electronics).

A well-designed power electronic converter must have high efficiency, small volume, be lightweight and have low cost and a low failure rate. Therefore, the main goal of a

power converter design method is to identify the best trade-off among these performance indicators.

In their study, the team explored a new design method using artificial neural networks (ANN) that uses algorithms and computing systems that mimic the interconnected neural networks of the human brain. The ANN was trained on an existing dataset of over 2000 designs, so the team could select the most appropriate design for the desired efficiency and power density. The team selected four major components for the ANN-based design, including the gallium nitride (GaN) power field-effect transistors (FETs), inductors, capacitors, and heat-sinks.

The design approach was validated through experimental tests on a GaN-based single-phase inverter that was created using the specified design. The efficiency and power density of the device was well matched to the design and within the range of existing devices, making it technically competitive and commercially viable.

"Accurate and fast transient modelling/simulation approaches are essential to efficiently and to rapidly optimize the performance of wide-bandgap power electronics systems," says the study's co-author Dr Wenlong Ming, senior lecturer at Cardiff University and senior research fellow at CSA Catapult.

"Automated power electronics design optimization enables the full exploitation of wide-bandgap power semiconductor advantages when compared to their silicon counterparts," adds co-author Dr Ingo Lüdtke, head of power electronics at CSA Catapult.

Established in 2017 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a not-for-profit organization focused on accelerating the adoption of compound semiconductors and on bringing applications to life in four technology areas: power electronics, RF & microwave, advanced packaging and photonics. It works across the UK in a range of industry sectors from automotive to medical, and from digital communications to aerospace.

www.csa.catapult.org.uk
https://ieeexplore.ieee.org/document/9887949
https://ieeexplore.ieee.org/document/9506845

Zuken and CSA Catapult optimize power module design tools

3D power module design uses CR-8000 Design Force capability to capture ribbon bond wires and high-current metal clips

Zuken, which provides software and solutions for electronic and electrical engineering, and the UK's Compound Semiconductor Applications (CSA) Catapult have announced a milestone in their R&D collaboration aimed at building a development environment for state-of-the-art compound semiconductor products.

Established in 2017 by UK Government agency Innovate UK (which provides funding and support for business innovation as part of UK Research and Innovation), CSA Catapult is a not-for-profit organization (headquartered in Newport, South Wales) focused on accelerating the adoption of compound semiconductors and on bringing applications to life in four technology areas: power electronics, RF & microwave, advanced packaging and photonics. It works across the UK in a range of industry sectors from automotive to medical, and from digital communications to aerospace.

Collaborating with Zuken on a project to bring a power module layout from a graphical concept to a 3D model, CSA Catapult has identified several requirements and optimizations to Zuken's CR-8000 Design Force chip, package and PCB co-design software that will provide designers of power electronic products with the ability to co-develop mechanical and electrical design in unison. The integration with industry simulation tools enables the efficient design iteration needed to effectively explore the design envelope for new compound semiconductor products.

As a result of the collaboration, an intuitive function was created that is used to generate interconnections between chips and copper layers in a substrate or a printed-circuit board, as well as a function to export a CAD model in a format compatible with finite-element modelling (FEM) software. These advanced features will help designers to significantly decrease the time required to generate a 3D model of the power module substrate, chip layout, and chip-to-chip as well as chip-to-copper interconnections.

"The creation of a 3D model of the substrate, chip layout and chip interconnections is an important part of the early-stage power module design process," says Dr Alejandro Villarruel Parra, senior power electronics engineer at CSA Catapult. "Zuken's advanced design solutions have helped to provide a preview of the module performance, which in turn makes our decision-making process faster when several concepts are being compared or helps to steer the refinement of the module geometry if a concept has already been selected."

The new capability is included in the 2022 release of CR-8000 Design Force.

www.csa.catapult.org.uk
www.zuken.com/en/product/cr-8000/3d-multiboard-pcb-design

Virginia Tech gains $1.5m, four-year NSF grant to research optically driven power switches

Principal investigator Yuhao Zhang and three other professors from the Bradley Department of Electrical and Computer Engineering have been awarded a $1.5m grant from the US National Science Foundation's Electrical, Communications and Cyber Systems flagship program ASCENT (Addressing Systems Challenges through Engineering Teams), which is focused on future semiconductor technologies.

Zhang and his team are proposing what is said to be a first-of-its-kind semiconductor technology that is optically driven for use in grid power electronics.

Key collaborators in the project include faculty from the Center for Power Electronics Systems (CPES) in Arlington and Blacksburg and the Center for Photonics Technology (CPT). Both of these research centers are based at Virginia Tech.

Working with Zhang (an expert in power electronics, micro/nano-electronic devices, and advanced semiconductor materials) are assistant professors Dong Dong and Christina DiMarino and associate professor Xiaoting Jia.

Dong is a faculty member of the Center for Power Electronics Systems with research expertise in power electronics and power conversion systems. DiMarino is also a member of that center's faculty and has expertise in power electronics packaging. Jia is a faculty member of the Center for Photonics Technology with a background in fiber-based neural interfaces, nano-bio interfaces and fiber sensors and devices.

The existing US power grid relies primarily on coal and natural gas to produce electricity. Electricity generation is responsible for about 25% of greenhouse gas emissions. To reduce this environmental impact, the team will leverage the unique electronic and optical properties of ultra-wide-bandgap semiconductors that can withstand a very high electric field.

Most existing power switches are electrically driven, relying on the base drive current or the gate-drive voltage to turn the device on and off. As more renewable energies and higher power levels have been introduced into the grid structure, the high switching frequency needed has increased the risk of noise. Also, stacking hundreds of devices to enhance power makes it difficult for them to be driven synchronously.

When electrical noise occurs, devices can transition on and off very quickly (false triggering), which creates a disturbance. For multiple devices, the non-synchronous driving also will lead to false triggering. This can cause problems like short circuits and eventually system failure in the grid.

Optically driven semiconductors operate on the principle of photo-generation, using a light source from a laser fiber to turn the switch on and off. This approach provides more noise immunity because photons are used instead of electrons. The fast speed of light allows for an ideal synchronization for driving hundreds of devices, and the number of required electrical components can be reduced.

Implementing these devices into the semiconductor power grid would greatly simplify the complexity of grid-scale power, resulting in much improved scalability, efficiency, interactivity and resiliency.

"The power semiconductor market has reached $40bn and is forecasted to more than double that amount by the year 2030," says Zhang. "Innovation in power semiconductors is a driver for energy savings in data centers, electric vehicles, and the electric grid... it holds the key for realizing the unprecedented cuts in carbon dioxide for a greener and more sustainable environment."

"Our department is very diverse and transdisciplinary," says Zhang. "We are not just collaborating with individuals but also collaborating with different centers — in this case CPES and CPT," he adds.

Each team member will contribute to different areas of the project at different stages throughout the four-year timeline. Zhang, Jia and Dong are all National Science Foundation CAREER Award winners and provide strong knowledge in their respective fields. DiMarino has received the Virginia Tech College of Engineering Outstanding New Assistant Professor Award and the DOE ARPA-E OPEN 2021 Award.

As part of ASCENT, the team will provide educational opportunities to train future engineers in the areas of semiconductor technologies, optical systems, power electronics, and microelectronics. The researchers will partner with a team in electrical and computer engineering's Major Design Experience, a two-semester senior design project course that gives students industry-like experience.

The team members also will add project-related curricula to their undergraduate and graduate courses. With additional access to Center for Power Electronics Systems resources, students will have real-world learning experiences while interacting with industry professionals.

The team will also collaborate with the Center for the Enhancement of Engineering Diversity at Virginia Tech to introduce semiconductor, power electronics, and nanotechnology to students, particularly middle school and high school girls. Summer camps will provide hands-on experiences of the new technologies.

Zhang is hopeful for the future of the grid based on the research being done, technology being developed, and training provided to students — all focused in semiconductors. "The advancements we are going to develop are for the next generation of power electronics," he says. "In 10–20 years, we can have these devices built into the system."

www.photonics.ece.vt.edu

Tomás Palacios named director of MIT's Microsystems Technology Laboratories

MTL moving to Office of the Vice President for Research, furthering collaboration with Research Laboratory for Electronics

Maria Zuber (vice president of research and E.A. Griswold Professor of Geophysics) and Anantha Chandrakasan (dean of the School of Engineering and the Vannevar Bush Professor of Electrical Engineering and Computer Science) say that on 1 December Tomás Palacios assumed the role of director of the Microsystems Technology Laboratories (MTL) at Massachusetts Institute of Technology (MIT).

Palacios has served as director of the 6-A MEng Thesis Program; Industry Officer; and Professor of Electrical Engineering within the Department of Electrical Engineering and Computer Science (EECS). He succeeds Advanced Television and Signal Processing (ATSP) professor Hae-Seung (Harry) Lee, who has been MTL director since 2019.

"MTL's commitment to developing innovative technologies at all levels of the stack, from materials to devices, circuits and systems is an example to all," comments Palacios. "We just need to browse the internet, make a phone call, or recharge our electric vehicle to see how technologies that came out of MTL have found their place in applications all around us."

Palacios joined MTL in 2006, after receiving his PhD from the University of California – Santa Barbara, and his undergraduate degree in Telecommunication Engineering from the Universidad Politécnica de Madrid (Spain). An expert in gallium nitride electronics for both radio frequency and power applications, Palacios and his group have also made seminal contributions to two-dimensional materials and devices, and their heterogeneous integration with state-of-the-art silicon electronics. Palacios is the founding director of the MTL Center for Graphene Devices and 2D Systems, as well as the co-founder of MTL spin-off Finwave Semiconductor Inc, which is commercializing GaN power amplifiers for 5G communications.

Tomás Palacios, now MTL director.

Palacios is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), and has served the microelectronics community in many roles, more recently as the general chair for the IEEE Symposium on Very Large-Scale Integration (VLSI) Technology and Circuits. His work has been recognized with awards including the Presidential Early Career Award for Scientists and Engineers, the 2012 and 2019 IEEE George Smith Award, and the National Science Foundation (NSF), the Office of Naval Research (ONR), and the Defense Advanced Research Projects Agency (DARPA) Young Faculty Awards.

"Semiconductors and microsystems have never been more important. It is not only about their tremendous implications to computing and communication, but also that they are the key to solving the climate crisis, transforming healthcare and, even, the future of education," says Palacios, who promises that the lab will continue to build on its history of innovation. "We have a once-in-a-generation opportunity to set the foundation for the future of semiconductors and microsystems, and everything that means for the future of our society… The MTL community will play a vital role in setting this foundation."

Palacios is assuming this new role during a period of transition for MTL. In January, MTL will move to the Office of the Vice President for Research, maintaining a dotted line reporting to the School of Engineering. This move will help foster further collaboration between MTL and the Research Laboratory for Electronics (RLE) and grow the microelectronic and nanotechnology research community at MIT.

https://engineering.mit.edu

New silicon carbide device-making customer chooses Aehr's FOX-XP for wafer-level test and burn-in

Test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has received an initial production order from its new major silicon carbide (SiC) device-making customer for a FOX-XP multi-wafer test and burn-in system configured with Aehr's new fully integrated and automated WaferPak Aligner. The FOX-XP system is configured with Bipolar Voltage Channel Module (BVCM) and Very High Voltage Channel Module (VHVCM) options which enable new advanced test and burn-in capabilities for SiC power semiconductors using Aehr's proprietary WaferPak full-wafer contactors. This customer serves several key markets including the electric vehicle (EV) industry as well as other industrial applications.

This production system order is a follow-on to an order last quarter for a FOX-NP system that has already been installed at the customer's site. Shipments of the FOX-XP system with the new integrated and automated WaferPak Aligner are due to begin in Aehr's fiscal fourth quarter (beginning 1 March 2023).

"This customer has confirmed their commitment to Aehr with their selection of our FOX platform for production test and burn-in of their silicon carbide wafers," says president & CEO Gayn Erickson. "They have told us, and we believe, they will order a significant number of FOX-XP systems for volume production of their silicon carbide devices at facilities around the world to meet the exploding forecasted market demand for silicon carbide devices for electric vehicles and other industrial markets."

"In addition to the cost-effectiveness and scalability of our system, this customer has told us and expressed publicly how important automation is to them across their wafer fabrication and assembly & test, and that our fully integrated FOX-XP with automated WaferPak alignment and handling is key to meeting their automation needs that are critical to their scalability, as well as the quality and reliability goals of the customers and markets they serve," Erickson continues. "This customer will be our lead customer for high volume using our new FOX-XP wafer-level test and burn-in system with our new fully automated and integrated WaferPak alignment and material handling system."

"The FOX-XP with integrated WaferPak Aligner uses our proprietary WaferPak full-wafer contactors and supports 100mm, 150mm, 200mm and 300mm wafers sizes using industry-standard wafer cassettes and FOUPs (front-opening unified pods). This allows customers to easily support multiple wafer sizes, which is critical to the silicon carbide market where a high mix of wafer sizes is expected in high-volume production over the next several years. This new configuration allows our customers to move and align the wafers automatically into our proprietary WaferPaks and place the WaferPaks into and out of our multi-wafer FOX-XP systems that test and burn-in up to 18 wafers at a time."

The FOX-XP configured with the integrated and automated WaferPak Aligner has a number of additional features for automation of the test floor. These include unattended changeovers from one product to the next, and the ability to run multiple different product type wafers in parallel. "In addition, 100% tracking and traceability of wafers and logging individual die test results has become key to companies serving mission-critical applications and markets such as the electric vehicle engine inverters and their on-board and off-board chargers that are driving the explosive demand for silicon carbide devices," says Erickson.

Canaccord Genuity forecasts that the silicon carbide market for devices in electric vehicles, such as traction inverters and on-board chargers, will grow from fewer than 150,000 wafers in 2021 to more than four million 6-inch-equivalent wafers in 2030 to meet the demand of the automotive EV market (a growth rate of over 25 times the current wafer capacity just for the in-vehicle devices). Canaccord also estimates that the silicon carbide market will require an additional four million SiC wafers annually by 2030 to meet demand for electrification infrastructure, industrial and photovoltaic power devices.

"The FOX family of compatible systems including the FOX-NP and FOX-XP multi-wafer test and burn-in systems and Aehr's proprietary WaferPak full-wafer contactors provide a uniquely cost-effective solution for burning in multiple wafers of devices at a single time to remove early life failures of silicon carbide devices, which is critical to meeting the initial quality and long-term reliability the automotive, industrial and electrification infrastructure industry needs," notes Erickson. "The FOX-XP system can be configured with up to nine or 18 wafers depending on the customer's specific test requirements and power configuration and is fully compatible with Aehr's FOX-NP system, which is a two-wafer system that is a great fit for new production introduction and qualification."

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

www.aehr.com

Plasma-Therm receives follow-on Japan order for Heatpulse RTP system for automotive SiC MOSFET power devices

Platform redesign enables installed legacy system upgrades without interrupting processes of record

Plasma-Therm LLC of St Petersburg, FL, USA (which makes plasma-process equipment for the semiconductor and compound semiconductor markets) has received an order from a leading Japanese device maker for multiple systems built on its newly redesigned Heatpulse rapid thermal processing (RTP) platform, launched in July at SEMICON West 2022. The Heatpulse systems will be used to manufacture silicon carbide (SiC) MOSFET power devices in Japan for electric vehicles (EVs) and other automotive applications.

Plasma-Therm says that the new platform continues to garner significant interest among its global customer base to meet new processing demands and greater return on investment (ROI) — including multiple orders announced in Europe last month. The Japan-based customer selected Heatpulse RTP for its new dual-oven configuration, ability to reach temperatures over 1000°C, as well as for its all-new Cortex advanced monitoring and control software.

"Many device makers are struggling with supply chain issues impacting their ability to meet current demand for spare parts, including for legacy installed Heatpulse systems," says Jim Garstka, VP of sales & business development. "Our strategy is to provide our customers with a solution to modernize their existing installed systems and mitigate risk associated with sourcing spare parts. This allows customers to immediately benefit from critical system upgrades to boost performance and throughput, while keeping their existing processes running smoothly in production into the next decade," he adds.

"We are continuing to see rapid growth in specialty markets for 200mm and smaller substrates, including for the power devices for automotive applications, with 6.2% growth in Japan projected by industry analysts," says Plasma-Therm Japan country manager Hirokuni Shibata. "With the majority of our Heatpulse legacy systems installed in Japan, we are excited to offer our customers immediate solutions to boost processing performance and ensure maximum tool uptime."

The redesigned Heatpulse RTP platform is fully compatible with legacy AG Heatpulse 8108 and 8800 systems and existing processes. The flexible platform can accommodate multiple wafer sizes and features upgraded robotics and Plasma-Therm's Cortex process control software. With the dual-oven configuration, the new Heatpulse delivers higher throughput per square meter in a smaller footprint, enabling customers to realize higher ROI. The direct result is optimized production yields and capacity with maximized uptime during high-volume manufacturing, says Plasma-Therm. Additionally, the new Heatpulse RTP wafer size conversion kits are implemented, eliminating complicated, time-consuming system hardware changes to help further increase ROI and save time and money during conversion.

The newly redesigned Heatpulse RTP platform processes substrates up to 200mm in diameter for a wide variety of materials, including silicon, gallium arsenide, SiC, and other compound semiconductors. Offering greater flexibility to accommodate multiple wafer sizes, the new platform features upgraded robotics and Plasma-Therm's Cortex process control and monitoring software. The firm also offers easily implemented conversion kits to upgrade currently installed systems, eliminating complicated hardware changes and ensuring full compatibility with existing processes.

Cortex is Plasma-Therm's core advanced process control software offering a seamless, intuitive user interface for process development, operations and maintenance across all etch, deposition, RTP and plasma-dicing product lines. The software enables increased tool reliability and optimization with the ability to develop and maintain process recipes, safe and secure maintenance, and real-time data analysis for performance fine-tuning and repeatability. Cortex also features integrated end-point detection for tighter process control utilizing laser interferometry for precise rate determination and optical emission spectrometry. All Cortex systems provide secure remote access for diagnostics and process support.

www.plasmatherm.com

Disco develops fully automatic grinder for 100–200mm silicon and silicon carbide wafers

DFG8541 cuts footprint by 15% and air consumption by 50%

At SEMICON Japan 2022 in Tokyo (14–16 December), Tokyo-based equipment maker DISCO Corp – which makes semiconductor manufacturing equipment including chemical mechanical polishing (CMP) systems and laser-based ingot slicing equipment and processes – is exhibiting the new DFG8541, a fully automatic grinder that can process silicon (Si) and silicon carbide (SiC) wafers up to a maximum diameter of 8-inches (100–200mm).

For grinding wafers smaller than 8-inches, DISCO has been providing the fully automatic grinder DFG8540, which has been shipped to many device manufacturers and electric component manufacturers as a standard dual-axis grinder. However, two decades have passed since the initial release of DFG8540, and customers' processing targets have expanded from not only silicon but also to compound semiconductors including SiC. In addition, with growing needs for wafer thinning along with the development of high-density packaging technologies, maintaining higher cleanliness inside the equipment is now required in order to reduce breakage risks caused by the adherence of particles during processing, transferring and cleaning.

DISCO has hence developed the successor, DFG8541, aiming for stable thinning while maintaining high cleanliness as well as improved operability and productivity. By making a high-torque spindle an option, it is possible to support difficult-to-process materials that have high rigidity such as SiC, responding to the needs of SiC power semiconductor manufacturing that have been growing due to the global trend toward decarbonization.

The DFG8541 is said to prevent the adherence of particles inside the equipment and reduce the breakage risk of thin wafers by adopting a non-contact wafer-centering mechanism that uses a camera, and adopting atomizing nozzle cleaning as standard functions for the chuck table; processed wafers on the chuck table; spinner table; and processed wafers on the spinner table.

Disco's DFG8541 fully automatic wafer grinder.

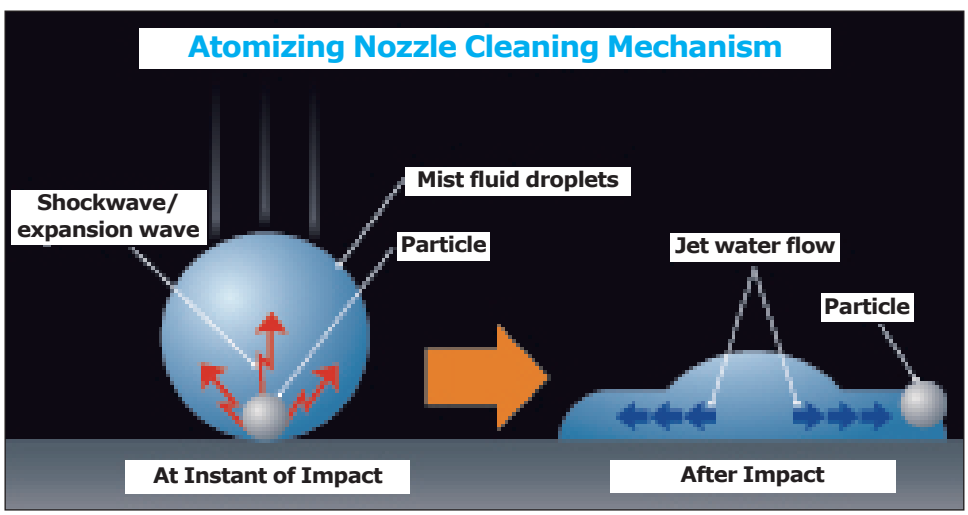
For improved operability and productivity, the installed monitor size has been expanded from 15-inches (DFG8540) to 19-inches (using a capacitive touch panel). As recipes can be set for each wafer, continuous processing can be performed even when multiple recipes are present. The DFG8541 can support multi-variety low-volume production. Also, by installing an electric axis for chuck table inclination adjustment, the processing shape can be corrected by inputting the value on the monitor screen, reducing the downtime for adjustment.

Regarding wafer protection functions, the DFG8541 reduces the risk of breakage of high-cost wafers such as developmental products, cutting-edge products, and SiC. Also, a wafer mapping function detects cross-slotted wafers in the cassette using a sensor. A pre-processing wafer thickness detection function detects thickness irregularities such as the attachment of multiple surface protection tapes in advance. A vacuum retention function sends an alert when a power outage occurs during wafer transfer.

By adopting a built-in vacuum pump, the footprint has been reduced by 15% compared with that of DFG8540. Also, by adopting a new bearing structure, air consumption is reduced by about 50%. The DFG8541 hence contributes to energy saving in plant facilities (compressors).

Sales of the DFG8541 are scheduled to commence in June 2023.

www.disco.co.jp



Indium Corp introduces no-clean, halogen-free solder paste for advanced LEDs

Printability down to 60μm apertures compatible with existing mini-LEDs and beyond

Indium Corp of Clinton, NY, USA (which refines, smelts, manufactures and supplies materials to the global electronics, semiconductor, thin-film and thermal management markets) has expanded its portfolio of proven pastes with a new no-clean, halogen-free solder paste designed for advanced LED applications, including COB, COG, SMT and other varieties of LED.

LEDPaste NC38HF combines what is claimed to be superior wetting performance with excellent stencil print transfer efficiency to satisfy a broad range of process requirements for mini-LED applications. Mini-LEDs typically feature a length of less than 240μm on the component edge. Offering printability

down to 60μm apertures, the new material offers compatibility with the current size of mini-LEDs and as future die continue to miniaturize.

LEDPaste NC38HF delivers:

- consistent and tight solder deposit spread across multiple prints and excellent response-to-pause characteristics;
- minimal voiding on tight-pitch components, ensuring joint strength on small components;
- what is claimed to be industry-leading non-wet open (NWO) performance using superior oxidation barrier technology, enabling reduced solder ball and solder beading defects and enhanced graping performance;
- enhanced slump performance with minimal bridging during the assembly process, improving yields for tight-pitch components.

A proven product, LEDPaste NC38HF was recognized with an award for Excellent Product of the Year at the MiniLED conference in Shenzhen, China on 10 November.

www.indium.com

Indium Corp promotes Theo Ruas to global sales manager, Metals and Compounds

Role spans gallium tri-chloride, high-purity indium, and reclaim of indium, gallium and tin

Indium Corp has promoted Theo Ruas to the role of global sales manager, Metals and Compounds.

In his new role, Ruas leads all aspects of global sales for Metals and Compounds, including gallium tri-chloride, high-purity indium, and the reclaim of indium, gallium and tin. Ruas also supports product management with market information for the development of new technologies.

Indium says Ruas ensures a healthy sales opportunity funnel and progress, engages with its largest customers and manages pricing. He also leads and develops the global sales team and channel partners, works with product management and marketing on strategies and promotional activities, and collaborates with manufacturing teams to ensure that capabilities and capacity are in place to meet and exceed customer expectations.

Ruas joined Indium Corp in 2020 as a field sales representative based in Italy. He holds a mechanical engineering degree with a focus on surface plasma treatment from the Federal University of Santa Catarina, Brazil.

www.indium.com

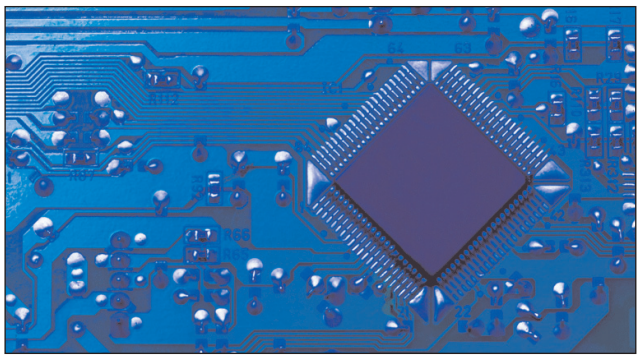
Hamamatsu Photonics adopts Siemens' mPower digital software

Software to be used for power integrity analysis of next-generation optical semiconductor devices

Siemens Digital Industries Software of Plano, TX, USA says that Japan-based Hamamatsu Photonics K.K. has adopted Siemens' mPower digital software for the power integrity analysis of its next generation of optical semiconductor devices.

Hamamatsu Photonics provides products such as photodiodes, photo ICs, image sensors, infrared detection devices and LEDs – all of which support multiple wavelength ranges (e.g. infrared, visible, ultraviolet, x-ray, high-energy). The products are widely used in many applications, including the scientific measurement, medical and automotive markets.

"Power integrity analysis is a critical technology for us, because our optical IC products need to achieve extremely high performance and reliability in order to meet stringent functionality requirements," says Masaaki Matsubara, manager for the second design group, Design Center, Solid State Division. "Siemens' mPower digital software is our best option for improving IC performance and reliability. Our designers use the mPower solution to analyze their designs at early



stages of development, and the software definitely helps to optimize the power source design faster."

Introduced last year, Siemens' mPower solution aids customers to more quickly and accurately perform sign-off analysis of the power, electro-migration and IR-drop performance of integrated circuits, helping them to confirm that their as-implemented design will meet performance and reliability targets when manufactured.

Siemens says its mPower digital software provides power integrity analysis with high accuracy through fast and efficient distributed processing. Featuring an intuitive graphical user interface for optimal ease-of-use, the solution supports analysis across the IC design process, from initial concept design to design sign-off, helping users to create better designs with no compromise in quality or speed. For optimal reliability and IC traceability, mPower also integrates seamlessly with Siemens' Calibre RVE software, which is part of its Calibre platform for IC physical verification.

"As image sensors grow in size and complexity, it becomes both harder and more critical to verify the power integrity of these very large designs," notes Joe Davis, senior director for Interfaces and EM/IR Product Management for Siemens EDA. "Hammamatsu Photonics quickly determined that the mPower solution provides the capacity, performance and integration that they need in order to bring high-performance, high-resolution sensors to the market, and we look forward to working with them as they bring more advanced designs to the market."

www.hamamatsu.com
www.siemens.com/software

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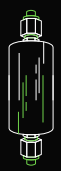
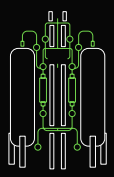
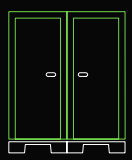


Point-of-Use Purifiers



Frame-Mounted Purifiers



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Cambridge's Rachel Oliver awarded Royal Academy of Engineering Chair in Emerging Technologies

Professor Rachel Oliver of the University of Cambridge's Department of Materials Science and Metallurgy has been awarded a Royal Academy of Engineering (RAE) Chair in Emerging Technologies. The award is worth £2.5m over ten years to develop emerging technologies with high potential to deliver economic and social benefits to the UK.

Funded by the UK Department for Business, Energy and Industrial Strategy (BEIS), the Chair in Emerging Technologies scheme aims to identify global research visionaries and provide them with long-term support, enabling them to focus on strategic approaches for taking their technology from the bench to the boardroom.

Oliver is a Fellow of Robinson College and director of the Cambridge Centre for Gallium Nitride. Creating porosity in gallium nitride (GaN) vastly extends the range of materials properties achievable. By controlling the porosity, engineers can select the properties they need to create new device concepts or to improve existing products.

Oliver's aim is to create a set of materials fabrication processes that control the structure and properties of porous GaN. Alongside this, she will develop a modelling toolbox for designing new devices. By developing new devices and embedding porous GaN in the UK's compound semiconductor industry, Oliver hopes to drive this emerging materials platform towards widespread industrial adoption.

Potential applications are broad. Developing the use of UV LEDs for disinfection would give healthcare professionals new weapons in the fight against viral epidemics and antibiotic-resistant bacteria. Work on micro-displays using micro-LEDs could improve augmented reality (AR) and virtual reality (VR) headsets. As well as providing immersive experiences for gamers, this technology could be used by organizations for more effective online collaboration. By reducing the need for business travel, the ecological benefits could be significant.

"The Academy places huge importance on supporting excellence in engineering, and often the key to engineers fulfilling their potential in tackling global challenges is the gift of time and continuity of support to bring the most disruptive and impactful ideas to fruition," says professor Sir Jim McDonald FREng FRSE, president of the RAE.

www.gan.msm.cam.ac.uk

CrayoNano releases preliminary lifetime results for CrayoLED CLH-N3S

Average output of 79.3% maintained after 3000 hours; extrapolated to >10,000 hours based on TM-21

CrayoNano AS of Trondheim, Norway — which develops and makes semiconductor components based on patented and proprietary nanomaterials technology — has released the preliminary results of the CrayoLED CLH-N3S H-Series UV-C LED room-temperature operating life (RTOL) test conducted by an independent, accredited third-party testing and qualification lab.

The lifetime testing aims to demonstrate the quality and reliability of the CrayoLED and generate data to predict the LED's lifetime until it reaches 70% of its original power output based on TM-21 modeling. The RTOL testing follows the EIAJ-ED-4701/100(101) standard, an industry-accepted test method to measure output power maintenance of LED packages. The CrayoLED CLH-N3S LEDs are tested at the standard forward driving current, 350mA per LED, under continuous operation for a minimum of 6000 hours. The test condition and set-up consist of the CLH-N3S LED mounted on an aluminium metal core printed circuit board (MCPCB), attached to an aluminium heat-sink for thermal management, and running inside a temperature-controlled chamber.

CrayoNano has demonstrated after 3000 hours (about 4 months) that the CLH-N3S UV-C LED at 350mA has maintained an average performance output of 79.3%. This preliminary test data is extrapolated based on the TM-21 model and predicts an estimated lifetime of more than 10,000 hours.

CrayoNano says that this unprecedented lifetime in a small-footprint, high-power-density UV-C LED will enable solutions in challenging applications requiring better performance and where maintenance is difficult — reducing customers' total cost of ownership. The firm adds that the corroborated data reinforce its customers' confidence in CrayoLED quality, robustness and reliability for an efficient design-in and product qualification processes. The CrayoLED is available immediately from stock for sampling and volume quantities.

"We have taken great care in creating the CrayoLED —optimizing our LED package design and assembly technology using higher-quality materials, combined with our understanding of the thermal efficiencies and performance of LEDs," says chief product officer Alejandro Basauri.

The CrayoLED is a high-power UV-C LED with compact footprint, offering what is claimed to be the highest power density with a 10,000 hour lifetime. It is optimized for disinfection with a typical peak wavelength of 275nm. Its small package footprint (3.5mm x 3.5mm) and high-power performance (typical 80mW optical power at 350mA) easily integrates into systems for residential, commercial and industrial segments, enabling system miniaturization and longer-lasting solutions.

CrayoNano says that it will continue testing until the results have reached 6000 hours to complete the TM-21 testing criteria. "Quality and reliability are key factors for solutions towards automated disinfection solutions," notes Basauri.

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

www.crayonano.com/uvc-led

ITRI introduces high-resolution full-color micro-LED display for AR glasses

Heterogeneous integration of μLED, CMOS, QD color conversion layers

Taiwan's Industrial Technology Research Institute (ITRI) has introduced the High Resolution Full-Color Micro-LED Display for AR Glasses, which aims to assist panel makers and other industry players to upgrade their technology, expand their micro-LED applications, meet market demand and secure business opportunities in next-generation augmented reality (AR) display products for immersive experiences in the metaverse.

The High Resolution Full-Color Micro LED Display for AR Glasses has four key features:

- High resolution (>2000PPI), suitable for AR applications.
- High brightness (>20,000nits), 10 times higher than the smart glasses currently on the market and hence usable in outdoor scenarios, meeting the brightness requirements of the existing plug-in side-projection AR light machines and potentially surpassing the performance of counterpart displays such as OLED-based designs.
- Compatibility (<0.5-inch), the display and sensor functions are integrated in a compact design, giving a slim look.
- Low power consumption (<1W), by consuming less than half the energy of conventional smart glasses, the device can be worn for long hours without recharging.

The design adopts heterogeneous integration technology similar to semiconductor processes to create micro-displays with wide color gamut by bringing together micro-LED, CMOS silicon and quantum-dot color conversion layers within a single panel.

Global availability for technology transfer

The High Resolution Full-Color Micro LED Display for AR Glasses is sold as system-oriented industry integration and fabrication platform services, and is available globally for transfer.

"ITRI's High Resolution Full-Color Micro LED Display for AR Glasses has high commercial value and can enhance user experience due to its high resolution, high brightness, device compatibility, compact size and low power consumption," says Dr Shih-Chieh Chang, general director of ITRI's Electronic and Optoelectronic System Research Laboratories. "This high-resolution micro-LED will help leading global display players to capitalize on the vast range of emerging micro-LED applications," he adds. "ITRI has assisted manufacturers in pilot production and technology transfers, which have laid the foundation for developing in-vehicle displays and next-gen XR glasses."

Micro-LED Alliance

To introduce its micro-LED technology into augmented reality applications and deliver it from lab to market, ITRI founded an alliance in 2016 to integrate the industry chain horizontally. The alliance connects about 50 industry chain suppliers in advanced materials, semiconductor processes, and precision equipment. It provides comprehensive upstream to downstream solutions to fulfill industry needs for the various stages of verification, development, and IP licensing.

Micro-LED applications

Micro-LEDs are attracting attention for wearable electronics, lighting and biomedicine because of their high efficiency, small form factor, and low power consumption. Wearable micro-LED displays have thin, lightweight and unbreakable features, enabling the application of displays on curvilinear surfaces. Good color purity and high brightness with low power consumption, high-resolution quantum-dot (QD) array patterning, and ultrathin and ultrasmall form factors make QD-based micro-LEDs promising for flexible and wearable electronics. Micro-LEDs are suitable for advanced display applications such as smartphones, wearable watches, micro-projectors, AR/MR displays, automotive heads-up displays, ultra-high-definition (UHD) (>4K resolution) televisions, and large-scale monitors including outdoor TVs, sports and advertisement signage.

Micro-LED manufacturing process

The manufacturing process for the High Resolution Full-Color Micro-LED Display for AR Glasses requires semiconductor-grade device processing, micron-grade accuracy of assembly and a highly accurate yet rapid testing methodology. These steps usually require an upgrade or improvement in equipment, operation, logistics, materials and training.

The micro-LED display manufacturing process differs from the traditional LED manufacturing process in requiring a high-efficiency micron-grade LED process and heterogeneous bonding technology with high precision and high resolution on an active backplane. The overall process requires additional semiconductor processes such as high-precision photolithography, chemical-mechanical planarization (CMP), plating and high-precision alignment wafer bonding. Compared with the Class 1000 cleanroom processing used by traditional LEDs, a micro-LED lab needs a Class 10 cleanroom to heterogeneously integrate all components without concerns for particle contamination.

www.itri.org.tw/eng

MICLEDI Microdisplays forms US subsidiary

MICLEDI USA in Chandler, Arizona to support key personnel

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 nanoelectronics research center IMEC in 2019 – has established a US subsidiary, located at 2820 S. Alma School Rd, in Chandler, Arizona.

"Most of our target customers have locations in the Western US or Asia, and have expressed interest in having our customer-facing support closer to them," says CEO Sean Lord. "MICLEDI USA was formed in anticipation of expanding our presence in the US and Asia." MICLEDI USA is a Delaware Corporation, formed in December 2021.

While MICLEDI has operated in the US for almost two years, the new headquarters provides a stateside location to support key personnel. "Corporate headquarters functions, R&D, process development, and operations will continue in Leuven, Belgium, where we work closely with IMEC as a partner in technology and process development," says Lord.

MICLEDI says that its new US headquarters was formed in response to customer interest in its unique expertise in micro-LEDs for AR headsets. Customer engagement has been favourable, it adds, with many tier-1 OEMs evaluating early samples of the company's blue and green micro-LED arrays.

"We are excited to take this next step to opening the door for greater levels of collaboration with customers and partners in the US and Asia," says Seonaidh MacDonald, chairman of the board. "The team has been very effective as a Belgian start-up since its inception in late 2019. This is a major step forward and should position us attractively for partners, customers and investors," he reckons.

At the Consumer Electronics Show (CES 2023) in Las Vegas (5–8 January), MICLEDI will be exhibiting in booth #54946 at the Venetian Expo.

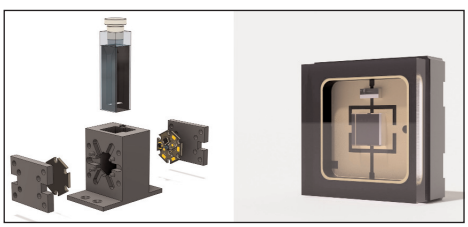
www.ces.tech
www.micledi.com

Silanna UV launches SF1 series of UV-C LEDs, highlighting nitrate sensing applications

Far UV-C and deep UV-C 230–260nm wavelength range targets detecting nitrate contamination in water

UV-C LED maker Silanna UV of Brisbane, Australia says that its newly developed ultraviolet LEDs for nitrate sensing applications promise cleaner and safer drinking water free from nitrate contamination. The SF1 series of LEDs leverage the firm's patented short-period superlattice (SPSL) technology for the challenging 230–260nm UV range (far UV-C and deep UV-C). Silanna now provides a complete reference design for a nitrate detector based on this technology.

Nitrate contamination of drinking water is a growing threat around the world, with nitrates from agricultural, industrial and natural biological processes increasingly contaminating water supplies as populations grow and expand. Detection of nitrates traditionally relied on an expensive process in which broadband light generated by a UV lamp is passed through spectroscopy to extract the far UV-C wavelength needed for sensing.



Silanna says its SF1 series of LEDs can provide a far more cost-effective, compact, reliable, low-power alternative to traditional methods of nitrate detection. In particular, SF1 series UV-C emitters with a peak wavelength under 235nm and a full-width half-maximum (FWHM) of 10nm are an ideal candidate for nitrate sensing applications, the firm claims.

As well as nitrate detection, Silanna's SF1 and SN3 UV LEDs are also suitable for sterilization, water and gas sensing, instrumentation, and medical analyzers.

Nitrate sensor reference design

To help users evaluate this new technology and develop products based on it, Silanna has created a nitrate sensing reference design featuring its SF1 series LEDs. This module rapidly and accurately measures the nitrate content of a liquid sample.

The microcontroller-based reference design features a capacitive touch display, safety interlock, and compensates for thermal effects to maintain accuracy and avoid warm-up delay. The UV-C LED package's built-in 30-degree parabolic lens eliminates the need for secondary optics, making the system even more compact and cost effective. The module requires less than a second to make a measurement (not only saving time but also extending component lifetime to over 100,000 measurements) and the concentration of the nitrate is measured at a resolution of 0.01mg/L-N according to estimates.

www.silannauv.com

Asahi Kasei demonstrates Crystal IS UVC LED-based water disinfection

Water treatment reactor achieves 75% higher performance than mercury lamp system

Tokyo-based Asahi Kasei and its subsidiary Crystal IS Inc of Green Island, NY, USA, which makes proprietary ultraviolet light-emitting diodes (UVC LEDs), have concluded in a bacterial performance test that an experimental Klaran WR water treatment reactor demonstrated over 75% higher performance than a traditional low pressure mercury lamp system using an equivalent power consumption level.

Klaran WR is an inline point-of-use (PoU) water treatment reactor (see Figure 1, left) that combines Crystal IS' UVC LEDs based on aluminium nitride (AlN) substrates (Figure 1, right) with Asahi Kasei's R&D capability in the design and application of optics and fluid dynamics.

While conventional UV water treatment systems have used mercury lamps as a light source, nations around the world have adopted stricter regulations after the Minamata Convention on Mercury became effective in 2017, due to the hazards that mercury poses to health and the environment. UVC LEDs have been developed as a mercury-free light source featuring small size, light weight and flexibility in design. A key milestone speeding the transition to this light source is demonstrating that the disinfection performance, power efficiency and value of LED technology can fully meet or exceed the incumbent mercury lamp.

While it is widely understood and accepted that UVC LED's instant on-off capability offers a significant advantage and better alignment with actual consumer use than an 'always on' mercury lamp system, a question remained whether an equivalent-powered LED system could demonstrate equivalent disinfection performance as a low-pressure mercury lamp system.

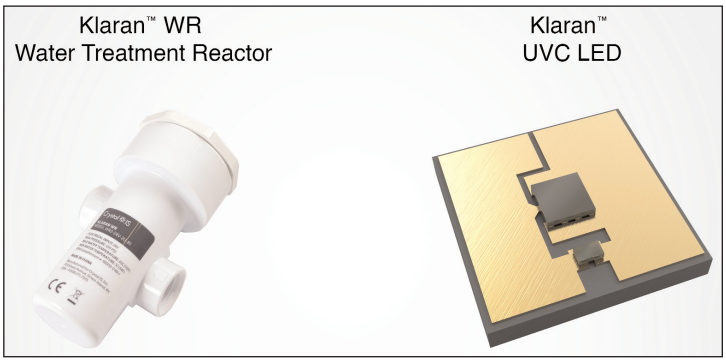


Figure 1. Klaran WR is an inline point-of-use (PoU) water treatment reactor (left) which combines Crystal IS' UVC LEDs based on aluminium nitride (AlN) substrates (right), with Asahi Kasei's R&D capability in the design and application of optics and fluid-dynamics.

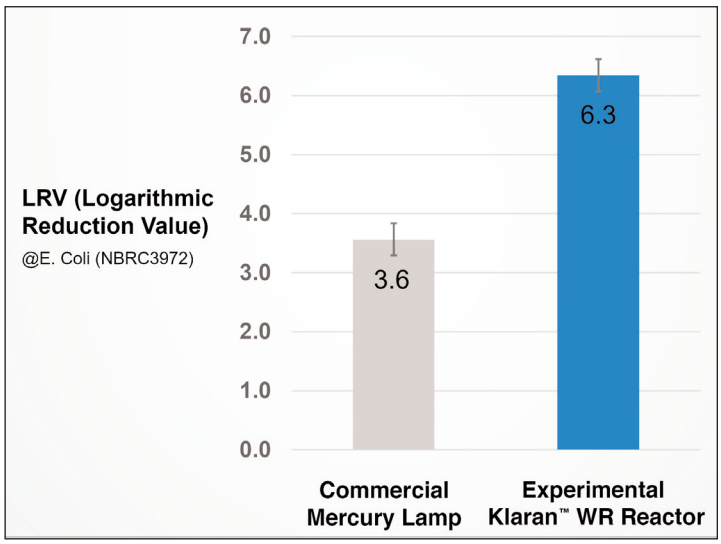


Figure 2. Disinfection performance of the mercury lamp system (left) and the experimental Klaran WR (right).

The experimental Klaran WR reactor was developed to demonstrate that UVC LEDs can achieve this.

A standard Klaran WR was enhanced and modified to operate with the same power consumption level (6W) as a comparable mercury lamp system. Both systems were tested using water at a flow rate of 8 liters per minute (2.1 gallons per minute), with a UV transmittance of 97% at 265nm and dosed with the addition of about 106CFU/mL of E. coli (a common gram-negative, facultative anaerobic, rod-shaped bacteria) for testing. As there is no established testing method for this type of comparison, Asahi Kasei devised the testing method and contracted an independent laboratory to perform the evaluation. Water quality samples recorded after 2 minutes steady operation with both systems were compared (Figure 2), demonstrating how the Klaran WR had over 2 LRV (logarithmic reduction value) better performance than the mercury lamp system, i.e. the Klaran WR system reduced E. Coli in the water to 1/100 of the level of the water disinfected by the mercury lamp system.

Asahi Kasei believes that, by replacing mercury lamps in water treatment systems with Crystal IS UVC LEDs, it can contribute to the realization of a mercury-free world and meet the global need for energy efficiency and safer water. In addition to water treatment systems, Crystal IS aims to apply the advantages of UVC LEDs to expand their application to surface and air disinfection.

www.asahi-kasei.com
www.cisuvc.com/products/klaran

Lumileds adds 14 new 80 and 90CRI 3V parts to LUXEON 2835 Commercial range

Now over 150 LUXEON 2835 LEDs in white and 21 in direct and phosphor-converted colors

LED product and lighting maker Lumileds of San Jose, CA, USA has added to its LUXEON 2835 Commercial portfolio of LEDs by releasing 14 new 3V parts that deliver higher flux and efficacy to enable rapid upgrading of existing solutions and design of new lighting solutions.

The new parts are available in all standard correlated color temperatures (CCTs) from 2700K to 6500K. Currently, Lumileds offers over 150 different LUXEON 2835 LEDs in white across CCTs of 1800K to 6500K and color rendering indexes (CRIs) of 70–95 — all at various light output and efficacy levels selected to address the needs of a broad customer base. Also, Lumileds' 2835 portfolio includes 21 color LEDs including direct and phosphor-converted options.

For the latest 14-part expansion, 0.2V voltage bins and 3- and 5-step simplify system design. Reliability is proven through extensive testing including high-temperature operating life, moisture high-temperature operation life, powered temperature cycle test, A-A thermal shock, temperature cycle, and power switching. "We believe LUXEON 2835 to be the most reliable LED in its class available today," says Lumileds.

"Each year, LUXEON 2835 Architectural, Commercial and Color LEDs are some of the highest-volume products, in part because we continuously develop options based on our customers' specific needs and objectives in the professional and consumer lighting segments," says product manager Ryan Dong. "This allows us to engineer 2835 LEDs that deliver superb in-application price-to-performance results and offer unmatched reliability for in-market end-customer satisfaction."

www.lumileds.com/products/mid-power-leds/luxeon-2835-commercial

Kyocera develops smallest GaN laser chip mass produced from silicon substrate

New process creates functioning 100μm-long micro-light sources with higher yield, lower cost

Kyocera Corp of Kyoto, Japan has developed a new thin-film process technology for making unique silicon substrates for gallium nitride (GaN)-based micro-light sources (with a side measuring less than 100μm), including short-cavity lasers and micro-LEDs.

Because they offer key performance advantages such as higher definition, smaller size and lighter weight, micro-light sources are considered to be essential to next-generation automotive displays, wearable smart glasses, communication equipment, and medical devices. TrendForce forecasts that the market for micro-LED chips alone will rise at a compounded annual growth rate (CAGR) of about 241% to $2.7bn by 2026.

Technical challenges in making micro-light sources

GaN-based light-source devices, both micro-LED and laser, have typically been fabricated on sapphire and GaN substrates. Conventional processes involve forming a thin GaN device layer for the light source directly onto the sapphire substrate by heating it to a high temperature (1000°C or more) in a controlled gas atmosphere. The device layer has to be then removed (peeled) from the substrate to create a GaN-based micro-light source device. Despite rising demand for smaller devices, however, three separate challenges threaten the ability of this process to achieve miniaturization targets in the near future:

1. Difficulty in peeling the device layer

In case of micro-LEDs, existing processes require difficult steps to divide the device layer into individual light sources on the substrate; and then, to separate the device layer from the substrate. As devices become smaller, the technical challenge of this peeling process can result in unacceptably low yield.

2. High defect density, inconsistent quality

Fabrication of micro-light sources is also problematic because device layers must be deposited onto sapphire, silicon, or other materials with crystal structures that differ from that of the device layer. This creates high defect density and inherent quality-control challenges.

3. High manufacturing costs

GaN and sapphire substrates are very expensive. Although silicon substrates cost less than sapphire, separating the device layer from a silicon substrate is extremely difficult.

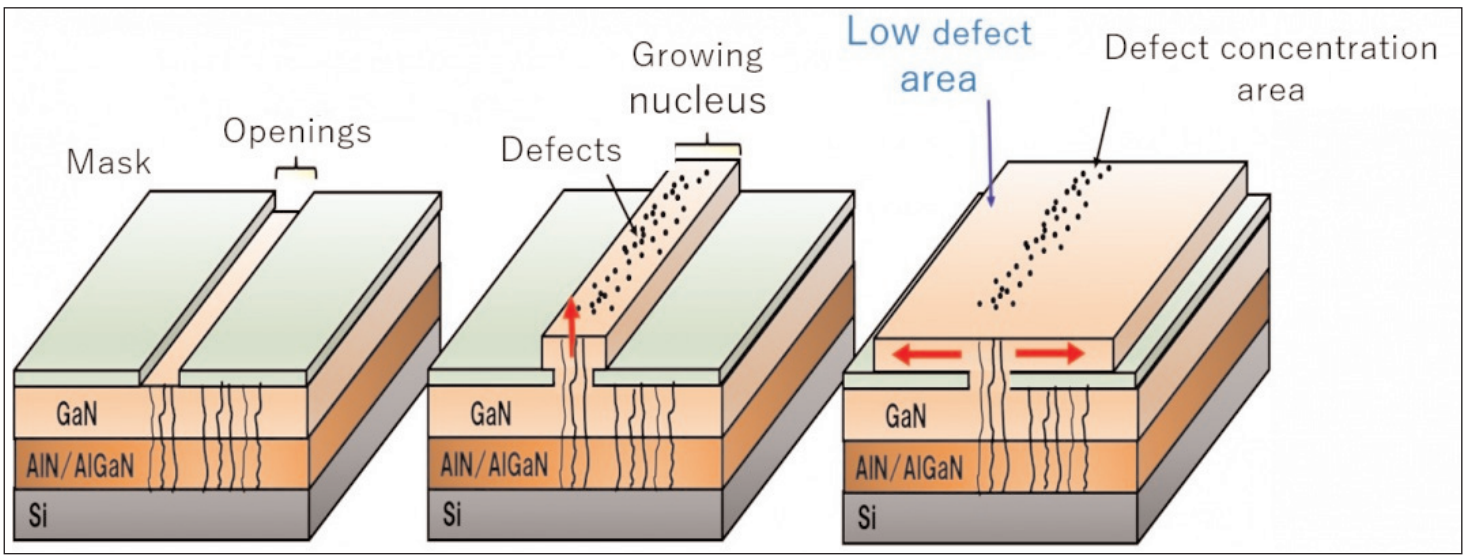
New process developed by Kyocera

Kyocera has developed the new process technology at its Research Institute for Advanced Materials and Devices in Kyoto. First, it grows a GaN layer on silicon substrate, which is available in high volumes at a low cost. The GaN layer is then masked with a non-growing material that features an opening in the center. After this, when a GaN layer is formed on the silicon substrate, GaN nuclei grow over the opening in the mask. The GaN layer, which is a growing nucleus, has many defects at the initial stage of growth; but, by forming the GaN layer laterally, high-quality GaN layers with low defect density can be created, and devices can be fabricated successfully from this low-defect region of the GaN layer.

Kyocera lists advantages of the new process as:

● *Easier peeling of the GaN device layer*

Masking the GaN layer with a material that does not grow suppresses bonding between the silicon substrate and the GaN layer, greatly ►



simplifying the peeling process.

● *High-quality GaN device layers with low defect density*

Since Kyocera's process can deposit low-defect GaN over a wider area than before, consistent fabrication of high-quality device layers is possible.

● *Lower manufacturing costs*

Kyocera's new method facilitates successful and reliable separation of the GaN device layer from the relatively inexpensive Si substrate, which will greatly reduce manufacturing costs.

Applications of micro-light sources are listed as:

● *Next-generation automotive transparent displays*

In the future, the advent of autonomous driving will create demand for displays that are brighter, higher-definition, power-efficient, more highly transparent, and lower cost.

● *Micro-light sources for AR/VR*

The market for micro-light sources used in augmented reality (AR) and virtual reality (VR) is expected to expand rapidly. Smart glasses and other products are being developed to facilitate the creation of virtual spaces through the metaverse in VR and 'de-smartphoning' in AR. While conventional semiconductor lasers for AR have been miniaturized to as small as 300μm in length, Kyocera says that it is first to achieve a size of just 100μm. This was achieved by developing a completely new production process that is an evolution of the cleaving method, says the firm. This so'novel cleaving method' results in a size reduction of about 67% and helps to minimize power consumption. Semiconductor lasers with lower power consumption make it possible to reduce the size and weight of the battery, thus improving fit.

Kyocera says that it will offer a wide range of platform, substrate and process technologies to bring high-quality, low-cost micro-light sources to market in the near future, as it aims to transform next-generation display and laser markets using the new platform.

www.kyocera-sldlaser.com

UCSB's Steven DenBaars and Jonathan Klamkin honored by Optica

DenBaars made Fellow for "leadership and pioneering contributions to GaN-based materials and devices for solid-state lighting & displays"

University of California Santa Barbara (UCSB) College of Engineering professors Steven DenBaars and Jonathan Klamkin are among the 109 members from 24 countries who have been elected to the 2023 Fellow Class of Optica (the society advancing optics and photonics worldwide), formerly known as the Optical Society (OSA). Fellows are selected based on several factors, including outstanding contributions to business, education, research, engineering and service to Optica and the field.

"Congratulations to professors Steven DenBaars and Jonathan Klamkin," says Tresa Pollock, interim dean of UCSB's College of Engineering and Alcoa Distinguished Professor of Materials. "This prestigious and well-deserved recognition from their peers reflects their work to advance the field of optics and photonics and contribute to the next generation of energy-efficient technology."

DenBaars, a distinguished professor in the Materials and Electrical and Computer Engineering (ECE) Departments, was recognized for his "leadership and pioneering contributions to gallium nitride (GaN)-based materials and devices for solid-state lighting and displays". Since joining the faculty at UCSB in 1991, DenBaars has helped to pioneer the field of solid-state lighting, establishing and improving GaN materials and devices used for lighting and displays. His specific research interests include growth of wide-bandgap semiconductors and their application to blue light-emitting diodes (LEDs) and lasers, and high-power electronic devices.

Professors Steven DenBaars (left) and Jonathan Klamkin (right).

An elected member of the National Academy of Engineering, DenBaars is also a fellow of the National Academy of Inventors and the Institute of Electrical and Electronics Engineers (IEEE).

Klamkin was recognized for his "major contributions to integrated microwave photonics and photonic ICs, particularly integrated optical beam forming networks". Klamkin's research areas of focus include: integrated photonics; silicon photonics; optical communications; nanophotonics; microwave photonics; compound semiconductors; photonic integration techniques; and electronic-photonic integration. His previous honors include the Young Investigator Award, US Defense Advanced Research Projects Agency (DARPA); Director's Fellowship, DARPA; Early Career Faculty Award, NASA; and the Young Scientist Award, Photonics and Electromagnetics Research Symposium (PIERS).

http://ssleec.ucsb.edu

www.optica.org

Ganvix partners with BluGlass to develop green gallium nitride VCSELs

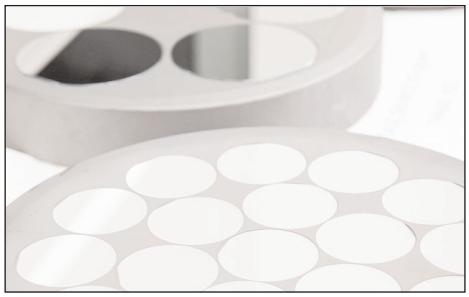
BluGlass' RPCVD complements Ganvix's DBR technology

BluGlass Ltd of Silverwater, Australia has entered into a collaboration agreement with early-stage startup company Ganvix Inc of Wilmington, DE, USA — which specializes in developing nanoporous gallium nitride (GaN) vertical-cavity surface-emitting lasers (VCSELs) – to develop GaN VCSELs for green wavelengths (515–525nm).

Surface-emitting lasers require distributed Bragg mirrors (DBRs) to enable their unique properties and, while highly successful in other materials, have been prohibitively difficult to fabricate in GaN.

Under the paid development agreement, BluGlass will provide Ganvix with green quantum well epitaxy services using its proprietary remote-plasma chemical vapor deposition (RPCVD) technology, which is said to offer key performance advantages for green wavelengths, enabling higher-power, brighter green performance. RPCVD complements Ganvix's DBR technology for GaN VCSELs.

Green GaN VCSELs have broad



market applications including consumer electronics, industrial, medical, life sciences, light engines for laser scanning displays, and laser arrays for fiber-based communications.

"The advantages of BluGlass' low-temperature RPCVD technology provides significant commercial benefits for longer-wavelength lasers, including green," says BluGlass' president Jim Haden. "Our unique low-temperature, low-hydrogen growth technology enables brighter, higher-performing green quantum wells — the key light emitting region in lasers. This collaboration highlights the significant competitive advantages of RPCVD, which transform how GaN lasers are made to improve performance," he adds. "Our collaboration with Ganvix will advance our RPCVD roadmaps and expands our market opportunity. Importantly, the collaboration complements our own product and commercialization roadmap, which is focused on edge-emitting laser diodes."

"This significant collaboration to combine nanoporous VCSEL architecture with BluGlass' unique RPCVD technology provides a path to bring green GaN VCSELs to market," says Ganvix's CEO John Fijol. "There are many high-growth markets for this exciting technology, including advanced applications such as augmented and virtual reality headsets, pico-projectors, and 5G wireless communications."

During the initial development phases BluGlass will receive payment for services, which it does not consider material. On successful commercialization, BluGlass expects to receive material revenues from ongoing orders.

www.bluglass.com.au

Vector fast-tracks PCSEL commercialization with all-Scottish prototype supply chain

Vector Photonics Ltd of Glasgow, UK says that it is commercializing its all-semiconductor photonic-crystal surface-emitting lasers (PCSELs) using a prototype supply chain based entirely in Scotland's photonics cluster (a capability claimed to be unique in the industry).

Each step of the supply chain is provided by a Scottish company that is established, profitable, independent and competing successfully in their own respective vertical markets. Also, each firm is a member of Technology Scotland, the industry association representing Scotland's wider enabling technologies sectors.

"Prototype compound semiconductor lasers can be made entirely within the Scottish photonics cluster. This capability was identified by Vector Photonics whilst commercializing their PCSEL technology," notes Technology Scotland's CEO Dr Alastair McInroy, who visited Vector Photonics recently to discuss the supply chain capability further.

"The prototype supply chain provides epitaxy; front-end processing; resist, e-beam, etch and clean; overgrowth; post-overgrowth processing; back-end-of-line; and packaging – all from companies in Scotland's central belt," says Vector Photonics' sales & marketing director Euan Livingston.

"All the companies in the supply chain are Technology Scotland members so, on their behalf, we are keen to raise awareness of this unique capability to government," says McInroy. "Strategic funding and investment could enable the collaboration necessary to develop alpha and beta supply chains, with both individual and collective company benefits. Scotland's place as a world-leader in compound semiconductor laser development and production would be secured, with high gross value-added (GVA) jobs created and wider positive implications for Scottish GDP."

www.vectorphotonics.co.uk

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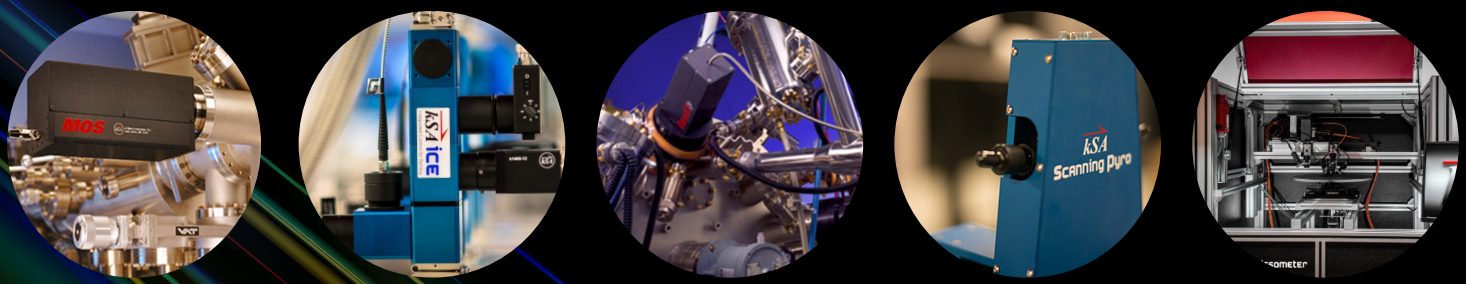

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Antimonide LiDAR sensor start-up Phlux gains £4m

High-performance infrared sensor designer Phlux Technology has secured £4m in a seed funding round led by Octopus Ventures and joined by Northern Gritstone, the Foresight Williams Technology Funds and the Innovation Fund, plus UK Government agency Innovate UK (which, as part of UK Research and Innovation, provides funding and support for business innovation).

A spin-out of Sheffield University, Phlux has used its in-depth research into semi-metal element antimony to develop what it says is a unique, patented approach to infrared sensors to dramatically improve their performance in light detection & ranging (LiDAR) systems. The new architecture is 10x more sensitive and with 50% more range compared with equivalent sensors, reducing the cost of manufacture of LiDAR sensors and opening up mass-market adoption, it is reckoned.

"This innovative breakthrough is critical to the future direction of transport, communication and emission monitoring systems," comments Amy Nommeots-Nomm, deep-tech investor, Octopus Ventures. "Today, there is market consolidation among the silicon-based sensor companies, precisely because they can't solve the problem that Phlux has cracked, making its potential hugely exciting."

According to the Compound Semiconductor Applications Catapult, the UK compound semiconductor market was worth about $8bn in 2020 and will grow to $11bn in 2024 (about 8% of the global market). techUK highlights the country's strength in semiconductor design and intellectual property (IP), with 110 design firms based in the UK. Phlux is based in Sheffield, a center of III–V semiconductor research, with research and facilities at Sheffield University, and The National Epitaxy Facility, which was awarded £12m in funding from UK Research and Innovation (UKRI).

"The company's innovative approach demonstrates how world-beating technology, with the potential to change entire industries, is emerging from the Sheffield, Leeds and Manchester triangle," comments Northern Gritstone's CEO Duncan Johnson. "Northern Gritstone exists to support and supercharge businesses like Phlux."

Infrared sensors, such as those that Phlux is designing, have applications beyond LiDAR in satellite communications and enabling internet in remote regions, fiber telecoms, autonomous vehicles, gas sensing and quantum communications. Phlux was recently awarded an Innovate UK project with QLM, developing sensors for a single-photon LiDAR-based camera that monitors greenhouse-gas emissions. "Climate control requires very large-scale deployment of monitoring solutions, which demands low-cost technology and complete supply chain control of critical components such as sensors," says QLM's CEO Murray Reed. "Phlux's technology is particularly exciting as it offers a higher-performing alternative to the current approach and opens up a new UK supplier with significant potential for us."

Overcoming the limitations of silicon-based sensors

Phlux was founded by CEO Ben White, professor Jo Shien Ng and professor Chee Hing Tan, who met at Sheffield University where they researched novel semiconductor materials and devices for infrared detection. Existing infrared sensors based on indium gallium arsenide (InGaAs) have reached a plateau in terms of performance. Having studied alternatives for more than 10 years, the founders identified antimony as a material capable of revolutionizing the LiDAR sensor market. It opens access to the 1550nm infrared space, offering higher sensitivity and capacity as it operates in the 'eye safe' region of the electromagnetic spectrum. Well over 1000 times more photons can safely be launched compared with silicon-compatible emitters, enabling antimony-based sensors to see further, with greater pixel density at a mass-market cost, it is reckoned.

"Our ambition is to become the Nvidia of the infrared sensor market, starting off with delivering the world's first LiDAR receiver chip using antimony," says CEO & co-founder Ben White. "Industry will never achieve full autonomy with LiDAR if it relies on silicon-based sensors, so our approach will reshape the sensor market for robotics and self-driving machines," he adds. "We are delighted to be spinning Phlux out of Sheffield University at a time when it has ambitious plans to become a global center of excellence for semiconductor research."

In the first stage of commercialization Phlux has developed a single-element sensor with what's claimed to be world-leading sensitivity that is retrofittable into today's LiDAR systems and will be part of the Phyllo series product line. Longer term, Phlux is building an integrated subsystem and array modules forming a high-performance sensor toolkit and, over the next year, it will grow its engineering team in areas such as fabrication, mixed-signal circuit design, optics and testing.

"Increasing sensor performance whilst driving down cost are key enablers for accelerating the uptake of higher levels of driving automation and, with this seed funding, we look forward to seeing Phlux's sensor technology transition to full commercialization," comments Matthew Burke, head of technology ventures at Williams Advanced Engineering.

"Phlux's innovative technology has the potential to become the prevailing standard in the automotive LiDAR systems," believes Christopher Wiles, investment director at Foresight Williams Technology Funds. "We look forward to supporting its entrepreneurial team as they deliver on this ambition."

www.phluxtechnology.com

Scantinel raises €10m in Series A funding

Funds to be used to roll out FMCW LiDAR devices for AVs and industry

Scantinel Photonics GmbH of Ulm, Germany, which was founded in 2019 and is developing frequency-modulated continuous wave (FMCW) sensing technology for light detection & ranging (LiDAR) solutions in autonomous mobility and industrial applications, has secured a €10m extended Series A round of funding backed by PhotonDelta and existing investors Scania Growth Capital and ZEISS Ventures. Scantinel will use the funding to roll out its FMCW LiDAR devices to customers.

LiDAR has more accuracy and precision in detecting objects and mapping than other solutions such as radar and RGB cameras. It is also more immune to interference. This makes it suitable for enabling autonomous driving, as well as in logistics — such as conveyor belts and autonomous cranes. However, LiDAR devices have previously been too large, expensive or difficult to produce to be practical alternatives.

By using photonic chips, Scantinel has developed its FMCW LiDAR solution, which has the power, affordability and mass production scalability to enable LiDAR to have broad application across industry and mobility. The technology delivers a detection range beyond 300m with superior resolution and solid-state scanning. Scantinel has signed a number of partnership agreements with major global automotive, mobility and industrial companies.

The investment by Netherlands-based PhotonDelta marks another step in its mission to build a European photonics ecosystem that researches, designs, develops and manufactures solutions with integrated photonics technology. In April, PhotonDelta secured €1.1bn in public and private investment to scale up production, build 200 startups, create new applications for photonic chips, and develop infrastructure and talent.

"Photonic chips are a next-generation chip technology which will bring new innovations like FMCW LiDAR on chip to life," comments PhotonDelta's CEO Ewit Roos. "We see the investment in Scantinel as a perfect fit to grow and strengthen our photonics ecosystem," he adds.

"We are looking forward to maximizing the collaborations and benefits from PhotonDelta's leading integrated photonics ecosystem," comments Andy Zott, managing director & co-founder of Scantinel.

"The investments from our existing investors ZEISS Ventures and Scania Growth Capital, along with our new investor PhotonDelta, will accelerate our product development together with our customers and partners," says Dr Michael Richter, managing director of Scantinel.

Since they integrate photonic functions into microchips to create smaller, faster and more energy-efficient devices, photonic integrated circuits (PICs) can sense, process and transmit data much more effectively than their electronic counterparts. As with traditional chips, the production process is carried out using automatic wafer-scale technology, allowing the chips to be mass-produced and hence reducing costs. Crucially, PICs can overcome the expected limit to Moore's Law and will also help to tackle energy sustainability issues.

The biggest challenge in the automotive sector in the near future lies in the availability of affordable sensors to enable autonomous driving at various stages. With the advantages of photonic chips (weight, speed, cost), the possibilities for self-driving transport are increasing. This has positive implications for road safety and lost travel time is made available again, notes Scantinel. Photonics can also mean a lot for battery management in electric vehicles and the control of traditional cars. For the aircraft industry, the emphasis is on sensor systems, adds Scantinel.

www.scantinel.com

Emcore announces sale & leaseback of Tinley Park plant

Emcore Corp of Alhambra, CA, USA — which provides mixed-signal products for aerospace & defense, communications and sensing markets — says that, following a purchase and sale agreement entered into on 1 November, it has completed the sale and leaseback of its Tinley Park, IL facility, generating $10.3m in net cash proceeds.

Emcore has vertically integrated manufacturing capability at its facilities in Alhambra, CA, Budd Lake, NJ, Concord, CA, and Tinley Park, IL. The firm leverages photonic integrated circuit (PIC), quartz MEMS, lithium niobate, and indium phosphide chip-level technology to deliver component- and system-level products across its end-market applications including navigation and inertial sensing, defense optoelectronics, broadband communications, optical sensing, and specialty chips for telecoms and data centers.

On 11 August, Emcore announced the acquisition of the Fiber Optic Gyroscope (FOG) and Inertial Navigation Systems business segment of KVH Industries Inc, including all its intellectual property and outstanding assets and liabilities, and the 100,384ft^2 production facility in Tinley Park. The EBITDA-positive acquisition adds a new business generating over $30m in revenue on an annual basis (with an established customer base in the Army and a variety of terrestrial applications, while opening up new opportunities in the growing industrial autonomy market). Synergies are anticipated for the next two years.

www.emcore.com

National Grid Renewables orders 1.6GW of First Solar modules, for delivery in 2026–2027

Order follows June's 2GW order, raising total to over 4GW

First Solar Inc of Tempe, AZ, USA has entered into an agreement to supply 1.6GW$_{DC}$ of its Series 7 cadmium telluride (CdTe) thin-film photovoltaic (PV) modules to Minneapolis-based National Grid Renewables, for delivery in 2026 and 2027. The deal was booked prior to the release of First Solar's third-quarter 2022 earnings in October.

The latest order expands First Solar's relationship with National Grid Renewables to over 4GW$_{DC}$, with an earlier agreement for 2GW$_{DC}$ of modules announced in June. National Grid Renewables and First Solar have also partnered on multiple projects over a decade-long relationship that includes the 200MW Prairie Wolf Solar Project in Illinois and the Noble Solar (275MW) and Storage (125MWh) Project in Texas.

National Grid Renewables is part of the Ventures division of National Grid plc and has a portfolio of large-scale renewable energy assets including solar, wind and energy storage projects located throughout the USA in various stages of development, construction and operation.

Developed in close collaboration with engineering, procurement & construction (EPC) companies, and structure and component providers, First Solar's Series 7 modules combine its CadTel technology with a larger form factor and a new back rail mounting system to deliver improved efficiency, enhanced installation velocity, and superior lifetime energy performance for US utility-scale PV projects.

"National Grid Renewables is an experienced developer and operator of large-scale solar projects, and its decision to invest in Series 7 is a testament to the track record of our CadTel platform, and its ability to enhance the competitiveness of solar assets," says First Solar's chief commercial officer Georges Antoun. "It is also a testament to our value proposition of providing our customers and partners with long-term supply certainty and lower political and compliance risks. This critical point of differentiation separates us from many of our competitors," he claims.

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are said to set industry benchmarks for quality, durability, reliability, design and environmental performance. The modules are claimed to have the lowest carbon and water footprint of any commercially available PV technology.

Additionally, First Solar's thin-film semiconductor, integrated manufacturing process and tightly controlled supply chain helps to eliminate the risk of exposure to solar supply chains identified by the US Department of Labor's 2022 List of Goods Produced by Child Labor or Forced Labor as being tainted by forced labor. First Solar is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain. The firm is also the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics.

As the only US-headquartered company among the world's largest solar manufacturers, First Solar is expanding its manufacturing capacity at home and abroad. In addition to a third factory under construction in Ohio, the firm recently announced that it is expanding its Ohio manufacturing footprint and establishing a new manufacturing facility (its fourth American manufacturing facility) in Alabama. These latest investments are expected to bring First Solar's total investment in American manufacturing to over $4bn, while its annual US manufacturing capacity is forecasted to expand to over 10GW$_{DC}$ by 2025. The firm also plans to invest about $270m in a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024, contingent upon permitting and pending approval of various state, regional and local incentives.

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Invitalia and Midsummer agree final terms for Italian CIGS PV factory start-up

Grants for €22m to contribute to €57.5m project

The Italian Ministry of Finance's state investment and economic development institution Invitalia has agreed the final contractual term sheet for grant payments supporting the factory investment by Midsummer AB of Järfälla, near Stockholm, Sweden – a provider of turnkey production lines as well as flexible, lightweight copper indium gallium diselenide (CIGS) thin-film solar panels for building-integrated photovoltaics (BIPV).

Midsummer will receive incentives of about €22m in the form of grants to start manufacturing thin-film solar panels for the global market. The production capacity at the factory in Bari (in the Puglia region) will be 50MW per year.

In the past 12 months, Midsummer has announced 75MW of Italian offtake agreements and recently 107MW of new offtake agreements with Swedish and international roof materials manufacturers and other players in the industry. Simultaneously, the factory is being prepared and equipped with machines from the parent company, recruitment of staff etc.

Midsummer's factory in Bari, Italy.

In the final term sheet, the project has been slightly modified with more focus on the manufacturing of end products and a slightly smaller budget for the R&D part of the project. The entire project is now set to be an investment of about €57.5m (slightly less than the original agreement), of which Midsummer will receive about 38.2% in grants (higher than the original agreement, which stated 35%). The grant amount of €22m (SEK240m) is in line with earlier statements.

After signing of the term sheet, the next step in the process is for Midsummer to hand in documentation for the costs incurred in the project so far, to facilitate the first grant payment from Invitalia. After receipt of Midsummer's verified expenses, the payments are normally made within 60 days.

www.midsummer.se

Midsummer signs four new LOIs for extra 224MW

Convertible bond issue to fund 20MW new factory in Järfälla then expansion to 200MW

Midsummer has signed new letters of intent (LOI) with four Swedish and international roof material producers, house manufacturers and solar cell installers for the pre-sale of 224MW of solar panels.

Previously, on 5 November, the firm announced the signing of LOIs with six Swedish and international industry players for a total of 107MW of solar panels. This brings the number of offtake agreements to ten in November for a collective 331MW.

Together with previously announced deals with three Italian roof and building companies for 15MW per year for five years (totaling 75MW), the cumulative number of offtake agreements is 13, with a combined volume of more than 400MW of solar panels.

"Many large industry players around Europe are lining up for our products as they see a big market for our discreet and sustainable thin-film panels," says CEO Sven Lindström. "It is our defined strategy to enter into these offtake agreements to ensure sale of our products parallel with us scaling up our production capacity."

The signed LOIs equate to 406MW of solar panels to be supplied in the coming 3–6 years, compared with the firm's annual production capacity of 2MW at the existing Swedish factory and 50MW at the Italian factory in Bari (due to enter production in 2023).

Midsummer also aims to establish a new factory in Järfälla, with an annual production capacity of 20MW initially and 200MW eventually. The long-term goal is an annual production capacity of at least 1000MW by 2030, which would require several new mega-factories around Europe.

Midsummer to raise more capital via convertible bond issue

Midsummer's board recently appointed DNB Markets as sole financial advisor to explore raising further capital through an issue of convertible bonds, in fourth-quarter 2022 at the earliest (subject to shareholder approval). Proceeds would be used to redeem the firm's outstanding SEK200m senior unsecured green bonds (ISIN: SE0012455772) maturing in April 2023, as well as to further expand production capacity and growth.

Midsummer also previously decided to review its capital structure and to arrange industrial and/or strategic investor meetings regarding a contemplated new share issue during Q4/2022, for the purpose of expanding its production capacity and working capital for its facility in Järfälla.

ZSW's perovskite-CIGS tandem solar module reaches 21%+ efficiency

Efficiency of 26.6% achieved in laboratory cells smaller than 9cm² prototype

Germany's ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung — or Center for Solar Energy and Hydrogen Research — Baden-Württemberg) has achieved 21.1% solar energy conversion efficiency with a tandem module comprising copper indium gallium diselenide (CIGS) and perovskite materials. Not only are these thin-film-based modules highly efficient, they can also be light and flexible. Modules made of lightweight, pliable materials open doors to many applications that remain closed to the standard rigid modules found in solar parks, says ZSW.

After decades of research, the efficiency of the prevailing silicon cells is approaching the practical limit of about 27%. As it stands, only tandem solar module technology promises further increases to well over 30%, through layering on top of each other different materials that absorb different wavelengths of the solar spectrum, collectively making better use of the width of the solar spectrum than a single solar cell.

Metal-organic perovskite materials holds great promise for tandem solar modules. "Some compounds in this class of materials exhibit excellent optical and electronic properties and are abundantly and inexpensively available on Earth," says Dr Jan-Philipp Becker, head of ZSW's Photovoltaics: Materials Research department. "With their high optical energy bandgap, compounds in the top solar module are able to use the high-energy range of the solar spectrum very efficiently. At the same time, they allow a considerable share of the spectrum's low-energy range to pass through to the bottom solar module."

Conventional silicon PV cells would appear to be the obvious choice for the bottom solar module. However, an even more interesting proposition is to use thin-film technologies exclusively. The bottom module can also be made of perovskite or of CIGS, which is the case in ZSW's module. CIGS is a mix of materials — copper, indium and gallium vapor-deposited onto a rigid or flexible substrate in a selenium atmosphere. The institute's experts and industry partners had developed this technology and ramped it up for mass production in earlier projects. CIGS's spectral absorption can be tailored to a perfect fit for the tandem composite.

This thin-film technology can also be deposited on plastic or steel films to make light, flexible modules that lend themselves to many more use cases. They can be installed the conventional way in solar parks and be seamlessly integrated into vehicles and on factory roofs that cannot handle heavy loads. It costs less to generate power with thin-film PV modules. For the other, PV production consumes less material and energy to leave a better environmental footprint

ZSW's prototype tandem solar module has an area of 9cm² and achieves 21.1% efficiency, and features a scalable component architecture suitable for industrial manufacturing. The best performance attained to date with tandem solar modules made of perovskite and CIGS is just slightly higher, at 22%. ZSW has already achieved efficiency of 26.6% with this combination of materials in smaller laboratory cells.

To achieve these values, the researchers first optimized the submodules. The top perovskite half-module must be not only highly efficient but also semi-transparent to allow enough light to pass through to the bottom module. Several improvements were hence made, including developing more transparent electrodes and enhancing the passivation of boundary layers.

The tandem structure as a whole in all prepared cells and modules outperformed individual cells or modules in terms of efficiency. ZSW now aims to further scale up and develop tandem thin-film technology in a joint effort with interested industry clients.

Tandem solar cells that pair perovskite with CIGS offer benefits beyond high efficiency. This thin-film technology can also be deposited on plastic or steel films to make light, flexible modules that lend themselves to many more use cases. They can be installed the conventional way in solar parks and be seamlessly integrated into vehicles and on factory roofs that cannot handle heavy loads.

Recent studies point to even more benefits. For one, it costs less to generate power with thin-film PV modules. For the other, PV production consumes less material and energy to leave a better environmental footprint.

ZSW partnered with the Karlsruhe Institute of Technology (KIT) in this research initiative, which was part of the recently completed CAPITANO project funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK).

www.zsw-bw.de

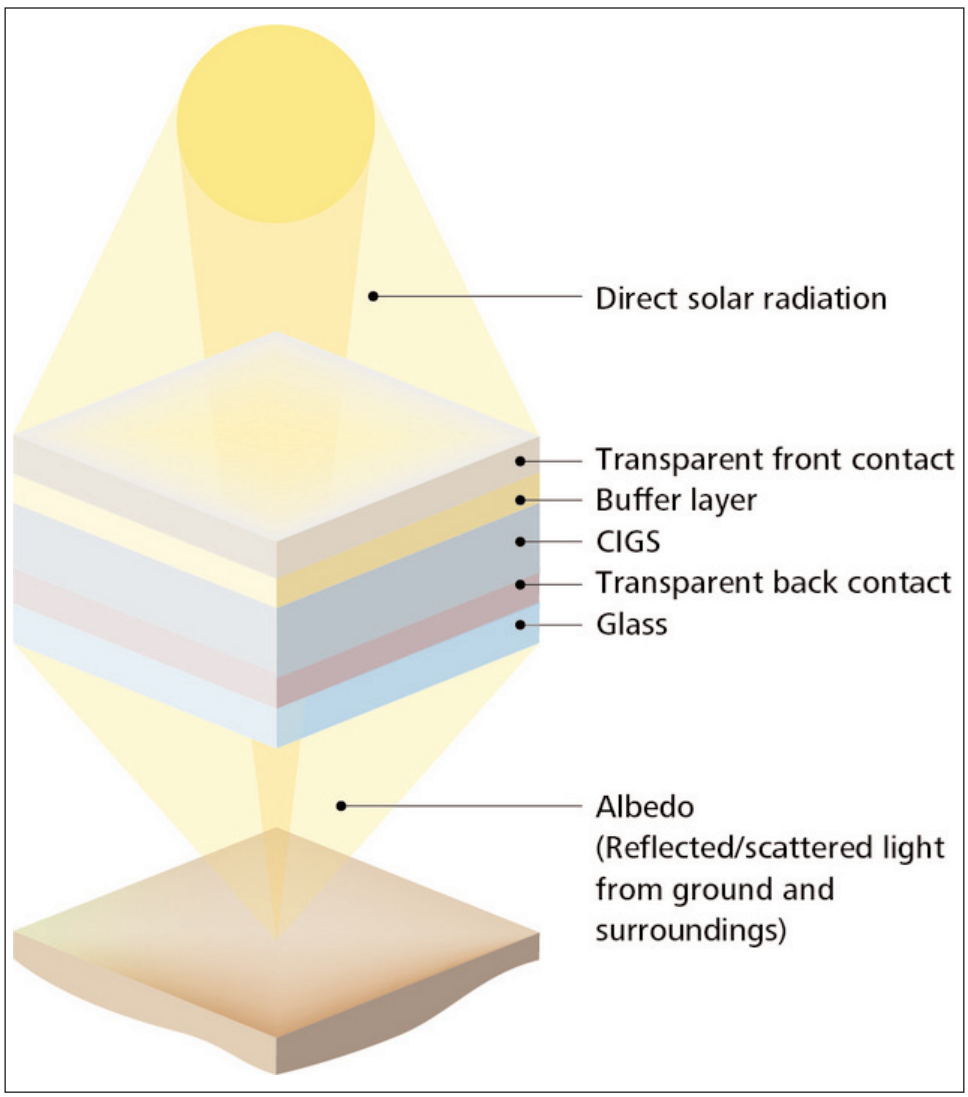
Empa achieves record efficiencies of 19.8% for front illumination and 10.9% for rear illumination in bifacial CIGS solar cell

Silver-assisted low-temp deposition process avoids formation of current-blocking gallium oxide at interface with transparent conductive oxide back contact

Bifacial thin-film solar cells based on copper indium gallium diselenide (CIGS) can collect solar energy from both their front side and their rear side – and thus potentially yield more solar electricity than their conventional counterparts. So far, however, their fabrication has led to only modest energy conversion efficiencies.

A team at the Swiss Federal Laboratories for Materials Science and Technology (Empa) has now developed a new low-temperature production process resulting in record efficiencies of 19.8% for front illumination and 10.9% for rear illumination. Moreover, they also produced the first bifacial perovskite-CIGS tandem solar cell, opening up the possibility of even higher energy yields in future (S-C Yang et al, 'Efficiency boost of bifacial Cu(In,Ga)Se_2 thin-film solar cells for flexible and tandem applications with silver-assisted low-temperature process', Nature Energy (2022); 21 November).

If both direct sunlight as well as its reflection (via the rear side of a solar cell) can be collected, this should increase the yield of energy that the cell produces. Potential applications are, for example, building-integrated photovoltaics (BIPVs), agrivoltaics – the simultaneous use of areas of land for both photovoltaic power generation and agriculture — and vertically or high-tilt installed solar modules on high-altitude ground. According to the International Technology Roadmap of Photovoltaics, bifacial solar cells could capture a market share of 70% of the overall photovoltaics market by 2030.



Although bifacial solar cells based on silicon wafers are already on the market, thin-film solar cells have so far lagged behind. This is, at least in part, due to the rather low efficiency of bifacial CIGS thin-film solar cells, caused by a critical bottleneck problem: For any bifacial solar cell to be able to collect reflected sunlight at the rear side, an optically transparent electrical contact is a prerequisite. This is achieved by using a transparent conductive oxide (TCO) that replaces the opaque back contact in conventional — i.e. mono-facial — solar cells made of molybdenum.

Detrimental oxide formation

High-efficiency CIGS solar cells are generally produced by a high-temperature deposition process, i.e. above 550°C. At these temperatures, however, a chemical reaction occurs between the gallium (of the CIGS layer) and the oxygen of the transparent conductive oxide back contact. The resulting gallium oxide interface layer blocks the flow of

sunlight-generated current and thus reduces the energy conversion efficiency of the cell. The highest values achieved so far in a single cell are 9.0% for the front side and 7.1% for the rear side. "It's really difficult to have a good energy conversion efficiency for solar cells with both front and rear transparent conducting contacts," says Ayodhya N. Tiwari, who leads Empa's Thin Film and Photovoltaics laboratory.

So, PhD student Shih-Chi Yang in the group of Romain Carron in Tiwari's lab developed a new low-temperature deposition process that should produce much less of the detrimental gallium oxide — ideally none at all. They used a tiny amount of silver to lower the melting point of the CIGS alloy and to obtain absorber layers with good electronic properties at just 350°C deposition temperature. When they analyzed the multi-layer structure with high-resolution transmission electron microscopy (TEM), with the help of Tiwari's former postdoc Tzu-Ying Lin(currently at National Tsing Hua University in Taiwan), the team could not detect any gallium oxide at the interface at all.

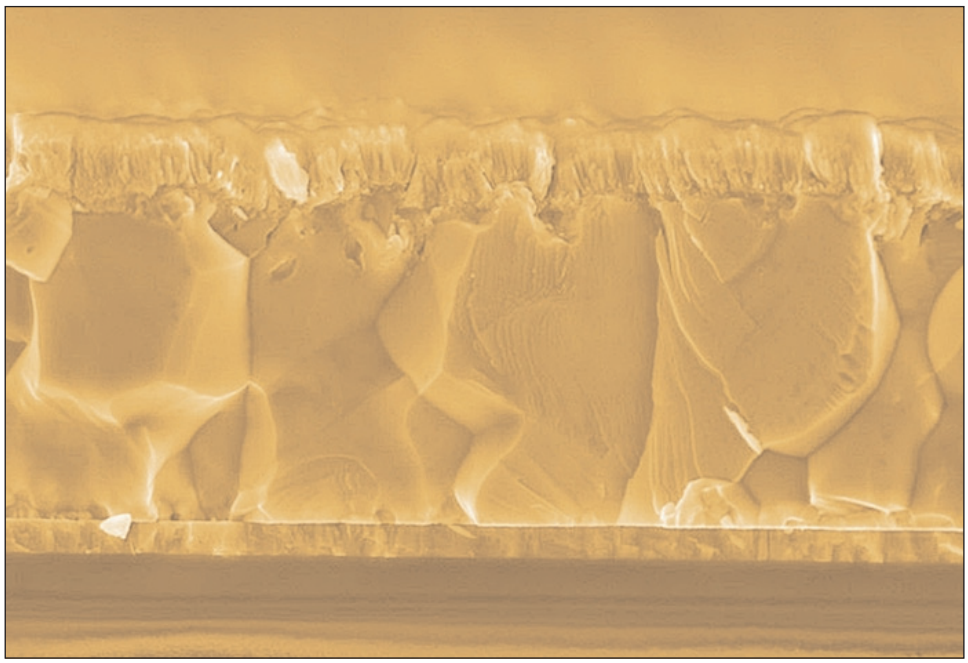
Targeting an energy yield of more than 33%

This was also reflected by a drastically improved energy conversion efficiency: The cell yielded values of 19.8% for front illumination and 10.9% for rear illumination that had been independently certified by the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany — in the very same cell on a glass substrate.

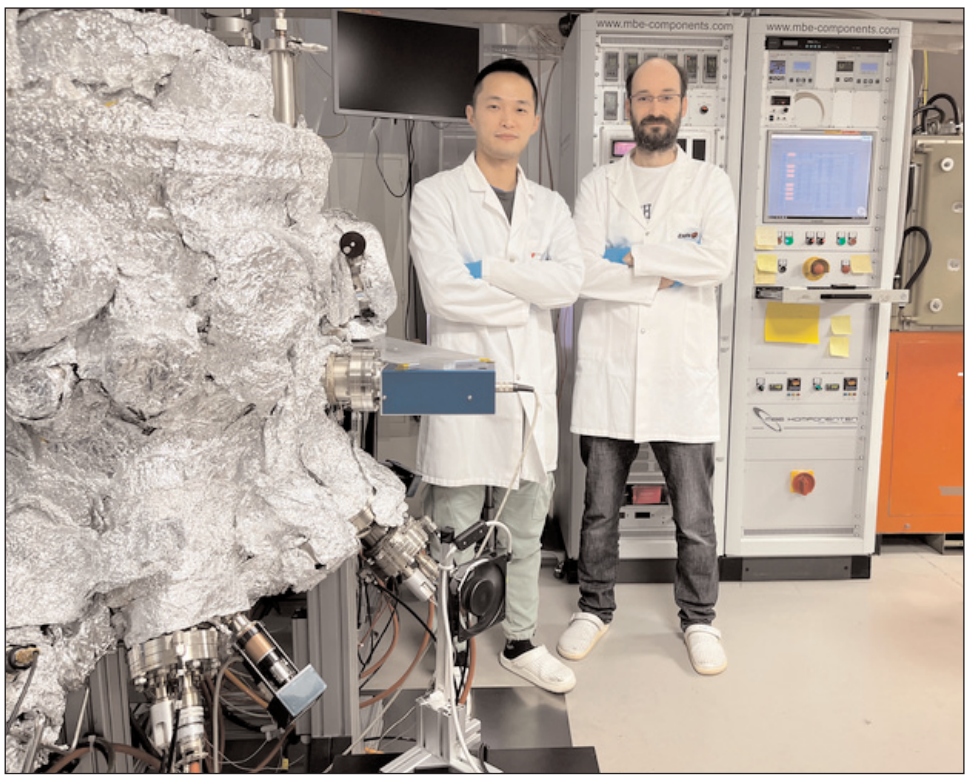
The team also succeeded in fabricating, for the very first time, a bifacial CIGS solar cell on a flexible polymer substrate, which — due to their light weight and flexibility — widens the spectrum of potential applications.

Finally, the researchers combined two photovoltaic technologies — CIGS and perovskite solar cells — to produce a bifacial tandem cell.

According to Tiwari, bifacial CIGS technology has the potential to yield energy conversion efficiencies beyond 33%, opening up further opportunities for thin-film solar cells in the future. Tiwari is now trying to establish a collaborative effort with key labs and companies across Europe to expedite the technology development and its industrial manufacturability on a larger scale.



Bifacial CIGS solar cells consist of very thin layers, only 3µm in total for the active materials. Deposited on top of a transparent electrical contact, the CIGS polycrystalline layer absorbs the light from both front and back sides. (Courtesy of EMPA.)



Empa researchers Shih-Chi Yang (left) and Romain Carron behind the deposition equipment for the CIGS layer. (Courtesy of EMPA.)

www.nature.com/articles/s41560-022-01157-9
www.empa.ch/web/s604/bifacial-cigs

Very-near-infrared InP QD laser diodes on silicon

Pulsed lasing at ~750nm wavelength up to 95°C.

Hong Kong University of Science and Technology (HKUST) has demonstrated electrically pumped quantum dot (QD) lasers grown on (001) silicon with pulsed lasing around 750nm wavelength, very near infrared, at room temperature and up to 95°C [Wei Luo et al, Optics Express, v30, p40750, 2022].

The dots consisted of indium phosphide (InP) in a gallium arsenide phosphide (GaAsP) quantum well (QW) with aluminium gallium arsenide (AlGaAs) barriers. The team sees potential for display, bio-photonics, and spatial mapping applications.

The researchers comment: "Embedding InP QDs in the simple ternary GaAsP/AlGaAs QW systems provides an efficient and reliable light source with emission wavelength at ~750nm on silicon, paving the way toward the integration with silicon photonics for a variety of applications near the infrared."

The team adds: "InP QD lasers on silicon with emission wavelength at 650–750nm are seldom explored."

HKUST also hopes that the achievements of visible red-emitting QD lasers on GaAs substrates may soon be transferred to (001) Si without offcut measures, often used to improve growth quality, as needed for integration with mainstream silicon complementary metal-oxide-semiconductor (CMOS) electronics and photonics.

The QD laser structures (Figure 1) were grown on GaAs/Si templates by metal-organic chemical vapor deposition (MOCVD). The templates were prepared by a separate MOCVD process where a number of steps

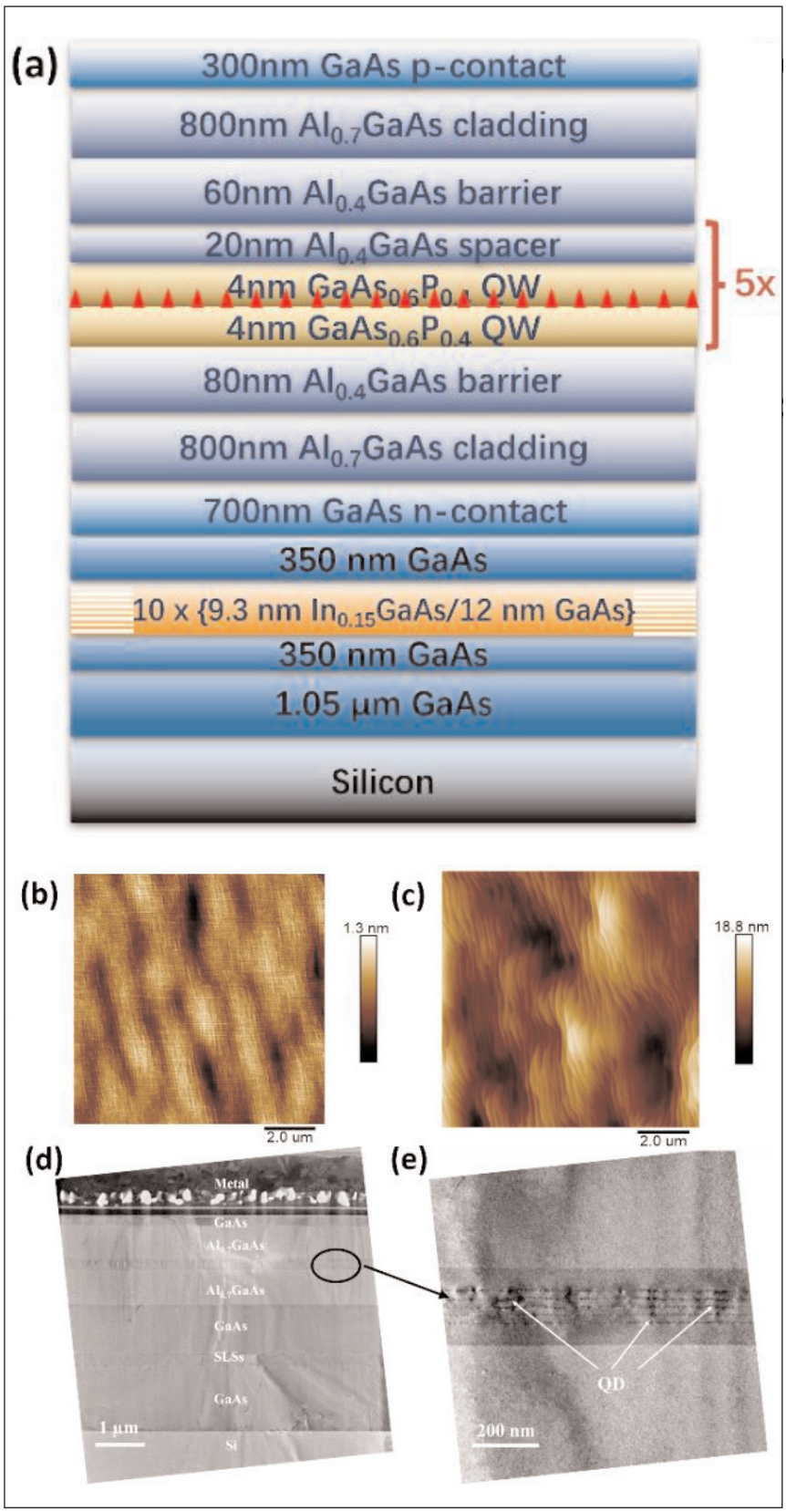


Figure 1. (a) Electrically pumped InP/GaAsP QD laser scheme on GaAs/Si template. Atomic force micrographs (AFMs) InP/GaAsP QDs grown on (b) GaAs and (c) GaAs/Si templates with 0.18nm and 2.76nm surface roughness, respectively. (d) Cross-sectional transmission electron micrographs (TEMs) of electrically pumped InP/GaAsP QD laser grown on GaAs/Si template. (e) Zoom-in cross-sectional TEM.

were taken to reduce defects arising from lattice mismatch such as thermal cycle annealing and InGaAs/GaAs strain-layer superlattice insertions. The template layer was 2μm thick with a threading dislocation density (TDD) of $2.8x10^7 cm^2$ and a 1.3nm surface roughness. The 2μm thickness is seen as a trade-off between TDD and the risk of crack generation.

The researchers found that five-layer QD in well structures grown at 680°C resulted in stronger photoluminescence than ones with three layers or those grown at 690°C. The lower growth temperature was particularly critical, giving around 4x emission intensity. The center wavelength was around 736nm.

Reference samples were also grown on GaAs substrates in the same process chamber at the same time.

The material was fabricated into ridge-waveguide edge-emitting laser diodes. The devices were subjected to 400ns pulsed operation with a 0.5% duty cycle. The devices had a 1.4V turn-on voltage. The laser threshold current density was as low as $573A/cm^2$ on reference 70μmx2mm laser diodes on GaAs substrate (Figure 2). The threshold was somewhat higher on the GaAs/Si templates at $657A/cm^2$. The laser wavelength at 20°C was 757nm.

Lasing continued in both types of device up to the 95°C temperature limit of the experimental setup. The characteristic temperatures of the devices were 62K and 74K for laser diodes on GaAs and GaAs/Si, respectively. A higher characteristic temperature, as seen in the GaAs/Si laser diodes, indicates a slower increase of the lasing threshold with increased temperature (a good thing).

The HKUST team comments: "The characteristic temperature of the InP/GaAsP QD laser grown on the GaAs/Si template is higher than that on GaAs, which may be a result of better thermal dissipation of silicon." ■

https://doi.org/10.1364/OE.474320

Author: Mike Cooke

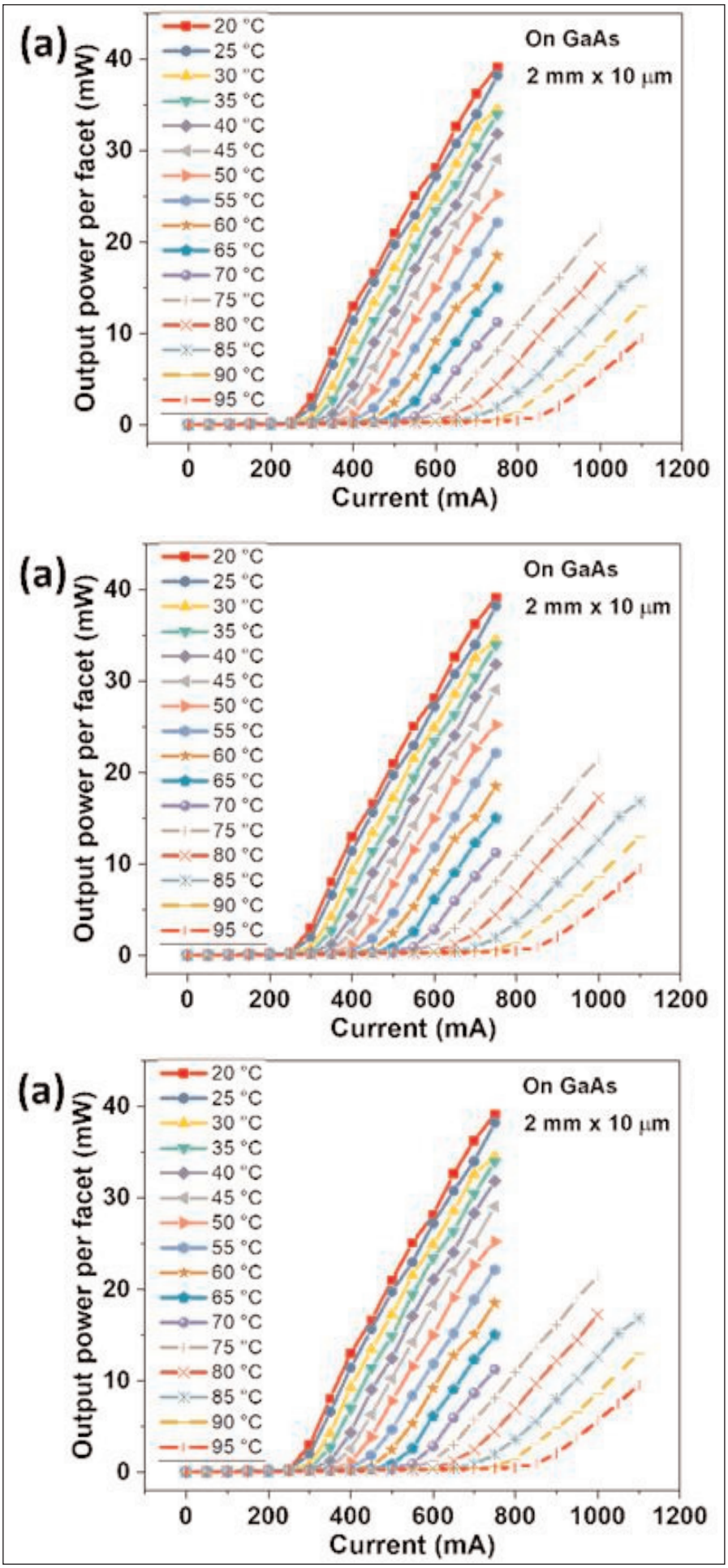


Figure 2. (a) Temperature-dependent light output power-current curves of 2mmx10μm InP/GaAsP QD lasers grown on (a) GaAs and (b) GaAs/Si templates, respectively. (c) Characteristic temperature graph.

Ultra-stable emission from green micro-LEDs on silicon

Researchers at the University of Michigan show how AlGaN barriers can reduce QCSE-related blue-shift of the emission wavelength in micro-LEDs.

University of Michigan in the USA reports "for the first time, μLEDs grown directly on silicon with submicron lateral dimensions" [Yuanpeng Wu et al, Light: Science & Applications, v11, p294, 2022]. The resulting indium gallium nitride (InGaN) devices featured ultra-stable green wavelength emission due to reduced quantum-confined Stark effects (QCSEs), which result from strain-dependent electrostatic fields from different charge polarizations of the various chemical bonds.

With the usual GaN barriers between the InGaN multiple quantum wells (MQWs), these QCSEs cause a large blue-shift in the emission wavelength of light-emitting diodes (LEDs) as the applied voltage increases for increased current injection. Such a shift in wavelength is particularly unwanted in full-color display applications. The Michigan devices used aluminium gallium nitride (AlGaN) barriers instead, enabling polarization and strain engineering to reduce QCSE.

The researchers comment: "This work provides a new approach for designing the active region of high-performance multi-color μLEDs."

The team sees opportunities in on-chip optical communication, and augmented reality/mixed reality (AR/MR) and ultrahigh-resolution full-color displays. Further, the deployment on low-cost silicon (Si) substrates could lead to seamless integration with mainstream CMOS electronics.

The template consisted of an N-polar 500nm n-GaN buffer on 100nm AlN seed grown on 2-inch Si(111) by plasma-assisted molecular beam epitaxy (PAMBE).

The nanowires were grown by bottom-up selective area epitaxy (SAE) using a thin titanium mask (Figure 1). The nanowire growth sequence consisted of ~450nm silicon-doped n-GaN, six periods of InGaN/AlGaN multiple quantum wells (MQWs), and ~170nm Mg-doped p-GaN. The InGaN QWs were 12nm thick. The successive AlGaN barrier layers extended to form AlGaN/GaN superlattice shells around the nanowire QWs. The barrier Al content was about 15%, according to x-ray energy-dispersive spectroscopy (EDS) line scans. The indium content of the wells varied up to around 30%.

The hexagonal cross-section of the wires came from the six equivalent m-planes of the GaN wurtzite crystal structure. The tops of the wires were flat, c-plane, unlike metal-polar III–N material that tends to result in pyramid tops.

The nanowires also did a decent job in filtering threading dislocations (TDs), reducing the density by 85% from ~$3x10^{10/}cm^2$ in the GaN buffer. The filtering was more effective in thinner nanowires, less than 150nm diameter.

Comparison was made with nanowires with GaN barriers. In photoluminescence (PL) experiments, the quantum-confined Stark effect in nanowires with GaN barriers was seen in narrowing of the spectral peak with increase in excitation power. No such narrowing was seen in samples with AlGaN-barrier nanowires. The GaN-barrier wires also showed a significant ~100nm blue-shift in photon wavelength (another signal of QCSE).

The researchers see the reduced QCSE in AlGaN-barrier nanowires as resulting from polarization doping effects in the shell region, creating donor-type surface states and bulk shallow donors. The induced electrons then migrate to the QWs in the nanowire core, screening the electrostatic fields that cause QCSE.

The AlGaN-barrier nanowires had two dominant peaks, which were attributed to different parts of the QW: in the central region the QW grew in the c-plane direction, resulting in polar material producing emissions at 2.36eV photon energy (525nm wavelength); toward the edge, however, the material became semi-polar, emitting at lower energy and longer wavelength (2.23eV/556nm).

Another effect of the AlGaN barrier was pseudomorphic growth, with the tensile strain of the InGaN layers being compensated by the smaller lattice constant of AlGaN relative to GaN. The smaller mismatch strain energy is expected to result in enhanced indium content in the QWs, giving longer-wavelength emissions, and significantly reduced strain relaxation.

The researchers fabricated the material into μLEDs of 900nmx900nm area (Figure 2). The sidewalls were passivated with atomic layer deposition (ALD) aluminium oxide (Al_2O_3) against leakage currents from short-circuiting caused by subsequent metal deposition. The p-GaN tops of the nanowires were passivated/insulated with 320nm plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide

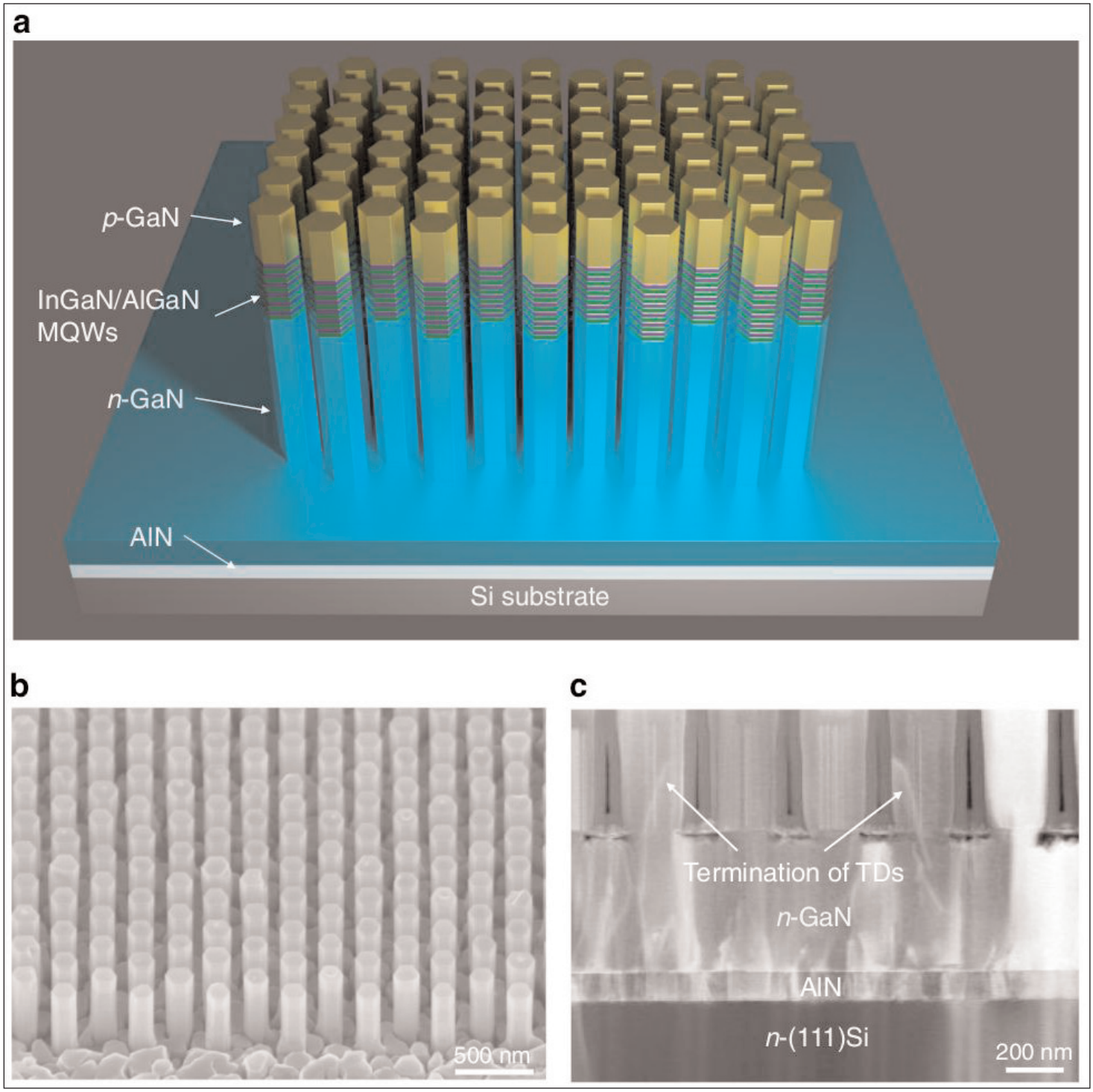


Figure 1. (a) Schematic of InGaN/AlGaN MQWs-in-nanowire heterostructure grown on silicon substrate. (b) Bird's-eye view scanning electron micrograph (SEM) of as-grown InGaN/AlGaN p-i-n nanowire arrays. (c) Cross-sectional scanning transmission electron micrograph (STEM) of nanowire on silicon substrate, showing termination of TDs on sidewall of n-GaN nanowire before reaching active region.

(SiO_2). The emission window/transparent conductor contact with the p-GaN was formed by annealed 2.5/2.5/180nm nickel/gold/indium tin oxide (Ni/Au/ITO). The n-contact was titanium/gold.

The devices demonstrated negligible leakage current at reverse bias with a rectification ratio of four orders of magnitude at ±8V. The diode turn-on came at ~3V. The dominant peak emission was ~2.3eV (537nm), which was barely affected by increasing current.

A red-shift from ~2.313eV (536nm) to 2.309eV (537nm) with increasing current is described as "slight". The researchers comment: "This is in direct contrast with previously reported green-emitting InGaN QW LEDs, wherein a blue-shift of 20–50nm due to QCSE and color instability were widely observed." The tiny red-shift observed in the Michigan devices is put down to "a combination of the current-induced heating effect and bandgap renormalization," by the team.

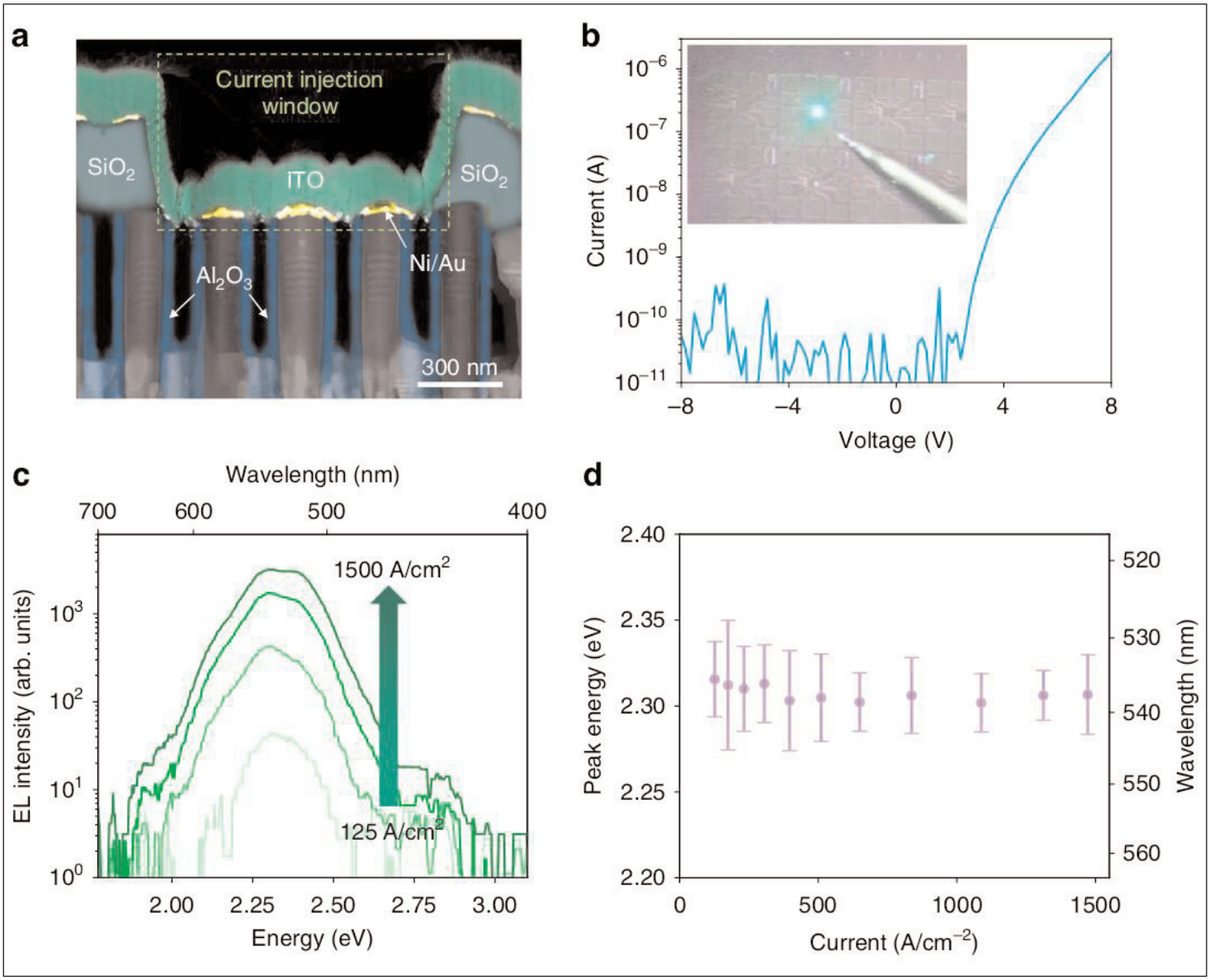


Figure 2. (a) Cross-sectional high-angle annular dark-field (HAADF)-STEM false-color image of as-fabricated InGaN/AlGaN μLED (blue: Al_2O_3; dark-cyan: SiO_2; yellow: Ni/Au; green: ITO). (b) Current-voltage characteristics at room temperature. Inset: Optical image of bright green emission under injection current of ~100A/cm². (c) Electroluminescence spectra. (d) Variation of peak position versus injection current.

The researchers also suggest that their structure could suppress the impact of Auger recombination due to reduced carrier density within the InGaN quantum wells, resulting in less efficiency droop with increased current, compared with conventional devices. ■

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Multi-wavelength emission from 3D structured InGaN

Research finds a wavelength spread of up to 90nm for quantum wells grown on convex-microlens-structured gallium nitride templates on sapphire substrate.

Kyoto University in Japan has demonstrated a 90nm wavelength spread for the light emission from indium gallium nitride (InGaN) quantum well (QW) structures grown on convex-microlens-structured GaN templates on sapphire [Yoshinobu Matsuda et al, Appl. Phys. Express, v15, p105503, 2022]. The researchers mainly attribute the spread to differing indium incorporation as the off-angle from planar deposition varied.

The team comments: "We believe that the gently sloping 3D structures will facilitate future LED device processing. In addition, the continuously changing off-angle of the microlens shape provides the continuously changing emission wavelength. Therefore, we expect that the desired wavelength components can be extracted by electrically accessing the corresponding local position."

The researchers hope their work could contribute to achieving white light-emitting diodes (LEDs) without phosphors, high-capacity communications by wavelength division multiplexing in LiFi systems, and spontaneously arrayed micro RGB LEDs for display applications.

The researchers used thermal reflow to form GaN microlens-shaped bumps on the surface on GaN/sapphire templates (Figure 1). The microlenses were defined by photoresist disks and lithography that were transformed into convex lens shapes by heating on a hotplate at 180°C for 40 minutes. The shaping was then transferred from the photoresist to the underlying GaN by inductively coupled plasma reactive ion etch (ICP-RIE). The device layers were applied by metal-organic vapor phase epitaxy (MOVPE): 500nm 1050°C undoped GaN (u-GaN), followed by a single 2.5nm/11nm 700°C InGaN/GaN quantum well.

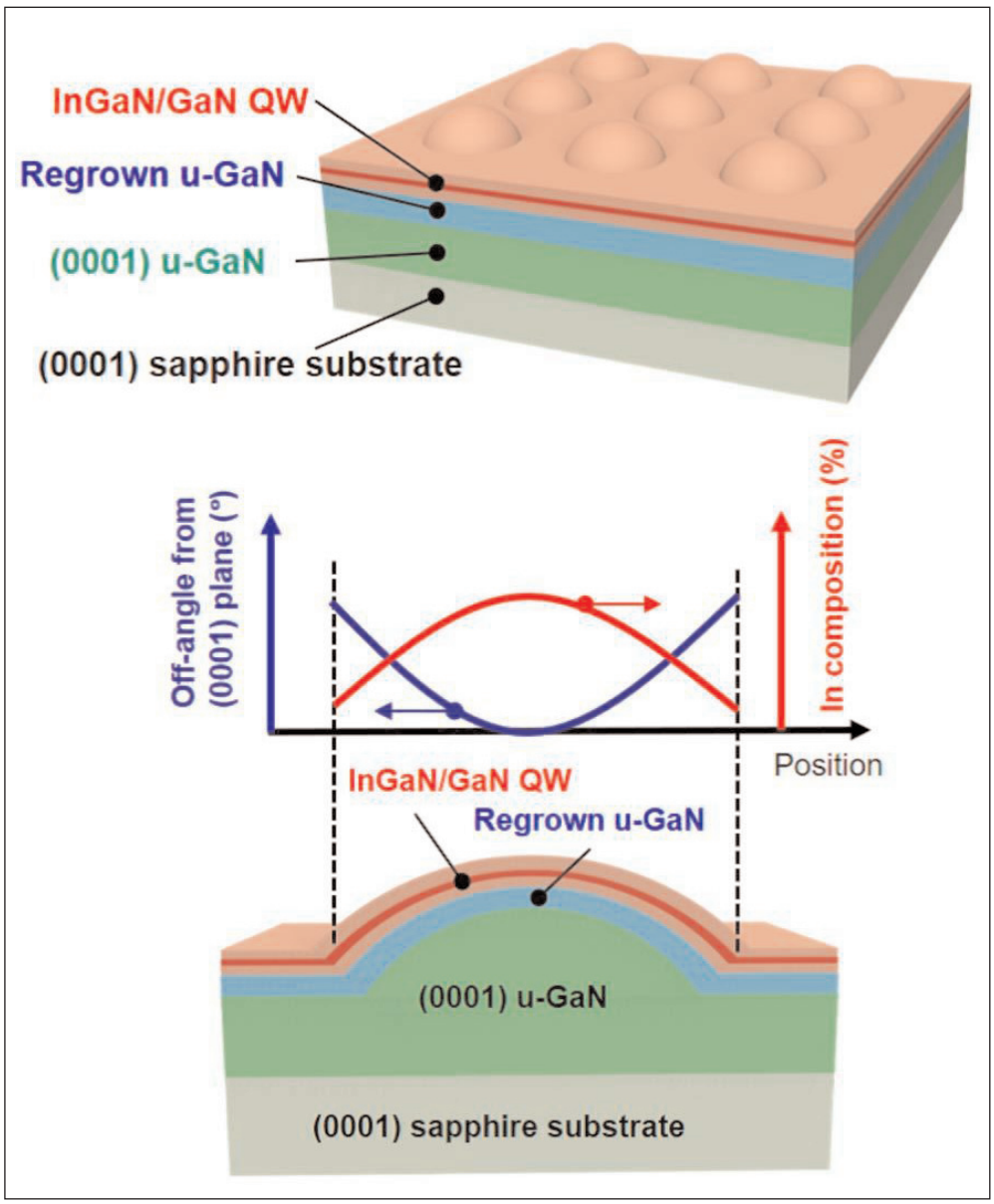

Figure 1. (Top) Material structure grown on microlens array on (0001) GaN/sapphire template and (bottom) cross-sectional view of single microlens, with sketch graph showing off-angle variation and expected indium composition distribution.

The convex lens shape was maintained up to 30μm diameter. Beyond that, the structures tended to exhibit a concave dip in the middle. Such dips also showed up when the reflow temperature or time were

reduced in smaller-diameter structures. The QW layers reduced the maximum off-angle from 11° to 8° in samples with 20μm-diameter microlenses. The microlens heights were ~1.5μm before and after MOVPE, but the lateral diameter increased from 20μm to 50μm. The researchers suggest that "the surface adatoms diffuse from the top of the microstructure or the planar region around the microstructure to the bottom."

The variation of indium incorporation across the microlens structure was evaluated using cathodoluminescence (CL) at various positions (Figure 2). The peak wavelength varied across the microlens from 490nm down at the center to 400nm near the edge. The total emission with a peak at 410nm was dominated by the shorter wavelengths due to the lower indium incorporation and larger area of the circumference relative to the regions towards the center. Higher-indium-content InGaN tends to have lower emission efficiency.

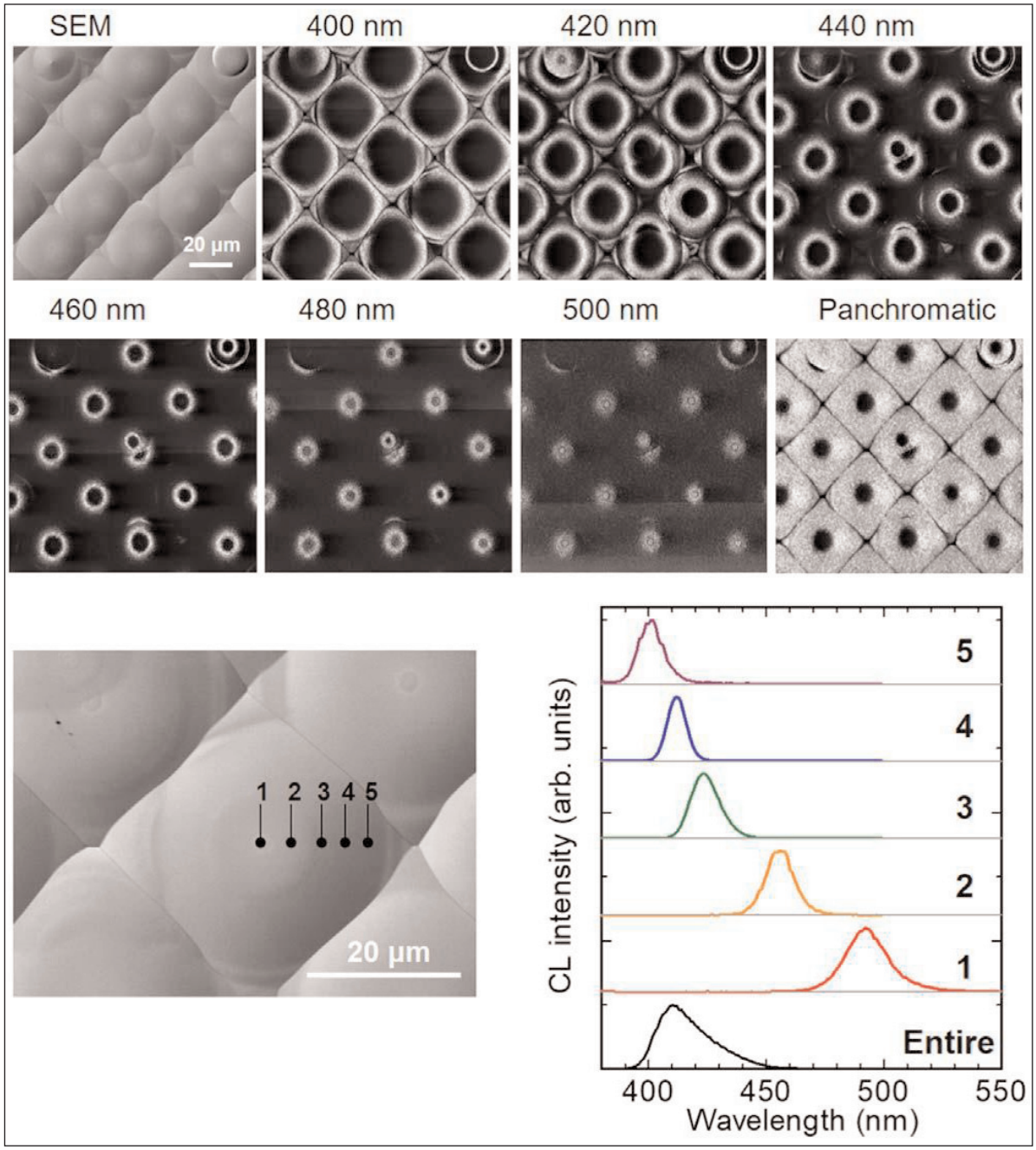

Figure 2. (Top) Scanning electron microscope (SEM) image of InGaN QWs on GaN microlens structures and monochromatic CL mapping images taken at various wavelengths. (Bottom) Spatially resolved CL spectra (right) at given positions of microlens (left) and across entire structure.

The wavelength spread of 90nm is wider than previously reported work by the Polish Institute of High Pressure Physics which showed a 40nm spread with the off-angle varying up to 2.4°. The off-angle profile of the Kyoto microlens structures reached around 8°. From other research, it is thought that, while off-angles in the low range exhibit reduced indium incorporation with increasing off-angle near zero, beyond about 30° the indium incorporation increases up to a maximum at 60°.

Another possible effect affecting the peak wavelength could be the effective width of the QW, which naturally varied through the microlens profile. However, on the basis of transmission electron microscope and energy-dispersive x-ray studies, the researchers conclude the dominant factor determining indium composition was the off-angle dependence of indium incorporation, modified by the surface diffusion of gallium atoms during the MOVPE process. ■

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Author: Mike Cooke

Compound semi substrate market growing at 16% CAGR to $2.4bn by 2027

Replacing silicon in segments from RF to power to photonics brings new opportunities at every level of the supply chain, notes Yole Intelligence.

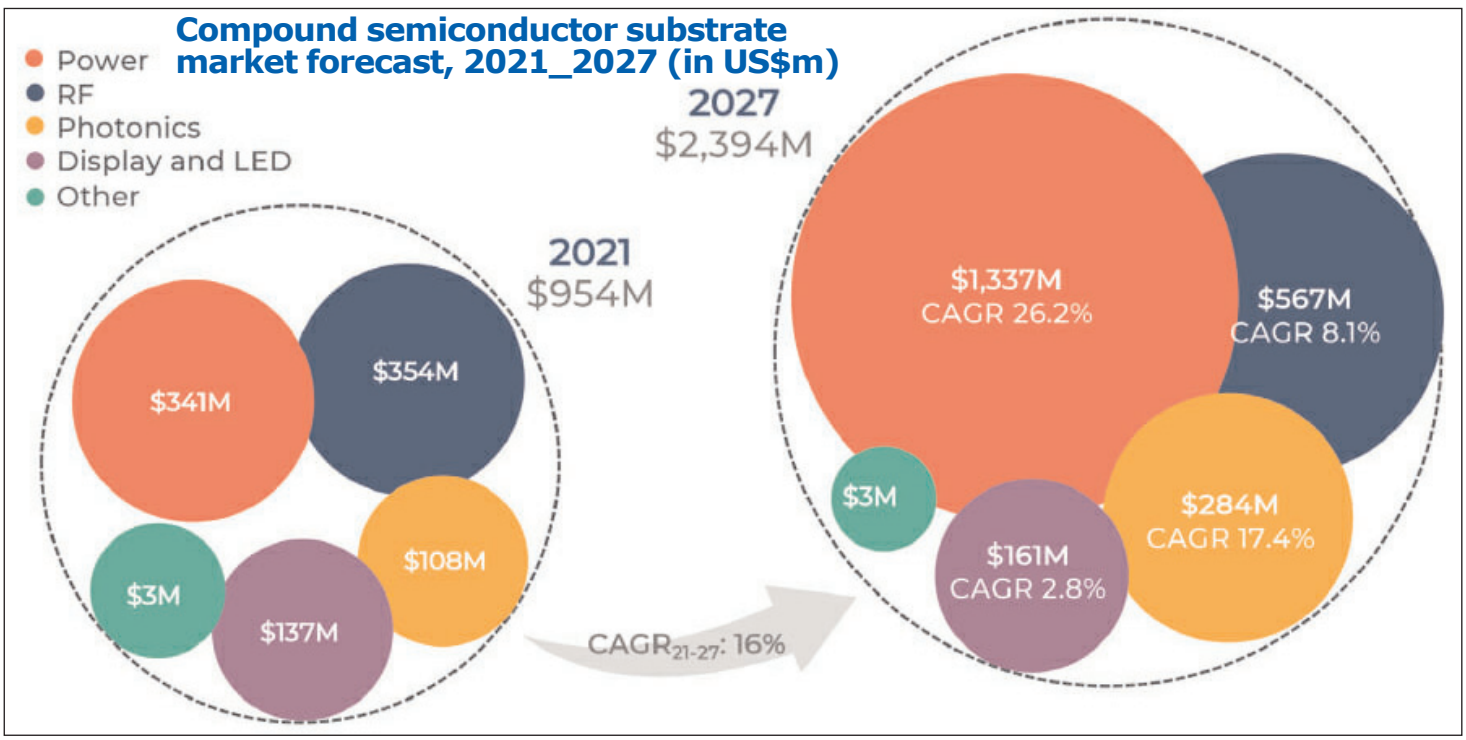
Driven by power and photonics applications, the compound semiconductor (CS) substrate market is rising at a compound annual growth rate (CAGR) of 16% to nearly US$2.4bn by 2027, according to the report 'Status of the Compound Semiconductor Industry 2022' from Yole Intelligence (part of Yole Group).

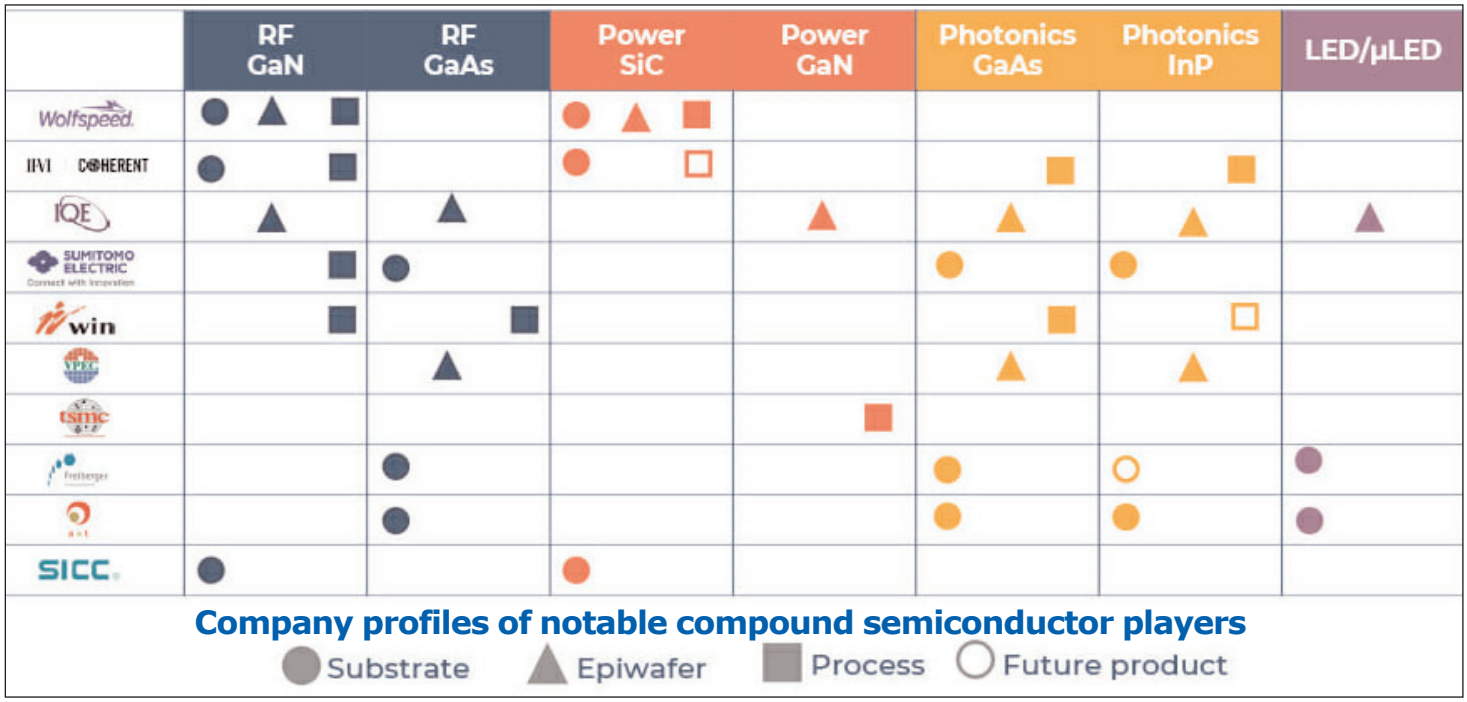
Compound semiconductors have been adopted in various applications over the past decades. Recently, however, silicon carbide (SiC) and gallium nitride (GaN) in power, GaN and gallium arsenide (GaAs) in radio frequency (RF), GaAs and indium phosphide (InP) in photonics, and LEDs and micro-LEDs in displays have all gained momentum. As a result, the substrate and epiwafer markets are also expected to grow.

"Wolfspeed is the leading SiC substrate and epiwafer supplier for power SiC and RF GaN," notes Poshun Chiu, senior technology & market analyst specializing in Compound Semiconductors and Emerging Substrates at Yole Intelligence. "As the larger-format substrate is the strategic resource in the next generation of device manufacturing, the opening of 8" wafer fabs and the expansion of material capacity illustrates the ambitious targets aimed at in the coming decade."

Meanwhile, II-VI closed its acquisition of Coherent and renamed itself, illustrating its change of focus. Now, Coherent is the leading photonic device player as well as the leading SiC substrate supplier for power and RF applications. Moreover, it is working with SEDI (Sumitomo Electric Devices Inc) on RF GaN device manufacturing and has entered the power SiC device business with GE. Both are strengthening their competitiveness from the substrate level to the device level.

AXT, Sumitomo Electric, Freiberger, and SICC are the leading suppliers of GaAs, InP and semi-insulating SiC substrates. Their objectives of growing their revenues rely on expanding into other compound semiconductor materials. Players are looking at the synergy between GaAs and InP substrates for RF, photonic and micro-LED applications. Also, players from semi-insulating SiC are entering the faster-growing n-type SiC market.





"Epiwafer suppliers benefit from the different dynamics of the compound semiconductor open epiwafer market," notes Taha Ayari Ph.D., technology & market analyst, Compound Semiconductor and Emerging Substrates, at Yole Intelligence. "IQE has been involved in various compound semiconductor markets (for example, RF GaAs and GaN), as the double-digit CAGRs of InP and GaAs photonics represent markets with both volume and scale. And micro-LED is a booming market, expected to double every year in the coming five years. VPEC has succeeded in becoming the largest supplier of RF GaAs epiwafer in the open market, and the company continues increasing its engagement in photonics for future growth".

"With LEDs, handset power amplifiers and telecom & datacom, compound semiconductor went through its first inflection point with GaAs and InP in the 1990s," says Ezgi Dogmus Ph.D., team lead analyst in Compound Semiconductor & Emerging Substrates activity, Yole Intelligence.

As demand for 5G connectivity, electric vehicles (EVs) and fast chargers for smartphones comes to the market, compound semiconductors will grow in both volume and market value, notes Yole. Looking into the future, e-mobility, including higher-voltage applications, sensing in various end-systems, the transition from 5G to 6G, and micro-LED displays will bring inflection points for different compound semiconductor materials, along with more emerging substrates and new applications to come. ■

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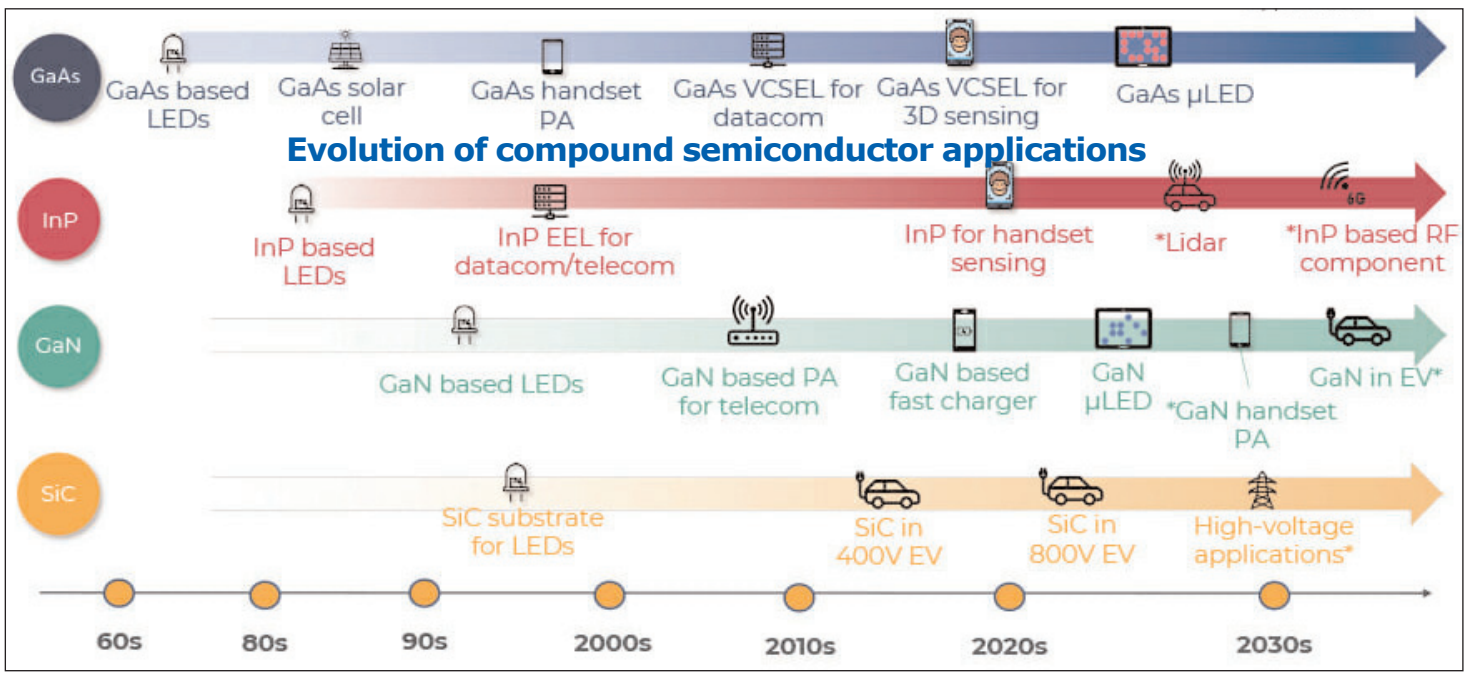

Imec introduces framework to model GaN HEMT and InP HBT RF devices for 5G & 6G

Monte Carlo simulation uses microscopic heat carrier distributions to predict 3D thermal transport.

At the 68th annual IEEE International Electron Devices Meeting (IEDM 2022) in San Francisco (3–7 December), nanoelectronics research center imec of Leuven, Belgium presented a Monte Carlo Boltzmann modeling framework that, for the first time, uses microscopic heat carrier distributions to predict 3D thermal transport in advanced RF devices intended for 5G and 6G wireless communication.

The results were presented in two invited papers, by Bjorn Vermeersch on thermal modeling and by Nadine Collaert on gallium nitride (GaN) and indium phosphide (InP) technologies for next-generation high-capacity wireless communication, respectively [papers 11.5 and 15.3].

Case studies with GaN high-electron-mobility transistors (HEMTs) and InP heterojunction bipolar transistors (HBTs) revealed peak temperature rises up to three times larger than conventional predictions with bulk material properties. Imec reckons that the new tool will be useful in guiding optimizations of next-generation RF devices toward thermally improved designs.

GaN- and InP-based devices have emerged as interesting candidates for 5G millimeter-wave (mm-wave) and 6G sub-THz mobile front-end applications, respectively, due to their high output power and efficiency. To optimize these devices for RF applications and make them cost-effective, much attention is paid to upscaling the III/V technologies to a silicon platform and making them CMOS compatible. However, with shrinking feature sizes and rising power levels, self-heating has become a major reliability concern, potentially limiting further RF device scaling.

"Tuning the design of GaN- and InP-based devices for optimal electrical performance often worsens thermal performance at high operating frequencies," notes Nadine Collaert, program director of advanced RF at imec. "For GaN-on-Si devices, for example, we recently achieved tremendous progress in electrical performance, bringing the power-added efficiencies and output power for the first time on par with that of GaN-on-silicon carbide (SiC). But further enlarging device operating frequency will require downsizing the

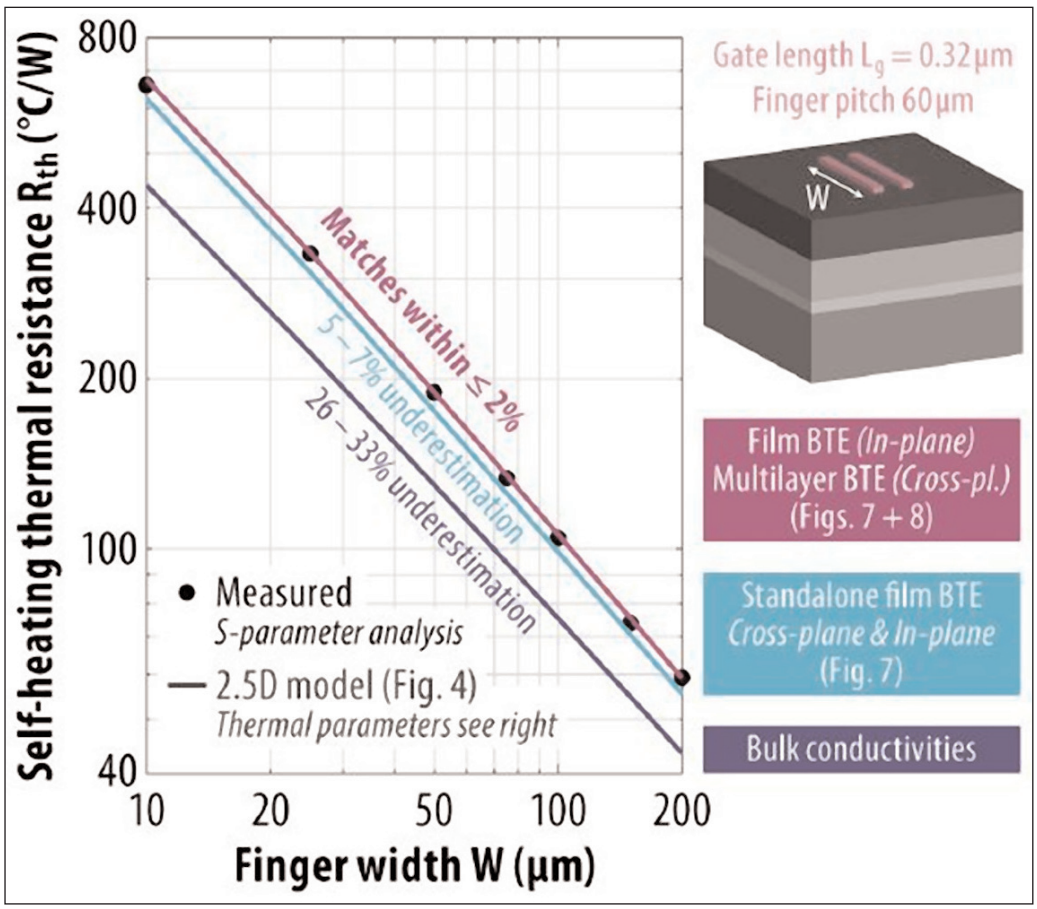

Figure 1. Measured and predicted thermal resistance versus finger width of two-finger GaN-on-Si HEMTs.

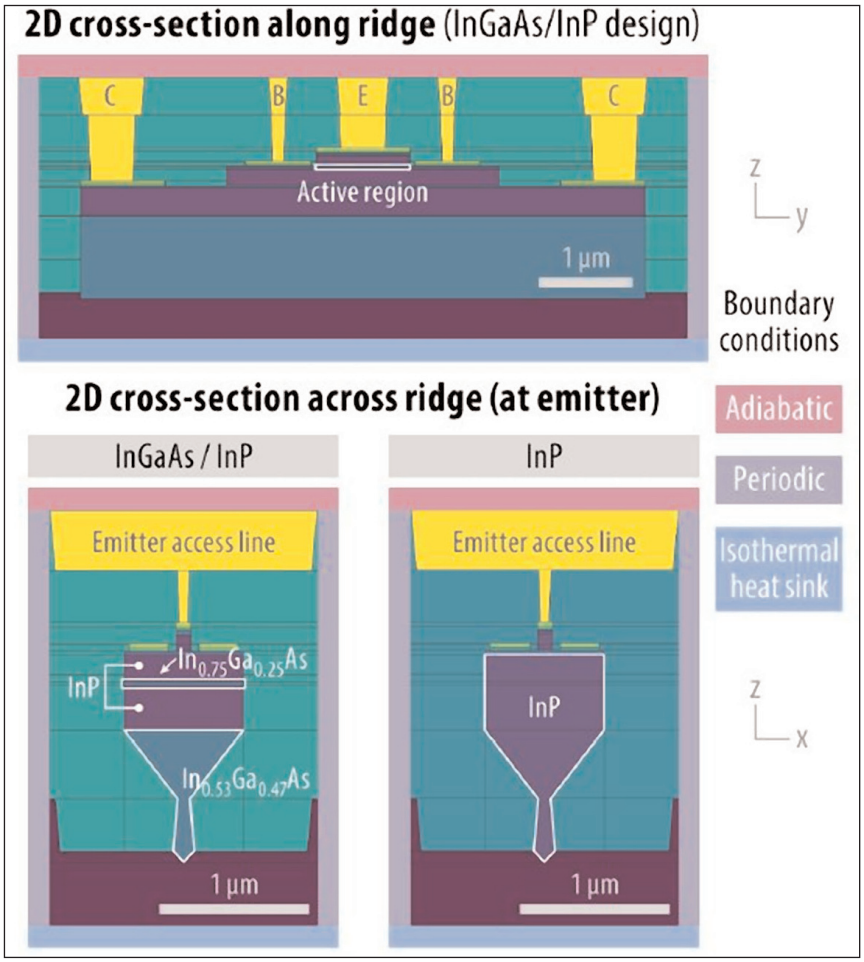

Figure 2. Geometry of InP nanoridge HBT used in the 3D simulation.

existing architectures. In these confined multi-layer structures, however, thermal transport is no longer diffusive, challenging accurate self-heating predictions," she adds. "Our novel simulation framework, yielding good matches with our GaN-on-Si thermal measurements, revealed peak temperature rises up to three times larger than previously predicted. It will provide guidance in optimizing these RF device layouts early in the development phase to ensure the right trade-off between electrical and thermal performance."

Such guidance also proves very valuable for the novel InP HBTs, where imec's modeling framework highlights the substantial impact that non-diffusive transport has on self-heating in complex scaled architectures. For these devices, nanoridge engineering (NRE) is an interesting heterogeneous integration approach from an electrical performance point of view. "While the tapered ridge bottoms enable low defect density within the III–V materials, they however induce a thermal bottleneck for heat removal towards the substrate," explains Bjorn Vermeersch, principal member of technical staff in the thermal modeling and characterization team at imec. "Our 3D Monte Carlo simulations of NRE InP HBTs indicate that the ridge topology raises the thermal resistance by over 20% compared to a hypothetical monolithic mesa of the same height," he adds. "Our analyses furthermore highlight the direct impact of the ridge material (e.g. InP versus InGaAs) on self-heating, providing an additional knob to improve the designs thermally." ■

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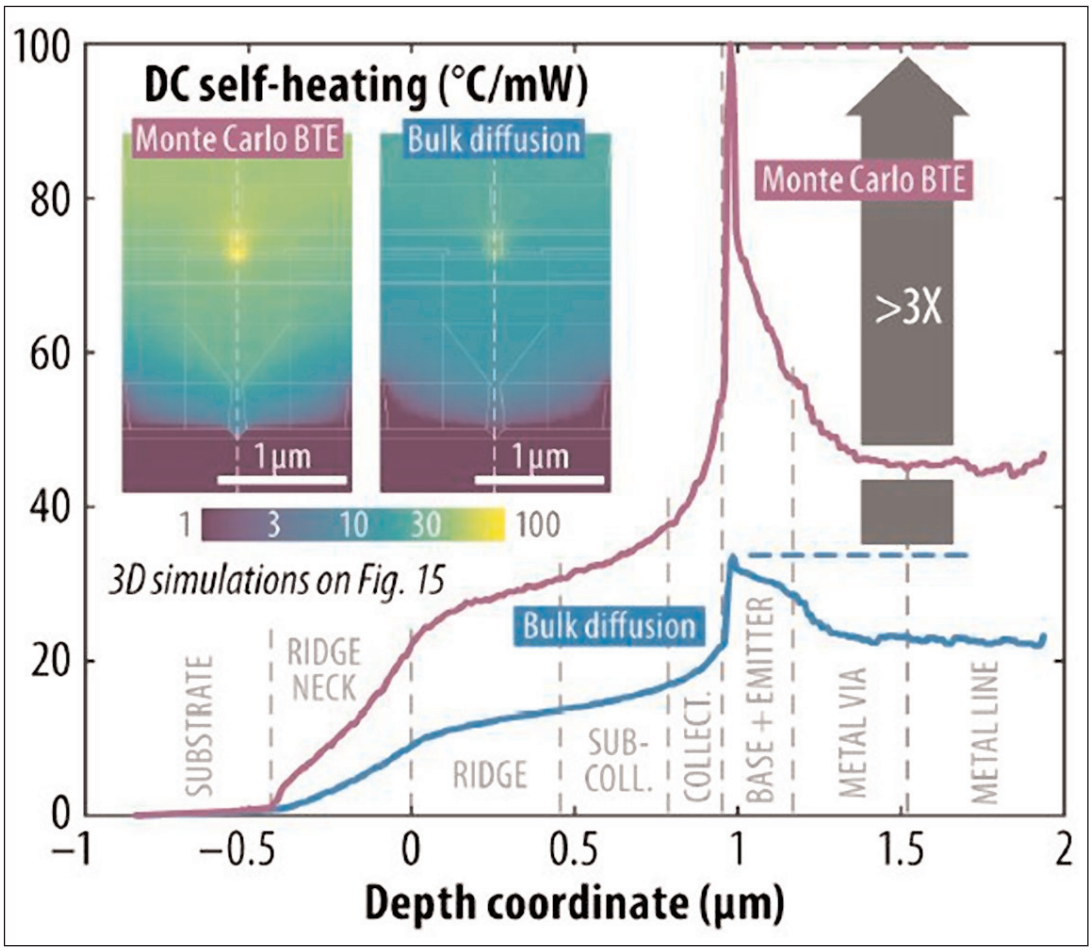

Figure 3. Impact of non-diffusive thermal transport effects (as captured by imec's Monte Carlo simulation) in InP nanoridge HBTs.

RF detection with InGaAs and GaN HEMTs

InGaAs device could probe beyond 1THz, researchers believe.

Researchers based in Spain and France report on the relative merits of indium gallium arsenide (InGaAs) and gallium nitride (GaN) high-electron-mobility transistors (HEMTs) as radio frequency (RF) signal detectors [G. Paz-Martínez et al, J. Appl. Phys., v132, p134501, 2022].

The researchers — six from Universidad de Salamanca, Spain, and one from Université de Lille/Université de Valenciennes, France — believe that the InGaAs HEMT RF detection frequency range could reach at least the sub-terahertz range and perhaps even above 1THz.

The devices were operated in the region of "third-quadrant conduction" (TQC) where a sharp non-linear increase in drain current occurs due to the channel opening for negative values of drain bias.

The researchers compared the RF detection performance of HEMTs with aluminium gallium nitride (AlGaN) and indium aluminium arsenide (InAlAs) barrier material (Figure 1). The GaN/InGaAs HEMT materials had Hall sheet electron densities of $1.3x10^{13}/cm^2$ and $1.5x10^{13}/cm^2$ with mobilities of 1800 and $3400cm^2/V-s$ at 300K, respectively.

The gate electrodes had two fingers of 2x25μm width in the GaN device, and 2x35μm for the InGaAs HEMT (Figure 2). The higher-mobility, wider InGaAs device had a lower open-channel resistance (R_{on}) of 32Ω compared with the GaN HEMT's 66Ω. The researchers comment: "This parameter will play an important role in the RF detection performances of the devices since it will strongly affect the input mismatch with the 50Ω RF source." To facilitate RF probing, the devices were fabricated with coplanar waveguide accesses.

The samples were probed with ground-source-ground (GSG) probes in a CRX-VF cryogenic probe station. The RF source was a PNA-X vector network analyzer (VNA). Two-channel source-measurement units (SMUs) were used to bias the drain and gate terminals of the transistors. Coupling of the AC and DC signals was through an internal bias-tee.

The devices were tested under a 1GHz RF signal with input powers of −15dBm and −31dBm for the GaN and InGaAs HEMTs, respectively. The researchers comment: "These values correspond to the actual power delivered to the device since the output power of the VNA has been increased to compensate losses due to the cables, connectors, and probes."

The transistors were operated with quiescent bias point (Q-point) in zero drain current(ZC)/open-circuit and zero drain–source voltage(ZV)/short-circuit modes to provide voltage and current responsivities, respectively, to input power from a 50Ω impedance supply, as typical from coax cables with balanced power handling and insertion loss. In the ZC mode the researchers measured the shift in drain–source voltage (V_{DS}). The ZV

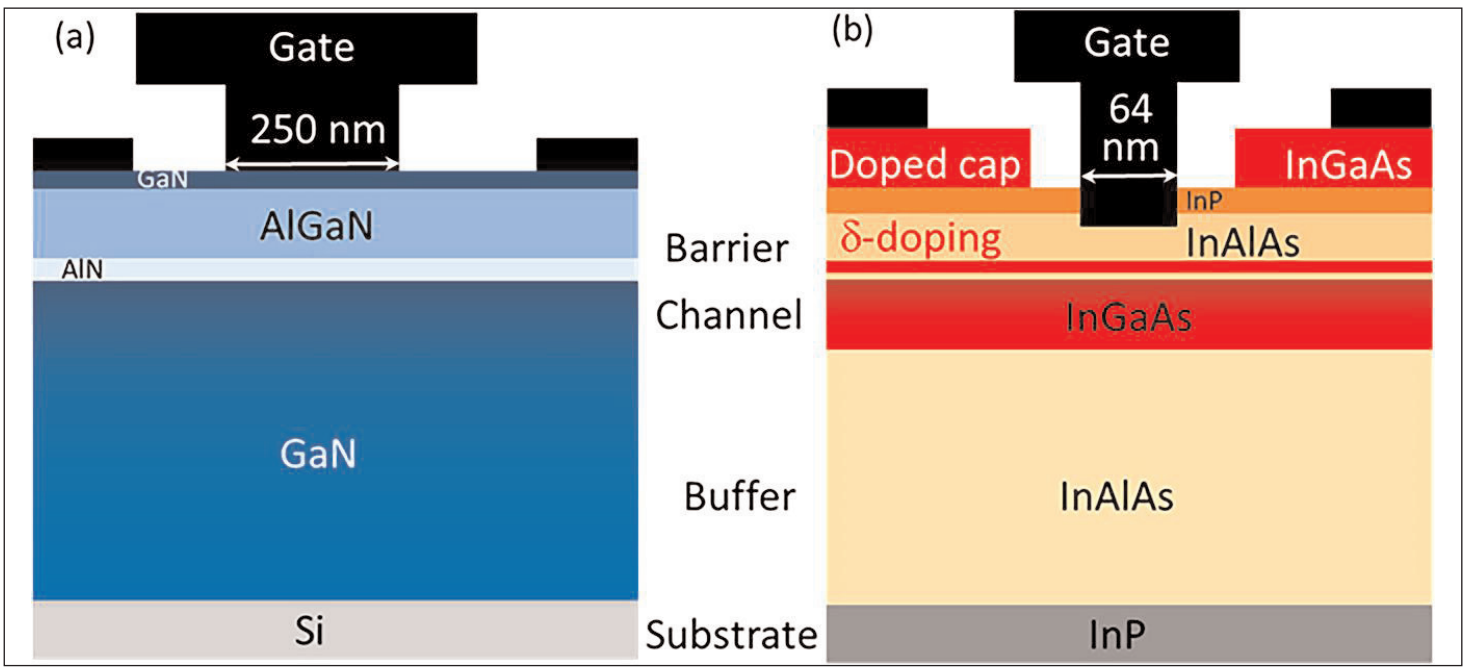

Figure 1. Sketch of (a) GaN and (b) InGaAs HEMTs.

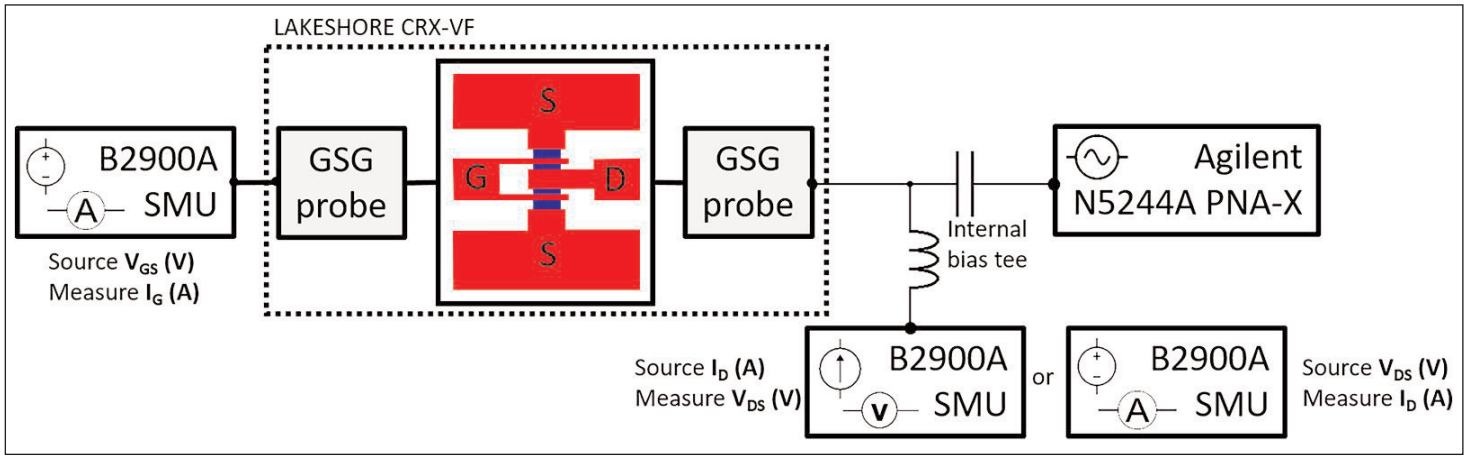

Figure 2. Schematic drawing of DC and RF characterization setup for drain terminal injection.

mode had the team looking for a shift in drain current (I_{DS}).

The results (Figure 3) showed that a quasi-static (QS) model, previously developed by the team, based on non-linearity of the DC current–voltage behavior, along with dependencies on the values of the drain conductance (g_D) and its bowing coefficient ($\beta=\partial(\log(g_D)/\partial V_{DS}$), gave a reasonable fit to the various performances.

The InGaAs device gave significantly better performance for RF detection at room (300K) and cryogenic (100K) temperatures. The failure of the GaN HEMT to give enhanced performance in a cryogenic environment was related to the lack of a back barrier provided in the InGaAs device by the double-heterostructure quantum well channel. The GaN device therefore suffered from buffer leakage and hence inadequate pinch-off.

The team explains: "Concerning the RF detection performances, InGaAs HEMTs provide much higher responsivity and lower noise equivalent power (NEP) due to the enhanced non-linearity of the g_D, evidenced by a much larger value of the β coefficient. This is closely linked to the better gate–channel control offered by this technology which, due to its higher mobility, intrinsically provides a superior transconductance level as compared to GaN HEMTs."

The researchers also investigated the ability to improve impedance matching of the InGaAs device by also studying devices with 2x15μm and 2x25μm widths. The team's QS model also adequately represented the performance, allowing the researchers to speculate on how to achieve perfect matching. Ideally the width would have to be increased, maybe up to 2mm for a low gate–source bias (V_{GS}). With a relatively high V_{GS} of –0.35V, the width would need to fall in the range 200–400μm for current-mode detection. ■

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Author: Mike Cooke

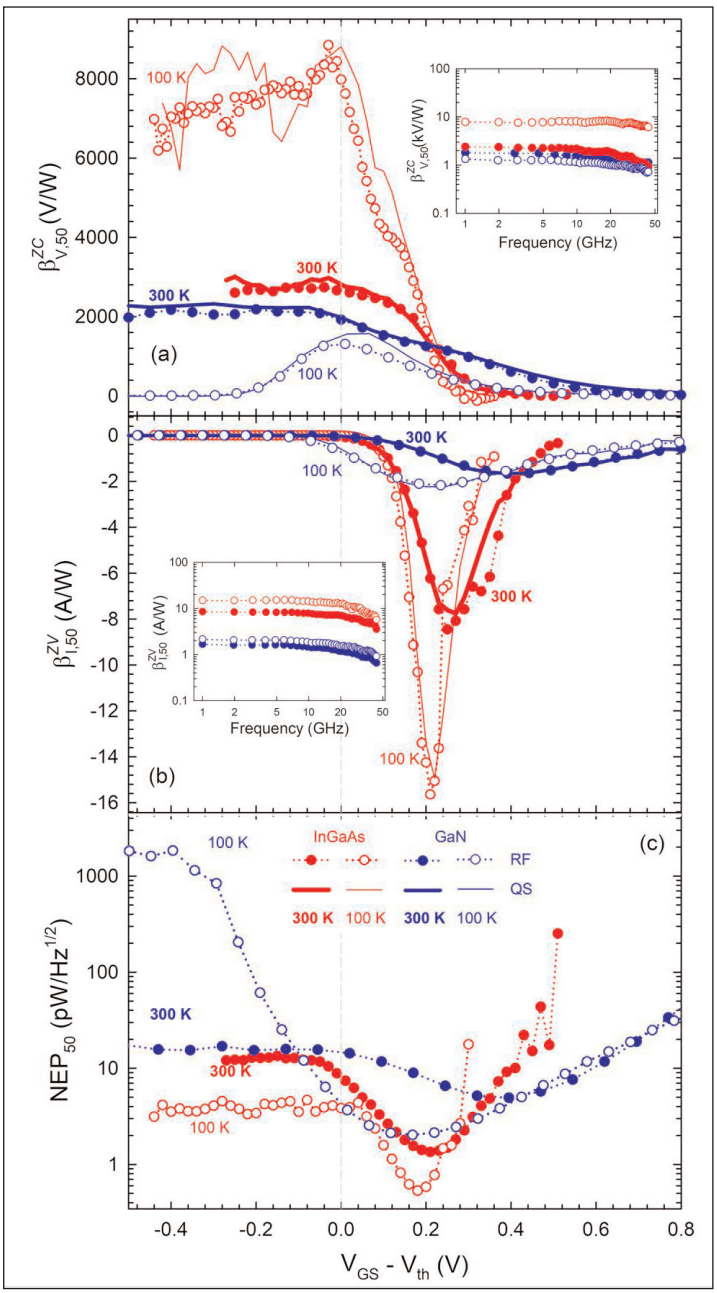

Figure 3. Comparison of QS values and experimental measurements with 50Ω input signals of (a) ZC and (b) ZV responsivities ($\beta^{ZC}_{V,50}$ and $\beta^{ZV}_{I,50}$, respectively) at 300K and 100K. Insets show frequency dependence of measurements at V_{GS} bias providing maximum responsivities. (c) Noise equivalent power (NEP_{50}) extracted from ZC measurements versus QS-model.

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Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com

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

SAMCO International Inc
532 Weddell Drive,
Sunnyvale, CA, USA
Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

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

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

Synova SA
Ch. de la Dent d'Oche,
1024 Ecublens,
Switzerland
Tel +41 21 694 35 00
Fax +41 21 694 35 01
www.synova.ch

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

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

9 Materials & metals

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

PLANSEE High Performance Materials
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Austria
Tel: +43 5672 600 2422
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www.plansee.com

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

10 Gas and liquid handling equipment

Cambridge Fluid Systems
12 Trafalgar Way, Bar Hill,
Cambridge CB3 8SQ,
UK
Tel: +44 (0)1954 786800
Fax: +44 (0)1954 786818
www.cambridge-fluid.com

CS CLEAN SOLUTIONS AG
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Ismaning, 85737,
Germany
Tel: +49 89 96 24000
Fax: +49 89 96 2400122
www.csclean.com

Entegris Inc
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Tel: +1 978 436 6500
Fax: +1 978 436 6735
www.entegris.com

IEM Technologies Ltd
Fothergill House, Colley Lane,
Bridgwater, Somerset TA6 5JJ, UK
Tel: +44 (0)1278 420555
Fax: +44 (0)1278 420666
www.iemtec.com

Vacuum Barrier Corporation
4 Barton Lane,
Woburn, MA 01801,
USA
Tel: +1 781 933 3570
Fax: +1 781 933 9428
www.vacuumbarrier.com

VACUUM BARRIER VBC CORPORATION

Vacuum Barrier's vacuum-jacketed dynamic and sealed SEMIFLEX LN2 pipe delivers LN2 at bulk tank pressure in two-phase condition for on-demand supply. Our liquid/vapor phase separators deliver low-pressure LN2 to each use point for on-demand supply. Combine with SEMIFLEX Triax LN2 pipe eliminates two-phase flow to all use points.

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

11 Process monitoring and control

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

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

KLA-Tencor
One Technology Dr,
1-2221I, Milpitas,
CA 95035, USA
Tel: +1 408 875 3000
Fax: +1 408 875 4144
www.kla-tencor.com

LayTec AG
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Germany
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Fax: +49 30 89 00 180
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www.vacuumbarrier.com

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

12 Inspection equipment

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

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

13 Characterization equipment

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

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

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

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

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

PI (Physik Instrumente) L.P.
16 Albert St . Auburn ,
MA 01501, USA
Tel: +1 508-832-3456,
Fax: +1 508-832-0506
www.pi.ws
www.pi-usa.us

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

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

18 Chip foundry

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

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

19 Facility equipment

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

Vacuum Barrier Corporation
4 Barton Lane, Woburn, MA 01801,
USA
Tel: +1 781 933 3570
Fax: +1 781 933 9428
www.vacuumbarrier.com

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20 Facility consumables

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

W.L. Gore & Associates
401 Airport Rd, Elkton,
MD 21921-4236,
USA
Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

21 Computer hardware & software

Crosslight Software Inc
121-3989 Henning Dr.,
Burnaby, BC, V5C 6P8,
Canada
Tel: +1 604 320 1704
Fax: +1 604 320 1734
www.crosslight.com

Semiconductor Technology Research Inc
10404 Patterson Ave.,
Suite 108, Richmond,
VA 23238,
USA
Tel: +1 804 740 8314
Fax: +1 804 740 3814
www.semitech.us

22 Used equipment

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

24 Resources

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7140 San Jose, CA 95126, USA
Tel: +1 408 289 9555
www.alshuktz.com

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

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

event calendar

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

28 January — 2 February 2023
SPIE Photonics West 2023, including: OPTO conference
The Moscone Center, San Francisco, CA, USA
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-west

28 January – 2 February 2023
SPIE AR/VR/MR
The Moscone Center West,
San Francisco, CA, USA
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/ar-vr-mr

1–3 February 2023
SEMICON Korea 2023
COEX, Seoul, South Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org/en

19–23 February 2023
2023 IEEE International Solid- State Circuits Conference (ISSCC 2023)
San Francisco, CA USA
E-mail: Issccinfo@yesevents.com
www.isscc.org

5–9 March 2023
Optical Fiber Communication Conference and Exhibition (OFC 2023)
San Diego Convention Center,
San Diego, CA, USA
E-mail: custserv@optica.org
www.ofcconference.org

17–21 March 2023
4th International Congress on Advanced Materials Sciences and Engineering (AMSE-2023)
Hilton Vienna Danube Waterfront, Vienna, Austria
E-mail: eve@istci.org
www.istci.org/amse2023

19–23 March 2023
IEEE Applied Power Electronics Conference and Exposition (APEC 2023)
Orange County Convention Center, Orlando, FL, USA
E-mail: apec@apec-conf.org
www.apec-conf.org

20–21 March 2023
China Semiconductor Technology International Conference (CSTIC) 2023, in conjunction with SEMICON China 2023
Shanghai, China
E-mail: cstic@semichina.org
www.semiconchina.org/en/5

22–24 March 2023
SEMICON China and FPD China 2023
Shanghai New International Expo Centre, China
E-mail: semichina@semi.org
www.semiconchina.org/en

26–30 March 2023
2023 IEEE International Reliability Physics Symposium (IRPS)
Hyatt Regency, Monterey, CA, USA
E-mail: IRPSreg@ieee.org
www.irps.org

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25–27 April 2023
26 Annual CMSE (Components for Military and Space Electronics) Conference and Exhibition (CMSE 2023)
Four Points by Sheraton (LAX), Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

7–12 May 2023
2023 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center, San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

21–25 May 2023
LightFair 2023
Javits Center, New York, USA
E-mail: michellem@lightfair.com
www.lightfair.com

23–25 May 2023
SEMICON Southeast Asia (SEMICON SEA 2023)
Setia SPICE Convention Centre & Arena, Penang, Malaysia
E-mail: semiconsea@semi.org
www.semiconsea.org

Microwave Week

11–13 June 2023
2023 IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: support@mtt.org
www.rfic-ieee.org

11–16 June 2023
2023 IEEE/MTT-S International Microwave Symposium (IMS 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/ims2023

11–16 June 2023
43rd Symposium on VLSI Technology & Circuits – 'Rebooting Technology & Circuits for a Sustainable Future'
Rihga Royal Hotel, Kyoto, Japan
E-mail: vlsisymp@jtbcom.co.jp (Asia and Japan) or vlsi@vlsisymposium.org (North America and Europe)
www.vlsisymposium.org

25–29 June 2023
World of PHOTONICS CONGRESS — International Congress on Photonics in Europe
Internationales Congress Center München, Germany
E-mail: info@photonics-congress.com
www.photonics-congress.com/en

11–13 July 2023
SEMICON West 2023
Moscone Center, San Francisco, CA, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

6–8 September 2023
SEMICON Taiwan 2023
TaiNEX 1&2, Taipei, Taiwan
E-mail: semicontaiwan@semi.org
www.semicontaiwan.org

17–22 September 2023
26th European Microwave Week (EuMW 2023)
Berlin Messe, Germany
E-mail: eumwreg@itnint.com
www.eumweek.com

1–5 October 2023
European Conference on Optical Communication (ECOC 2023)
Glasgow, Scotland, UK
E-mail: postmaster@theiet.org
https://ecoc2023.theiet.org

14–18 October 2023
2023 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Monterey, CA, USA
E-mail: cs@cshawevent.com
www.bcicts.org

14–17 November 2023
SEMICON Europa 2023
Messe München,
Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

13–15 December 2023
SEMICON Japan 2023
Tokyo Big Sight,
Tokyo, Japan
E-mail: semicon@sakurain.co.jp
www.semiconjapan.org

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

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