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COMPOUNDS & ADVANCED SILICON

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Silicon carbide power device adoption accelerates

CML buys Microwave Technology • Micross buys KCB Solutions • Ganvix and BluGlass co-developing green GaN VCSELs

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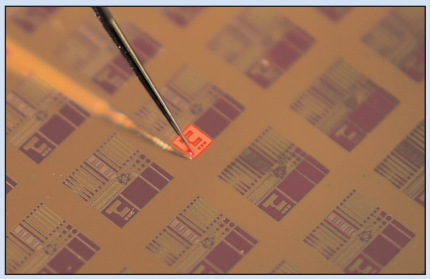
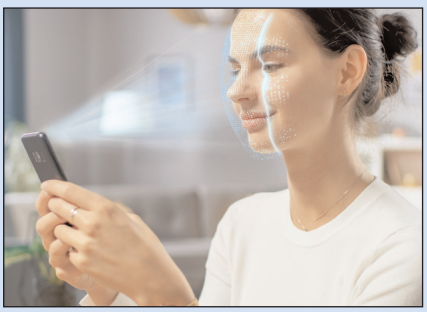
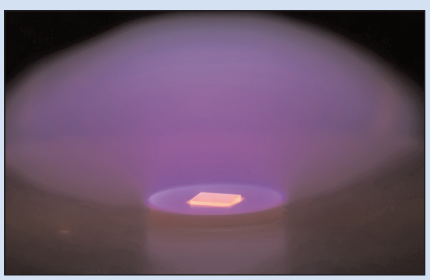


p36 MICLEDI has demonstrated red AlInGaP micro-LEDs at CES, completing its portfolio of RGB micro-LEDs.



p42 TRUMPF has expanded its portfolio of polarization-stable multi-mode VCSELs to improve illumination quality in 3D applications.



p69 Growth of diamond by Arizona State University's Advanced Materials, Processes, and Energy Devices Science and Technology Center.

Cover image: onsemi's EliteSiC power modules are to be used in the traction inverter of Kia's EV6 GT model of electric vehicle. onsemi is collaborating with Hyundai and Kia to use EliteSiC technology for high-performance electric vehicles based on HMC/KIA's Electric – Global Module Platform. **p12**

editorial

SiC relying on continued EV adoption

Over the last month there have been more developments throughout the silicon carbide (SiC) supply chain to meet the demand arising from the transition to electric vehicles (EVs).

In Japan, ROHM's new fourth-generation SiC MOSFETs are being adopted for the EV inverters of automotive parts maker Hitachi Astemo (see page 11). Meanwhile, South Korea's Kia is using US-based onsemi's EliteSiC power modules in its new EV6 GT model, and the technology will be used in Hyundai/Kia's Electric — Global Module Platform (E-GMP) — see page 12.

In addition, US-based Wolfspeed is to supply SiC devices for the next-generation powertrain systems of future EV platforms of Germany's Mercedes-Benz (page 15). The devices will be produced at Wolfspeed's fab in Durham, North Carolina and its new 200mm-wafer Mohawk Valley Fab in Marcy, New York. "Coming from a long-term technical collaboration history between our companies, we have now chosen Wolfspeed as one of our key partners for future SiC devices, thus securing preferred long-term supply, technology and quality of this decisive semiconductor component for our electrification offensive," says Mercedes-Benz.

Most recently, on 21 January, German business newspaper Handelsblatt reported that, together with Germany-based automotive supplier ZF as a minority partner, Wolfspeed is to build a factory near Saarbrücken, in the south-western German state of Saarland, to produce SiC power devices for EVs and other applications. Starting production in four years' time (depending on public-sector subsidies), the new plant would be larger than the Mohawk Valley Fab, which cost about $2bn to establish.

Previously, in November 2019, Wolfspeed (then called Cree) and ZF extended their prior collaboration with a strategic partnership to create electric drivelines. As the largest employer in the region, ZF operates its largest factory nearby, where 9000 staff make transmissions. Last November, it said it was converting its transmission plant in Saarbrücken to make purely electric drives. The firm already uses SiC devices in 800V inverters in series production. The new fab's location has reportedly also been chosen because of its proximity to automotive OEMs and tier-1s in south Germany.

Such developments explain why, despite automotive production being constrained by the shortage of silicon chips and the automotive semiconductor chip market rising at a moderate compound annual growth rate of 11.1% to $80bn in 2027, the use of SiC substrates is forecasted by market research firm Yole to grow more rapidly than that of silicon and gallium arsenide (GaAs)/sapphire substrates (see page 66).

All this relies on the continuing rapid adoption of EVs. However, although the war in Ukraine and consequent high fuel prices has given greater urgency to the need for more energy-efficient technology and renewable energy generation, the concomitant cost-of-living crisis could temporarily slow adoption of EVs by consumers. Also, while EVs reduce environmental pollution, the increased demand on electricity generation threatens to be made unnecessarily larger by the consumer/marketing-driven trend towards larger, heavier cars that consequently are less energy-efficient — many SUVs now weigh 2500–2800kg, including over 800kg of battery. EVs are already 15% heavier than combustion-based cars, and the average weight of cars has risen by 15% over the last 20 years. Although using SiC rather than silicon can reduce the size and weight of the electronics, much still depends on the battery technology, and consumer trends.

Mark Telford, Editor

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***Semiconductor Today* covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices** (e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers and LEDs in wireless and optical communications, etc).

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- news (funding, personnel, facilities, technology, applications & markets);
- feature articles (technology, markets, regional profiles);
- conference reports;
- event calendar and event previews;
- suppliers' directory.

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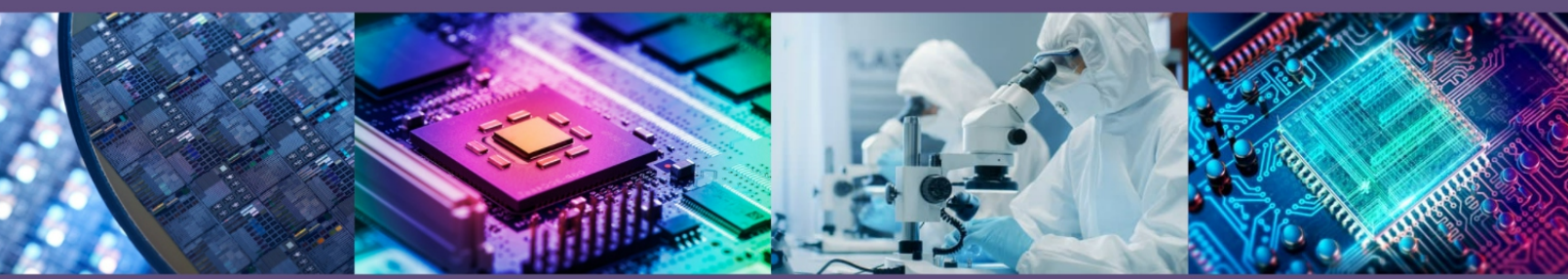

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news

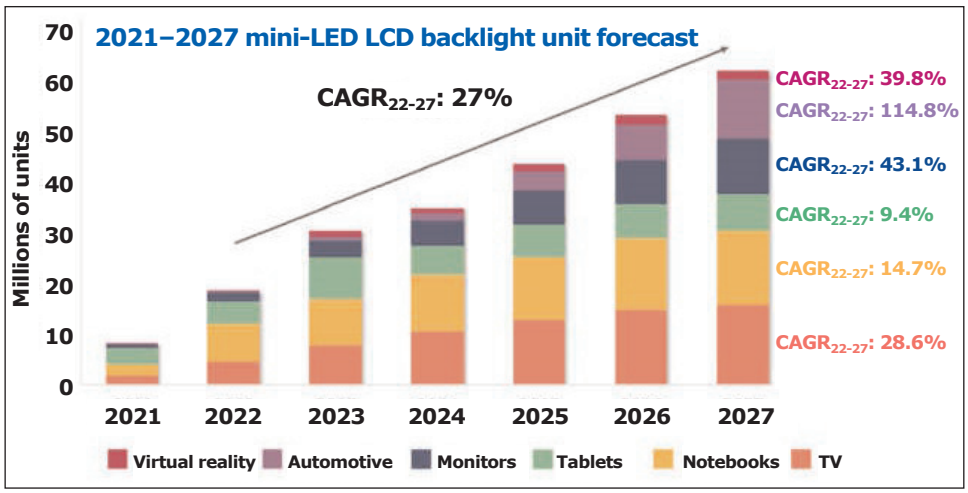
Mini-LEDs to challenge OLEDs in high-end display market

Analysis by Yole Group, PISÉO and DXOMARK estimates over $14bn of mini-LED investment in 2019–2021

With $14bn of investment in mini-LEDs between 2019 and 2021, mini-LED backlight units seem to be on a huge upswing. Neglected for some time by the high-end display market — which is dominated mainly by organic light-emitting diodes (OLEDs) — liquid-crystal displays (LCDs) are back in force with a new technology building block designed to compete with the contrast ratio and image quality provided by OLEDs. By integrating mini-LEDs into the backlight unit, a greater number of dimming zones is created, offering finer backlighting control, thus better managing contrast and halo. With this prospect of enhanced performance, LCD manufacturers aim to get a foot in the door of the high-end display market, further facilitated by greater existing manufacturing capacity and lower investment requirements compared with OLEDs.

However, despite the significant technological leap that mini-LEDs bring to LCDs, display makers are struggling to position themselves on a technology that still requires the consideration of multiple criteria in order to make the most of a mini-LED backlight unit.

Yole Intelligence, Yole SystemPlus, PISÉO and DXOMARK have hence combined their expertise to provide several reports targeting display system designers, system architects, and marketing teams. Through analyses of a selection of four representative displays, the companies highlight the technology options adopted by mini-LED backlight unit designers and identify the impact on product performance and the supply chain. For each display, two reports based on teardown analyses are available:



- a technology, process and cost report powered by Yole SystemPlus that shows the choices in material, backlight unit structure and driver architecture, as well as the associated estimated costs;
- a performance report powered by PISÉO and consumer electronics quality assessment firm DXOMARK combining an in-depth optical stack teardown and user-based visual performance analysis.

Yole Group and its partners studied the following displays and provide input on key issues:

- *TCL Mini-LED X9 85″ TV backlight unit*: considered a pioneer in mini-LED backlighting technology, the Chinese manufacturer TCL is promoting its third generation of mini-LED TVs with an OD-zero solution to reduce the thickness of the backlight unit and the screen. It is interesting to see how they do this and whether their experience in the domain will allow them to further extend their technological leadership, says Yole.
- *Mini-LED backlight unit in Samsung's Neo QLED TV*: first to market with LEDs, then with quantum dots, Samsung is eager to take the reins of the high-end TV market and knock LG and its OLED product range off the top of the leaderboard. Yole says that it is worth taking a look at this unique all-in-one plate construction and its impact on the TV assembly. From a broader point of view, will Samsung manage to close the performance gap with OLED?
- *Mini-LED backlight unit in Samsung's Odyssey Neo G9 49″ Monitor*: in a market that OLEDs struggle to enter, it is interesting to focus on Samsung's technology choices to implement mini-LEDs in what is said to be the first curved mini-LED PC monitor and to compare these choices with the Samsung TV.
- *Mini-LED backlight unit in the Apple iPad Pro 12.9″*: as a leader in the consumer market, all eyes are on Apple's choices to figure out the market and technology trends. In addition, the successful integration of a mini-LED backlight unit in 12.9″ displays could accelerate the adoption of the technology by the automotive display market.
- *A technology, process and cost report of the Skyworth Q72 TV Mini-LED with a Chip-on-Glass BSI is available*: Skyworth is the first manufacturer to integrate very large chip-on-glass technology for the BSI.

www.dxomark.com
www.piseo.fr
www.yolegroup.com

GaN device market grows at 12.13% CAGR from $6.24bn in 2021 to $7bn in 2022

Growth driven by rising use of GaN systems in defense & aerospace

According to a report from the Business Research Company, the global gallium nitride (GaN) device market is estimated to have risen at a compound annual growth rate (CAGR) of 12.13% from $6.24bn in 2021 to $7bn in 2022. This is despite the Russia–Ukraine war disrupting the chances of global economic recovery from the COVID-19 pandemic, at least in the short term, since it has led to economic sanctions on multiple countries, a surge in commodity prices, and supply chain disruptions, affecting many markets across the globe. Longer term, the GaN device market is expected to grow at a CAGR of 15.38% to $12.41bn in 2026.

The GaN device market is expected to be boosted by the increasing use of technically advanced GaN systems in the defense & aerospace sector. Growth is attributed to the rising need for increased bandwidth, as well as performance reliability in radio communications, radars, electronic warfare, and others. GaN-based integrated circuits are used in radars to enable efficient navigation and real-time air-traffic control. Moreover, GaN can provide higher operating frequencies for military jammers, terrestrial radios, and radar communication. For example, in April, US-based radio frequency and microwave solution provider MACOM Technology Solutions Inc was awarded a contract from the US Department of Defense (DoD) to develop a high-power transmitter.

GaN in 5G multi-chip modules

A growing trend in the GaN device market is the incorporation of GaN in multi-chip modules (MCMs) for 5G telecom infrastructure, since the increased electrical performance of such hybrid microcircuits boosts efficiency, and a primary concern is to reduce energy consumption. Because 5G multi-chip modules help to reduce the size and weight of radio units, mobile network operators can reduce the cost of putting 5G on cell towers and rooftops. For instance, in June 2021, Netherlands-based chip designer and maker NXP Semiconductors NV announced the integration of GaN technology into its multi-chip module platform for 5G energy efficiency.

TI the largest competitor in GaN device market

Texas Instruments Inc was the largest player in the GaN device market in 2021, with a 11.25% share of the market. TI's growth strategy focuses on offering innovative solutions through the launch of new products. For example, in November 2020 it launched its next generation of 600V and 650V GaN field-effect transistors (FETs) for industrial and automotive applications.

North America the largest region

North America was the largest region in the GaN device market, at $2.13bn in 2021. The GaN device market in North America is supported by government initiatives aimed at increasing the production of electric vehicles.

www.thebusinessresearchcompany.com

Micross acquires RF & microwave product maker KCB Solutions

RF & microwave switches, attenuators, amplifiers, multi-chip and functional modules added to portfolio

Micross Components Inc of Orlando, FL, USA (a global provider of bare die and mission-critical microelectronic components and services for high-reliability aerospace & defense, space, medical, energy and industrial applications) has acquired KCB Solutions of Shirley, MA, USA, which manufactures RF and microwave surface-mount microcircuits and hybrids. The acquisition further expands the proprietary Hi-Rel component product portfolio of Micross.

As a privately held company and portfolio investment of Artemis Capital Partners of Boston, MA, KCB Solutions has established itself as a supplier of leaded and leadless GaN/GaAs (gallium nitride/gallium arsenide) RF and microwave switches, attenuators, amplifiers, multi-chip and functional modules in both standard and custom form. KCB manufactures products for applications in the space, aerospace and strategic defense end-markets, and its design team has extensive experience serving the requirements of prime customers and system-level contractors. Products are designed to meet MIL-PRF standards, and KCB's US-based operating facility maintains AS9100 quality certification.

"Their 'one source–one solution' end-to-end product and services model makes Micross a valued partner to us and our customers, who expect high-quality RF and microwave solutions," says KCB Solutions' president & CEO Ralph Nilsson. "This is a winning combination of product innovation and the highest level of supply chain services for our hi-rel customers," he adds.

"We are very proud to have partnered with Ralph and the KCB team to grow the business over the past several years," says Artemis managing partner and KCB board member Peter A. Hunter. "As part of Micross, KCB is well positioned for continued growth," he adds.

"The acquisition of KCB Solutions will greatly expand Micross' proprietary portfolio of high-reliability RF and microwave products, which will enhance overall product performance and reduce supply chain risk for the benefit of our customers," says Micross' chairman & CEO Vincent Buffa. "In addition, Micross will leverage the capabilities of its design, packaging and test services to provide our RF and microwave customers with greater value from our 'one source–one solution' business model that will provide them with the most advanced microelectronic solutions available."

www.micross.com
www.kcbsolutions.com
www.artemislp.com

Altum RF achieves expanded scope of registration to ISO 9001:2015

Recertification of quality management system expanded to include design, development, manufacturing and sales

Altum RF of Eindhoven, The Netherlands (which designs high-performance RF to millimeter-wave solutions for commercial and industrial applications) has announced an expanded scope to its re-certification to ISO 9001:2015 for the quality management system. The firm says that the renewed registration demonstrates its commitment to excellence in the design and development of semiconductor products, along with areas of manufacturing and sales, and the expanded scope validates its dedication to regularly supplying high-quality and reliable semiconductor components to customers worldwide.

"We are proud to achieve another important milestone of our quality management system," says CEO Greg Baker. "The expanded scope of our renewed registration to ISO 9001:2015 reaffirms the strategic growth of our company and the transition to a trusted semiconductor supplier."

The ISO 9001:2015 recertification was awarded by TÜV Nederland, part of the international TÜV NORD Group, a global company located in 70 countries that has more than 100 years of experience with quality systems certification.

Altum RF is an international company, with strategic partnerships and office locations that span the globe to support its growing product portfolio. The firm says that it works closely with customers and partners to ensure technical support and customer service. With the help of global partners, it can shorten product development cycles by managing the entire supply chain from design to packaging, testing and qualification.

www.altumrf.com

CML buys Microwave Technology for $18m

Mixed-signal, RF and microwave firm acquires GaAs and GaN device designer

UK-based CML Microsystems Plc, which develops mixed-signal, RF and microwave semiconductors for communications applications, has entered into a definitive agreement to acquire Silicon Valley-based semiconductor firm Microwave Technology Inc (MwT), for up to $18m.

Founded in 1982, MwT designs and manufactures gallium arsenide (GaAs)- and gallium nitride (GaN)-based monolithic microwave integrated circuits (MMICs), discrete devices, and hybrid amplifier products for commercial wireless communication, defense, space and medical (MRI) applications. It became part of the IXYS Corp, which was then acquired in 2018 by Chicago-based technology manufacturing company Littelfuse Inc. In 2019, MwT underwent a management buy-out from Littelfuse, while transitioning away from manufacturing to a fabless semiconductor model with a specific focus on MMICs. The business currently has of just over 20 staff and operates from its sole location in Fremont, CA.

CML says that the acquisition will expand its product portfolio, strengthen and enhance its support resources and increase its R&D capabilities, providing essential knowhow and experience in system-level understanding, product manufacturing and packaging techniques. MwT's products are complementary to CML's existing range, and most of its focus and client concentration is within the USA. CML's board believes that there is a significant opportunity to increase its current market share by internationalizing MwT's products.

The acquisition, which is subject to US regulatory clearance, is valued at a maximum of $18m and will be funded from a mixture of CML's existing cash resources and the issue to the sellers of new CML ordinary shares in a ratio of about 60/40. The MwT team will provide highly complementary management capability for MMIC products, reckons CML.

MwT's unaudited US GAAP results for 2022 recorded revenue of $6.5m and a pre-tax loss of $132,000 with net assets of about $2.4m. The acquisition is expected to complete during first-half 2023. The board expects that MwT will be earnings enhancing in its first full year of ownership within CML.

Upon successful closing of the transaction, MwT's majority shareholder and current chairman Dr Nathan Zommer will join CML's board of directors in a non-executive capacity (subject to completion of normal regulatory due diligence checks). Zommer is the founder of IXYS Corp and was chairman & CEO of IXYS from 1993 until its acquisition in January 2018 by Littelfuse, of which Zommer is also a director. Prior to founding IXYS, he served in a variety of positions with Intersil, Hewlett Packard and General Electric. Zommer holds a bachelor's degree and MS in physical chemistry from Tel Aviv University and a Ph.D. in electrical engineering from Carnegie Mellon University.

"He has unrivalled knowledge of the semiconductor world and I have no doubt that CML can benefit greatly from his expertise," comments CML's group managing director Chris Gurry.

"MwT's dedicated and very experienced team will accelerate our multi-year growth strategy," reckons Gurry. "Their technical knowhow, product range and trading relationships enhance the group's existing competencies, and a shared strong emphasis on cultural synergy and strategic future direction bodes well for the combined businesses over the medium term. CML is committed to supporting MwT's existing customer base globally and, in particular, the USA market," he adds.

"Given the deep understanding of RF and Microwave Technologies that CML has, the combination offers us scaled-up growth with new opportunities," comments Zommer. "We found a great cultural fit, and the combination of silicon, GaAs and GaN design and production capabilities will provide our customers with wider solutions."

www.cmlmicroplc.com
www.mwtinc.com

NEC achieves record output power in 150GHz band using mass-producible GaAs technology

High-speed, high-capacity power amplifier developed for 5G Advanced and 6G networks

Tokyo-based NEC Corp has developed a power amplifier that can serve as a key device for mobile access and fronthaul/backhaul wireless communication equipment to enable high-speed, high-capacity communications for 5G Advanced and 6G networks. The power amplifier uses gallium arsenide (GaAs) technology that can be mass produced and has achieved record output power of 10mW in the 150GHz band. Capitalizing on this, NEC aims to fast-track both the equipment development and social implementation.

5G Advanced and 6G are expected to deliver 100Gbps-class high-speed, high-capacity communications, equivalent to 10 times the speed of existing 5G. This can be effectively achieved through the use of the sub-terahertz band (100–300GHz), which is able to provide a wide bandwidth of 10GHz or more. In particular, early commercialization of the D band (130–174.8GHz) — which is internationally allocated for fixed-wireless communications — is expected.

NEC says that it continues to make advances in technology development by leveraging its knowledge of high-frequency bands cultivated through the development and operation of radio equipment for 5G base stations and PASOLINK, an ultra-compact microwave communication system that connects base stations via wireless communication.

The new power amplifier uses a commercially available 0.1μm GaAs pseudomorphic high-electron-mobility transistor (pHEMT) process. Compared with silicon-based CMOS and silicon germanium (SiGe) used for the sub-terahertz band, GaAs pHEMTs have high operating voltage and lower initial costs for mass production.

In terms of circuit design, the power amplifier eliminates factors that degrade performance in the high-frequency band and uses an impedance-matching network configuration suitable for high output power. This has resulted in the achievement of excellent high-frequency characteristics between 110GHz and 150GHz as well as the world's highest output power for a GaAs pHEMT.

In addition to the realization of high-performance, low-cost radio communication equipment above 100GHz, it is expected that the power amplifier will accelerate the social implementation of 5G Advanced and 6G.

NEC says that, going forward, it will continue to develop technologies aimed at achieving high-speed, high-capacity, cost-effective wireless communications for 5G Advanced and 6G.

This research is supported by the Ministry of Internal Affairs and Communications in Japan (JPJ000254).

NEC is announcing further details regarding this technology at the IEEE Topical Conference on RF/Microwave Power Amplifiers for Radio and Wireless Applications (PAWR2023) in Las Vegas (22–25 January.

www.radiowirelessweek.org/conferences/pawr
www.nec.com

Guerrilla RF announces initial closing of $5m in private placement equity financing

Funds to be used on new HQ and supporting continued growth

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 announced the initial closing of its private placement, providing gross proceeds of about $5m (not including any additional proceeds that may be received upon further closings or the exercise of warrants).

Accredited investors purchased about 3,900,000 units, each comprising one share of the firm's common stock and one warrant to purchase 0.5 of a share for $1.30 per unit. The warrants have an exercise price of $2.00 per share and a term of five years.

"The successful execution of this offering is a testament to the opportunity that our investors see in the company," says CEO & founder Ryan Pratt. "Since 2020, we have grown the number of new products launched and also dramatically developed our GPS navigation and IoT sales," he adds. "The funds raised through this offering will be used to fund the company's new headquarters and also support our continued growth."

Laidlaw & Company (UK) Ltd served as the placement agent for the offering. GP Nurmenkari Inc (as consulted by Intuitive Venture Partners) served as a selected dealer, and Brooks, Pierce, McLendon, Humphrey & Leonard LLP served as legal counsel for the company.

http://guerrilla-rf.com

ROHM appoints new director for its Application and Technical Solution Center in Europe

Günter Richard succeeded by Aly Mashaly, reporting to president of ROHM Semiconductor Europe

Japan-based ROHM says that, following the retirement of Günter Richard (after 32 years working for the firm), he has been succeeded as the director of its European Application and Technical Solution Center (ATSC) by Aly Mashaly (as of 1 January).

Before joining ROHM in 2015, Mashaly gained more than 20 years of experience in the electronics industry. He has expertise in power electronics, especially in the field of automotive applications, and has worked as a development engineer and project manager in e-mobility and aerospace applications for several years.

Mashaly is also a regular speaker at conferences including PCIM, ECPE, EPE and CS International. He holds degrees from the Ain Shams University Cairo and Leibniz University Hanover, where he studied electrical engineering.

Aly Mashaly,

"With our highly skilled team, technical services and high-quality products we strive for excellence to be a competent partner to our customers. On top, we want to be a supplier and partner for innovative solutions to help our society to overcome some pressing challenges of our time," says Mashaly.

"I would also like to express my gratitude to my predecessor Günter Richard, who has established the Application and Technical Solution Center back in 2019 and who has made the transition very easy to me," he adds.

Mashaly now reports directly to Wolfram Harnack, president of ROHM Semiconductor Europe in Willich-Münchheide, near Dusseldorf, Germany: "Based on his huge amount of proven technical experience as well as his demonstrated leadership skills and commitment towards ROHM, I'm convinced that Mr Mashaly will bring the ATSC and the technical customer service involved to the next level," says Harnack.

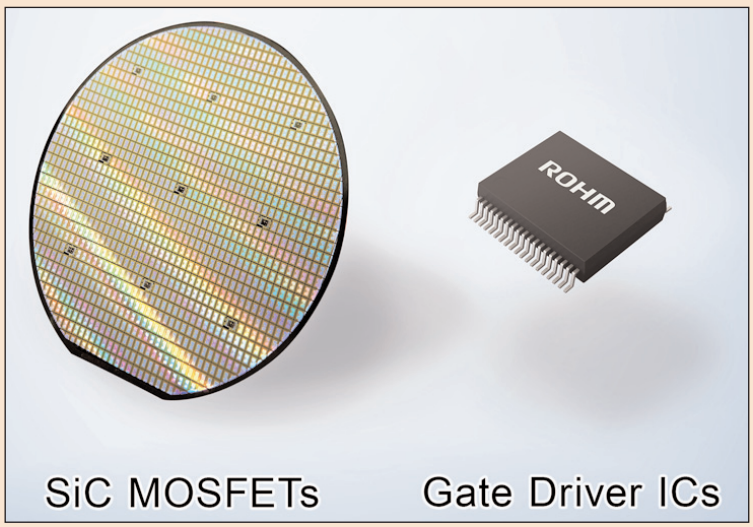
ROHM's fourth-generation SiC MOSFETs to be used in Hitachi Astemo's EV inverters

Inverters to be supplied to automakers from 2025

Japan's ROHM has announced the adoption of its new fourth-generation silicon carbide (SiC) MOSFETs and gate driver integrated circuits in electric vehicle (EV) inverters made by Japanese automotive parts maker Hitachi Astemo Ltd.

Especially for EVs, the inverter, which plays a central role in the drive system, needs to be made more efficient to extend the cruising range and reduce the size of the onboard battery, increasing the expectations for SiC power devices.

ROHM says that its latest fourth-generation SiC MOSFETs deliver improved short-circuit withstand time along with what is said to be the industry's lowest ON-resistance, making it possible to extend the cruising range of electric vehicles by reducing power consumption by 6% versus silicon insulated-gate bipolar transistors (as calculated by the international standard WLTC fuel efficiency test) when installed in the main inverter.



Hitachi Astemo, which has been developing advanced technologies for vehicle motors and inverters for many years, already has a track record in the increasingly popular EV market. However, this is the first time that SiC devices will be adopted for the main inverter circuit to further improve performance. The inverters are scheduled to be supplied to automakers from 2025, starting in Japan and then expanding overseas.

www.hitachiastemo.com/en
www.rohm.com

Onsemi's silicon carbide power module selected for traction inverter in Kia's EV6 GT model

EliteSiC to be used in high-performance electric vehicles based on Hyundai/Kia's Electric – Global Module Platform

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA says that its EliteSiC family of silicon carbide (SiC) power modules has been selected for Kia Corp's EV6 GT model. The electric vehicle (EV) accelerates from zero to 60mph in 3.4 seconds and reaches top speed at 161mph. Within the traction inverter of a high-performance EV, the EliteSiC power module enables high-efficiency power conversion from the DC 800V of the battery to the AC drive for the rear axle. onsemi continues to collaborate with South Korean auto makers Hyundai Motor Company and Kia Corp (HMC/KIA) to use EliteSiC technology for the upcoming high-performance EVs based on HMC/KIA's Electric – Global Module Platform (E-GMP).

onsemi says that its high-power-density SiC power module delivers the package technology to minimize parasitics and thermal resistance and offers robust package reliability using innovative interconnects. This leads to reduced power losses associated with DC-to-AC conversion along with reduced size and weight of the traction inverter, increasing performance and EV range by 5%.

onsemi notes that its power module technology delivers power traction solutions through the firm's decades of packaging expertise in high-density power solutions for automotive applications. Packaging technology alongside an evolutionary path from planar to trench cell structures in SiC enable onsemi to provide highly robust and reliable solutions to HKMC/KIA.

"Our collaboration with HMC/KIA is rooted in the superior performance of our EliteSiC technology," says Simon Keeton, executive VP & general manager of onsemi's Power Solutions Group. "As important is our quickly growing, vertically integrated SiC supply chain that allows onsemi to plan for the necessary scale to support high-volume production for EVs," he adds.

www.onsemi.com/products/discrete-power-modules/power-modules

Onsemi showcases EliteSiC MOSFETs & Schottkys at CES

1700V devices targeted at energy infrastructure and industrial drives

At the Consumer Electronics Show (CES 2023) in Las Vegas (5–8 January), onsemi showcased three new members of its EliteSiC family of silicon carbide (SiC) devices: the 1700V EliteSiC MOSFET and two 1700V avalanche-rated EliteSiC Schottky diodes. The new devices provide reliable, high-efficiency performance for energy infrastructure and industrial drive applications, the firm says.

With the 1700V EliteSiC MOSFET (NTH4L028N170M1), onsemi delivers higher breakdown voltage (BV) SiC solutions, required for high-power industrial applications. The two 1700V avalanche-rated EliteSiC Schottky diodes (NDSH25170A, NDSH10170A) allow designers to achieve stable high-voltage operation at elevated temperatures while offering high efficiency enabled by SiC.

"By providing best-in-class efficiency with reduced power losses, the new 1700V EliteSiC devices reinforce the high standards of superior performance and quality for products in our EliteSiC family as well as further expand the depth and breadth of onsemi's EliteSiC," says Simon Keeton, executive VP & general manager of onsemi's Power Solutions Group. "Together with our end-to-end SiC manufacturing capabilities, onsemi offers the technology and supply assurance to meet the needs of industrial energy infrastructure and industrial drive providers."

Renewable energy applications are consistently moving to higher voltages with solar systems from 1100V to 1500V DC buses. To support this change, customers require MOSFETs with a higher BV. The new 1700V EliteSiC MOSFET offers a maximum V_{gs} range of −15V/25V, making it suitable for fast switching applications where gate voltages are increasing to −10V, delivering increased system reliability.

At a test condition of 1200V at 40A, the 1700V EliteSiC MOSFET achieves a gate charge (Q_g) of 200nC — claimed to be market-leading compared with equivalent competing devices, which are closer to 300nC. A low Q_g is critical to achieving high efficiency in fast-switching, high-power renewable energy applications.

At a BV rating of 1700V, the EliteSiC Schottky diode devices offer improved margin between the maximum reverse voltage (V_{RRM}) and the peak repetitive reverse voltage of the diode. The new devices also provide what is said to be excellent reverse leakage performance with a maximum reverse current (I_R) of just 40µA at 25°C and 100µA at 175°C — significantly better than competing devices often rated at 100µA at 25°C.

www.ces.tech

onsemi's EliteSiC MOSFETs being used in Ampt's DC string optimizers

Collaboration to boost efficiency for utility-scale solar

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA and Ampt LLC of Fort Collins, CO, USA, which provides DC optimizers for large-scale photovoltaic (PV) solar and energy storage systems, have announced a collaboration to meet the high demand for DC string optimizers. Ampt uses onsemi's N-Channel SiC MOSFET, part of the EliteSiC family of silicon carbide devices, in its DC string optimizers for critical power switching applications.

Ampt string optimizers are used in large-scale PV power plants, enabling lower-cost and higher-performing solar and DC-coupled energy storage systems that are collocated within the solar power plant. The string optimizers deliver power from the PV array at a high and fixed voltage for system voltages ranging from $600V_{DC}$ to $1500V_{DC}$, reducing the overall current requirements and cost of the power plant. Ampt optimizers enable higher round-trip — charging and discharging — efficiency in the energy storage system and solar power plant by leveraging onsemi's latest SiC MOSEFT technology with lowest ON-resistance and switching loses.

"Incorporating onsemi's EliteSiC technology into our DC optimizers helps utility-scale solar developers and owners improve their project economics," says Ampt's CEO Levent Gun. "Clearly, the product performance was a critical decision point for us, but onsemi's technical support during the design phase and their ongoing supply assurance to support Ampt's rapid scaling are the hallmarks of a strong partner."

The EliteSiC device offers an $R_{DS(on)}$ of 80mΩ nominally and a low gate charge (Q_g) value of 56nC along with lower R_g of 1.7Ω. It is capable of operating at junction temperatures of 175°C, reducing the thermal management requirements in applications, resulting in smaller, lower-cost solutions.

"The combination of performance and reliability of our EliteSiC technology enables efficient and dependable DC optimizers and is what an industry leader such as Ampt expects," says Simon Keeton, executive VP & general manager of onsemi's Power Solutions Group. "We look forward to a continued collaboration on new products that drive renewable energy applications forward."

www.onsemi.com

Wolfspeed appoints Elif Balkas as chief technology officer

VP of research & development succeeds the late John Palmour

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — has promoted Elif Balkas to chief technology officer, succeeding the late Dr John Palmour, a co-founder of Wolfspeed, who died on 13 November.

"Since her start with Wolfspeed in 2006, Elif has been instrumental in our technology and production development, and she was the clear choice to help steer Wolfspeed as we continue to lead the transition from silicon to silicon carbide," says CEO Gregg Lowe. "One of John's greatest legacies is the talent he nurtured and developed on the Wolfspeed team, and we are confident Elif will continue to drive innovation in silicon carbide with passion, ingenuity and leadership."

In her role as VP of research & development in Wolfspeed's Materials organization, Balkas shaped the company's technical strategy on wide-bandgap materials and drove its development execution to maintain Wolfspeed's position in silicon carbide for power and RF device applications.

Elif Balkas.

During her tenure, she has overseen multiple technology milestones, including the development of 150mm and 200mm boule growth systems and processes, the dramatic reduction in crystal defect levels that saw higher device yields, and advancements in wafer processing.

The late John Palmour.

"I'm excited to continue building upon the legacy that John created and unlock new innovations and applications for silicon carbide," says Balkas. "I look forward to the new challenge of finding greater efficiencies as we continue to expand the reach of our technology."

Balkas has more than 20 years of experience in the technology industry. Prior to Wolfspeed, she served in leadership positions in R&D and operations, focusing on developing silicon carbide crystal growth and GaN technologies that are scalable for manufacturing purposes and that enable more efficient and powerful electronic systems. She received her Ph.D. in Materials Science from North Carolina State University and is a co-founder of the Wolfspeed Women's Initiative, an employee resource group focused on encouraging, developing and supporting women who lead the way in innovation.

www.wolfspeed.com

Wolfspeed appoints Stacy Smith to board

Ex-Intel veteran to aid scale-up to meet demand for silicon carbide power devices

Wolfspeed says that Stacy Smith has been appointed to its board of directors, effective 23 January.

Smith is executive chairman of flash memory company Kioxia Corp (formerly Toshiba Memory Corp) and non-executive chair of the board at design and make technology Autodesk Inc.

"With his vast experience in the technology and semiconductor industries, Stacy will be an invaluable asset for Wolfspeed as we work to capitalize on the steepening demand for silicon carbide power devices across the e-mobility, industrial and renewable markets," says chairman of the board Darren Jackson. "We look forward to his contributions and expertise," he adds.

Stacy Smith.

"I am really excited to join the Wolfspeed Board and work to help Wolfspeed scale and grow their leadership position in a fast-growing and important market," says Smith.

Prior to his board positions, Smith worked at Intel Corp for three decades in a variety of roles including group president of sales, manufacturing and operations, chief financial officer, chief information officer, and head of Europe Middle East and Africa.

Smith's management positions with Intel, including his finance and executive roles, provide him with insight into the operational requirements of a global company and the management and consensus-building skills necessary to serve on Wolfspeed's board of directors, says the firm. He also holds positions on the California Chapter of The Nature Conservancy Board of Trustees and University of Texas McCombs School of Business Advisory Board. Prior board roles include serving on the board of Virgin America Airlines and biofuels company GEVO.

Wolfspeed to supply silicon carbide devices for future Mercedes-Benz EV platforms

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — is to supply silicon carbide devices for future Mercedes-Benz electric vehicle (EV) platforms, enabling greater efficiency in the powertrain. Wolfspeed's semiconductors will be incorporated into next-generation powertrain systems for several vehicle lines.

"Coming from a long-term technical collaboration history between our companies, we have now chosen Wolfspeed as one of our key partners for future silicon carbide devices, thus securing preferred long-term supply, technology and quality of this decisive semiconductor component for our electrification offensive," says Dr Gunnar Güthenke, head of procurement and supplier quality.

Wolfspeed says that, by leveraging its expertise and silicon carbide devices to improve vehicle range and power, Mercedes-Benz plans to have some of the most efficient EVs on the road.

"We are pleased to be supporting Mercedes-Benz, an organization with a long, successful history of providing world-class performance and luxury vehicles, as they introduce next-generation EVs to the market with highly efficient power systems," comments Wolfspeed's CEO Gregg Lowe. "We are continuing to invest in our manufacturing capacity to support a steepening demand curve for silicon carbide devices that will not only improve EV performance and drive greater consumer adoption, but also support the sustainability efforts of global automotive leaders like Mercedes-Benz."

The silicon carbide power devices for Mercedes-Benz will be produced at Wolfspeed's facilities in Durham, North Carolina and its new 200mm Mohawk Valley Fab in Marcy, New York. The Mohawk Valley Fab is the world's largest silicon carbide fabrication facility and is dramatically expanding Wolfspeed's production capacity. In September 2022, Wolfspeed also announced it was beginning construction on a new silicon carbide materials facility in North Carolina, which will expand its SiC capacity by more than 10x.

Wolfspeed made Official Power Semiconductor Partner of Jaguar TCS Racing Formula E team

Lighter, more powerful and faster Gen3 car for 2023 championship

Jaguar TCS Racing has revealed the Jaguar I-TYPE 6, designed and engineered to compete for the 2023 ABB FIA Formula E World Championship, as the all-electric motorsport category moves into a new Gen3 era on 14 January in Mexico City for the first of Season 9's 17 races in 12 cities.

It is the first FIA Formula E race car to feature both front and rear powertrains, as 250kW regen is added to the front and 350kW regen added at the rear, doubling the regenerative capability over the Gen2 model and removing the need for conventional rear brakes.

The third generation of Jaguar's Formula E race car is 74kg lighter and 100kW more powerful than the prior generations, and can now reach a maximum speed of 200mph.

The next generation of Formula E will continue to be a real-world testbed for Jaguar TCS Racing and carmaker Jaguar Land Rover (which aims to be an all-electric brand by 2025, and to achieve carbon net zero across its supply chain, products and operations by 2039). As the team develops new technology, it will power race-to-road learning for electric powertrain, sustainability and software technologies.

Ahead of the 2023 championship, Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices — has been confirmed as Official Power Semiconductor Partner. The partnership builds on Wolfspeed's existing relationship with the team since 2017, where its SiC technology has been used to accelerate on-track efficiency and performance.

"Their expertise in silicon carbide technology will play a pivotal role in our powertrain performance," comments Jaguar TCS Racing's team principal James Barclay.

Jaguar Land Rover also recently announced a strategic partnership with Wolfspeed, securing supply of SiC devices for the next generation of electric vehicle inverters. Both partnerships will support the technology and knowledge transfer from race-to-road, with a particular focus on efficiency.

"Our silicon carbide semiconductor technology in the Jaguar I-TYPE 6 creates an 'Innovation Lab on Wheels' to engineer improved powertrain efficiency in a high-performance electric vehicle," says Jay Cameron, general manager of Wolfspeed's Power business. "Collaboration with Jaguar TCS Racing in the ABB FIA Formula E World Championship will support our shared goal of translating innovation from the race to the road."

www.wolfspeed.com

CEA and Renault develop wide-bandgap-based bidirectional on-board charger for EVs

More compact, high-efficiency charger to cut energy losses by 30% and recharge battery faster

CEA (the French Atomic and Renewable Energy Commission) and Renault Group are working on future generations of vehicle-to-grid (V2G), the bidirectional exchange technology that enables electric vehicles to restore part of the electricity stored in their batteries to optimize the operation of the grid and compensate for the intermittent nature of renewable energies.

To this end, the CEA and Renault Group have jointly developed a new electronic power converter architecture directly integrated into the charger of electric vehicles. The result of nearly three years of research and the subject of 11 joint patents, this power converter, developed from innovative materials and more compact, should reduce energy losses by 30%, improve the vehicle's recharging time and guarantee the battery's durability. Also, it will be bidirectional by storing energy from the electricity network.

Innovative materials

The CEA and Renault Group R&D teams have combined their expertise in on-board power electronics, in particular in wide-bandgap semiconductor materials, whether gallium nitride (GaN) or silicon carbide (SiC).

As a result, the new architecture based on the wide-bandgap semiconductor materials makes it possible to reduce energy losses by 30% during conversion, and to reduce heating by the same amount, making it easier to cool the conversion system.

Reducing volume of the loader

In addition, the engineers' work to optimize the active (semiconductors) and passive (capacitors and wound inductive components) components has enabled a reduction in the volume and cost of the charger. Due to the use of ferrite materials, dedicated to high frequency, and a shaping injection process (power injection molding), the converter has become more compact.

Towards more performance

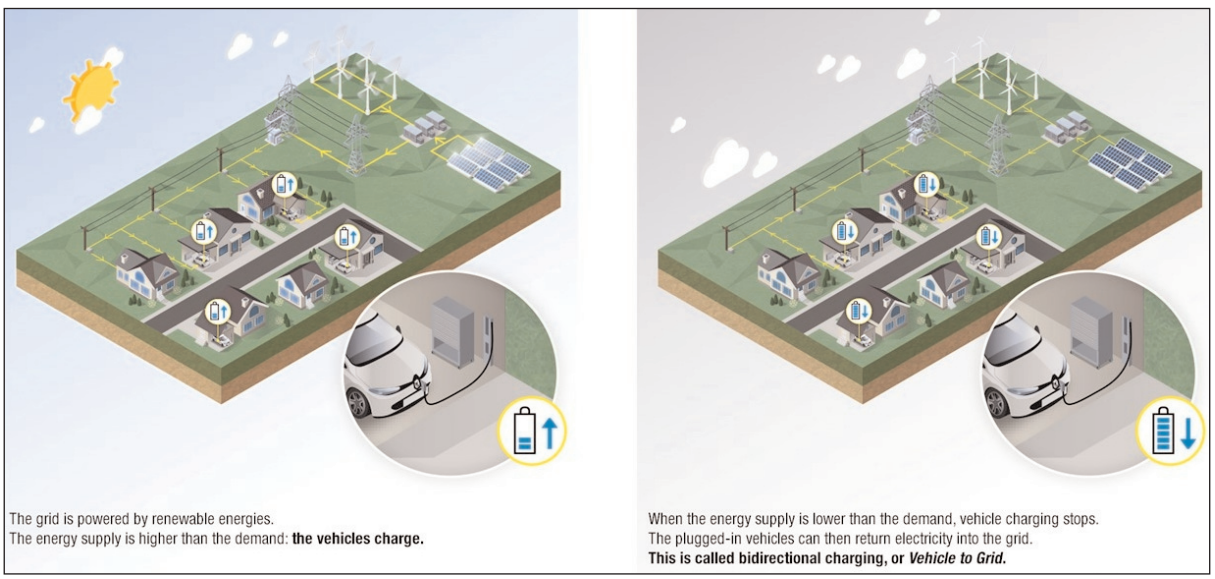
This new converter architecture offers a charging capacity of up to 22kW in three-phase mode, allowing for faster charging of the vehicle while ensuring the durability of the battery. It also allows the charger to be bidirectional, so that the energy stored in the battery can be fed back into the grid or used to supply the energy needs of an autonomous house, provided that the house is equipped with a bidirectional meter. The solution is compatible with the electromagnetic compatibility (EMC) standards of the networks and the car.

"This project with the CEA has exceeded our expectations by confirming the ability to achieve the expected performance in terms of efficiency and compactness," says Jean-François Salessy, VP advanced engineering, Renault Group. "It opens up strong prospects for power electronics, which is a real challenge in the electric vehicle, in order to make the best use of the batteries' capacities. With bidirectional charging, the vehicle serves the electrical network and enables the end consumer to reduce energy costs," he adds.

"We were able to bring together Renault Group's system vision for the electrification of the vehicle and the drive train, and the skills of our teams in converter architectures and components; in the end, we implemented an architecture adapted to the needs and with high added value," says CEA-Leti's CEO Sébastien Dauvé.

"The use of innovative materials with joint Renault Group-CEA patents on the charger made it possible to manufacture the dedicated transformer, which is a key component in this type of development, as it allows for a reduction in volume with performance that goes beyond the state of the art," says CEA-Liten's CEO François Legalland.

www.leti.fr



The grid is powered by renewable energies.
The energy supply is higher than the demand: **the vehicles charge.**

When the energy supply is lower than the demand, vehicle charging stops.
The plugged-in vehicles can then return electricity into the grid.
This is called bidirectional charging, or *Vehicle to Grid*.

Fuji Electric
Innovating Energy Technology

Fuji Electric G-Twin UL Plug-In Series

New High Quality Product with improved safety features, easy installation and compact

TÜV Rheinland IEC JIS EN c UL us LISTED CE

Global Standard

The New Generation of Molded Case Circuit Breakers and Earth Leakage Circuit Breakers.

- ★ Built-In Compact Ground Fault for Space Saving Designs
- ★ Same Footprint! MCCBs and ELCBs interchangeable without Panel Modifications
- ★ All frame sizes (50AF-250AF) can be mounted with the same mounting pitch of 70mm
- ★ Lock Out Tag Out (LOTO) safety devices (fixed and removable types) are available as an option
- ★ Improves safety measures and easy & quick installation
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Infineon's CoolSiC power devices chosen by Bloom for Energy Server and Electrolyzer

Silicon carbide MOSFETs and diodes used in power supply of hydrogen fuel cell system

Infineon Technologies AG of Munich, Germany says that its CoolSiC MOSFETs and CoolSiC diodes have been chosen by California-based Bloom Energy to process electrical power in its hydrogen-powered Energy Server and Electrolyzer.

Bloom Energy's fuel cells and electrolyzers address climate change and offer multiple pathways to zero-carbon emission. They enable a combustion-free method for generating resilient, sustainable and predictable energy. The individual solid oxide fuel cells (SOFC) of the energy platform run on natural gas, biogas or hydrogen. With high electrical efficiency, the system provides a continuous power supply that is robust to grid failures and weather conditions from –20°C to +45°C.

"The global reduction of CO_2 emissions and a successful energy transition are two of the greatest challenges to stop climate change on our planet," says Dr Peter Wawer, president of Infineon's Industrial Power Control Division. "At Infineon, we are convinced that hydrogen is an excellent alternative to CO_2-emitting energy sources, making it an important tool in the decarbonization of the energy industry and the automotive industry. We are therefore very pleased to seeing our CoolSiC devices make a major contribution to the optimization and further development of hydrogen technologies."

1200V CoolSiC MOSFET in a TO247-4 package.

For efficiency reasons, Bloom Energy has decided to integrate CoolSiC MOSFETs and diodes for the power supply of their fuel cell system. Compared with the previous silicon-based generation, this improved the system's energy efficiency by one percent and power density by 30%. In addition, both the size and cost of the system were reduced by 30%.

The CoolSiC MOSFET IMZ120R030M1H in a TO-247-4 package enables what is claimed to be best-in-class switching and conduction losses and offers a high threshold voltage of V_{th}>4V. For simple and straightforward gate control, it features 0V turn-off gate voltage. The device comes with a wide gate-source voltage range and a robust, low-loss body diode designed for hard commutation. It also offers temperature-independent turn-off switching losses.

The CoolSiC Schottky diode IDW30G120C5B comes in a TO-247-3 package and delivers what is claimed to be an industry-leading forward voltage. In addition, the diode has no reverse recovery charge and delivers what is claimed to be best-in-class surge current capability as well as excellent thermal performance.

www.infineon.com/green-energy

Infineon signs new SiC material multi-year supply and cooperation deal with Resonac

Former SDK focusing on 6" then 8", with Infineon providing SiC IP

Infineon Technologies AG of Munich, Germany is extending its cooperation with silicon carbide (SiC) suppliers by signing a new multi-year-supply and cooperation agreement with Tokyo-based wafer manufacturer Resonac Corp (formerly Showa Denko K.K. until its integration with Showa Denko Materials Co Ltd on 1 January), complementing and expanding the announcement of 2021. The new set of contracts will deepen the long-term partnership on SiC material. Resonac will supply Infineon with SiC materials for the production of SiC semiconductors, covering a double-digit share of the forecasted demand for the next decade.

While the initial phase focuses on 6"-wafer SiC material supply, Resonac will also support Infineon's transition to 8" wafer diameter during the later years of the agreement. As part of the cooperation, Infineon will provide Resonac with intellectual property relating to SiC material technologies. The Infineon–Resonac partnership is intended to contribute to supply chain stability.

"Demand for SiC is growing rapidly and we are preparing for this development with a significant expansion of our manufacturing capacities," says Infineon's chief procurement officer Angelique van der Burg. "We are pleased to deepen our collaboration with Resonac and strengthen the partnership between our two companies," she adds.

"The business opportunities in the area of renewable energy generation and storage, electro-mobility and infrastructure are enormous for the years to come," says Peter Wawer, president of Infineon's Industrial Power Control division. "Infineon is doubling down on its investments into SiC technology and product portfolio, to proliferate the most comprehensive product offering to its customers… Our partnership with Resonac will strongly support our market-leading position," he adds.

"We are pleased to team-up with Infineon as a global leader in power semiconductors in order to meet the growing demand for SiC in the years to come. We will continuously improve our best-in-class SiC material and develop the next generation of 8" wafer technology. We value Infineon as an excellent partner in this regard," says Jiro Ishikawa, executive adviser for Resonac's Device Solutions business unit.

Infineon is expanding its SiC manufacturing capacity in order to reach a market share of 30% by the end of the decade. The firm's SiC manufacturing capacity is about to increase tenfold by 2027. A new plant in Kulim is scheduled to start production in 2024. Infineon already provides SiC semiconductors to more than 3600 customers worldwide.

www.resonac.com
www.infineon.com

Odyssey shipping vertical GaN product samples to customers from Q1

Product development agreements with customers expected by end-Q2

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA, which is developing high-voltage vertical power switching components based on proprietary gallium nitride (GaN) processing technology, says that fabrication of 650V and 1200V vertical GaN product samples was completed as planned in fourth-quarter 2022 and that customer shipments start in first-quarter 2023.

"We will work closely with these initial customers to gain valuable feedback on their product features," says CEO Mark Davidson. "We expect to secure product development agreements with customers by the end of Q2/2023."

The completion of product sample fabrication requires significant intellectual property to fabricate products that apply to customer use-cases, says the firm. Odyssey adds that it continues to develop and protect the IP required and will gain further advantage by partnering with lead customers who will provide additional insights.

Odyssey reckons that its approach to vertical GaN will offer even greater commercial advantages over silicon than silicon carbide (SiC) or lateral GaN. Vertical GaN offers a 10x advantage over silicon carbide at performance and cost levels unattainable by the competing technologies, it is claimed.

Odyssey notes that the market it is pursuing is large and fast growing. The 650V segment is the larger market currently, expected to grow at a compound annual growth rate (CAGR) of 20%. The 1200V product market segment is expected to grow faster, at a 63% CAGR, and is forecasted to become the larger market in the second half of this decade. Collectively, the 650V and 1200V power device market is forecasted by market research firm Yole Group to grow at a combined CAGR of 40% to more than $5bn in 2027.

www.odysseysemi.com

Finwave joins American Semiconductor Innovation Coalition

ASIC aims to support research, development, prototyping and manufacturing transfer goals of NSTC and NAPMP

Finwave Semiconductor Inc of Waltham, MA, USA has joined the American Semiconductor Innovation Coalition (ASIC). ASIC recently expanded its membership to include representatives from all stages of the chipmaking supply chain, and Finwave will be joining fellow technology innovators to advance US semiconductor R&D.

ASIC is a coalition of more than 160 organizations developing a proposal to utilize CHIPS and Science Act funding — and serves as the main technical driver of the National Semiconductor Technology Center (NSTC) and the National Advanced Packaging Manufacturing Program (NAPMP). ASIC supports the research, development, prototyping and manufacturing transfer goals of the NSTC and NAPMP and ensures that they are met.

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

Currently, GaN semiconductors are almost exclusively manufactured outside the USA. Together with ASIC, Finwave aims to stimulate 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.

Seeking to unlock the promise of 5G, Finwave says that its 3DGaN FinFET technology combines best-in-class power amplification efficiency with high-volume manufacturing to overcome the performance and cost limitations that have together stymied widespread adoption of mmWave. The firm claims that it significantly improves linearity, output power and efficiency in 5G mmWave systems — while greatly reducing costs for carriers. By leveraging high-volume 8"-wafer silicon CMOS fabs for producing 3DGaN chips, Finwave's devices benefit from both the cost model and scalability of silicon technology. By joining ASIC's growing membership of companies, universities, startups and nonprofits, Finwave will have access to high-volume fabs and the lithography requirements necessary to bring its technology to volume production.

"Finwave is pleased to join ASIC and its members in the pursuit of strengthening US technology leadership and expanding domestic semiconductor production," says CEO Bin Lu. "ASIC's work to create technology hubs – and develop US supply chains and production for our future economic prosperity and national security – aligns perfectly with our goal to provide disruptive 3DGaN FinFET IC technology. Continued development of our technology will help strengthen America's technology supply chains and leadership, increase production and grow jobs in the US," he adds.

"Finwave is a proven GaN innovator, and the company's input and expertise will be key to helping advance US semiconductor R&D leadership," reckons Douglas Grose, Ph.D., spokesperson for ASIC. "With roots in MIT and the Northeast, Finwave is a shining example of U.S.-based innovation — and an ideal member company to support us in our mission to move manufacturing in this country forward."

www.finwavesemi.com
http://asicoalition.org

Navitas acquiring remaining stake in silicon control IC JV

Capability to accelerate GaN & SiC share gains vs silicon power devices

Gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA has agreed to acquire the remaining minority interest in its silicon control IC joint venture from Halo Microelectronics (which develops analog and power management integrated circuits) for $20m in Navitas stock.

In 2021, Navitas and Halo created a joint venture to develop application-specific silicon controllers that are optimized to work in combination with Navitas GaN ICs to set new standards for efficiency, density, cost and integration for a wide range of applications.

The first family of products has been developed and released to production, addressing AC–DC power supply applications across mobile, consumer, home appliance and auxiliary power supplies in enterprise, renewables, electric vehicles (EV) and other related markets. The silicon controller and GaN ICs combine either as a chipset or are co-packaged, to target 20–500W applications, and have already been adopted by dozens of customers set to introduce their next-generation products later this year.

As Navitas was already the majority shareholder, financial results from the joint venture have already been reflected in Navitas' historical financial statements and guidance. The transaction is expected to close in February. The addressable market potential for this additional silicon controller capability is estimated to exceed $1bn per year by 2026.

"This is another strategic acquisition for Navitas as we integrate critical silicon controller capabilities with our leading-edge GaN and SiC technologies," says CEO & co-founder Gene Sheridan. "Silicon controllers are needed in all power systems and largely define the architecture of those systems. By combining silicon controllers with GaN and SiC, Navitas is uniquely positioned to influence customer architecture decisions to maximize the system benefits and Navitas' value when using GaN or SiC in next-generation power electronics," he reckons.

www.navitassemi.com
www.halomicro.com

Navitas presents partner insights at CES 2023

Consumer brands Anker, OnePlus, Spigen and Ugreen highlight smartphone and laptop charging

A the Consumer Electronics Show (CES 2023) in Las Vegas (5–8 January), Navitas hosted a partner speaker series 'Navitas Presents', giving an end-market view of how next-generation technology is replacing legacy silicon chips in fast charging and small size for ultimate portability.

Each speaker is highlighting how the use of GaN advances their own designs, with additional references to sustainability. Each live presentation is followed by Q&A, and attendees also have the chance to win a variety of prizes in the GaNFast Giveaway and OnePlus-GaNFast Gaming Experience, plus the last chance to enter to win a Tesla Model 3 Performance, worth $60,000.

'Navitas Presents:' was designed to showcase 'Planet Navitas' — an immediate implementation of tomorrow's sustainable, achievable, everyday world built on advanced GaN and SiC technologies. Among the topics covered are the importance of GaN-based solutions in delivering the faster charging, extended battery life, compact form factors and sustainability demanded by consumers. The significance of these requirements was underlined in a recent OnePlus survey, referenced during the OnePlus speaker sessions.

The series also includes Navitas presentations covering diversified end-uses from 20W cell-phone chargers to 2kW data-center power, 20kW electric vehicle (EV) chargers and on to MW-scale grid-tied applications.

The presentations were as follows:

- Anker Innovations' chief communications officer Eric Villines — 'GaN - Driving the next generation of sustainable power delivery solutions';
- OnePlus North America's head of PR & Communications Spenser Blank — 'The Power of GaNFast Technology on the OnePlus 10T5G';
- Spigen's senior PR specialist Justin Ma — 'Something You Want with Navitas GaN';
- Ugreen's creative marketing manager Rollins — 'Charging Into The GaNFast Future';

Navitas speakers:

- CEO & co-founder Gene Sheridan — 'Electrify Our World'
- senior director Llew Vaughan-Edmunds — 'Living Well Off the Grid';
- VP corporate marketing & investor relations Stephen Oliver — 'The Silicon Chip is Dead!'.

"Navitas GaNFast technology has been adopted by leading brands looking to deliver speed, efficiency and optimum power density," says founder & CEO Gene Sheridan. "It gives us great pleasure to host a number of those brands at CES 2023 and to give visitors the opportunity to hear how GaN — and higher-voltage SiC technology — continue to make a significant difference as we Electrify Our World."

www.ces.tech

GaN Systems gives annual power semiconductor predictions for 2023

Power GaN: market to reach $2bn by 2027, driven by rising adoption across consumer electronics, automotive, data centers, and sustainability initiatives

In its annual power semiconductor predictions, GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) reckons that 2023 will be another landmark year for GaN — with the now widely adopted technology forecasted by Yole Intelligence's 'Power GaN 2022: Market and Technology Report 2022' to reach $2bn by 2027, driven by rising adoption across consumer electronics, automotive, data centers, and sustainability initiatives.

The predictions explore the overarching systemic changes underway around the global semiconductor supply chain and sustainability initiatives specific to key power-reliant industries, i.e.

- Supply Chain — The initiation of historic multi-year programs to change where and how semiconductors are fabricated and packaged.
- Sustainability — Motivations for efficiency and conservation will concur with new political imperatives for energy independence. GaN isn't just a good choice for high-frequency designs. It's also good for the planet.
- Data Centers — GaN makes new inroads to become the solution of choice as data centers upgrade processors to optimize their ability to address profitability and sustainability goals.
- Electric Vehicles — GaN is integrated into designs for energy-efficient electric vehicles (EVs) and charging stations needed to meet the 2030 goals of auto manufacturers and global governments, businesses, and other organizations that influence the future of the automotive industry and road transport.
- Consumer Electronics — GaN is further entrenched in the mainstream with continuing innovations and new product releases in chargers, audio, appliances, and power tool designs.

"We are at the inflection point for power GaN technology," believes GaN Systems. "Notwithstanding nearly three years of significant global economic and geopolitical headwinds, the GaN power semiconductor has established itself as a preferred product solution across multiple market segments, including data-center, electric vehicle, industrial, and consumer electronics industries. It has accomplished this by uniquely solving some of the most pressing and critical power systems challenges around energy efficiency and design in these industries," adds the firm. "With the strong momentum of the electrification megatrend and an increasing number of products containing semiconductors, economic winners and losers will be determined mainly by those who can better manage their supply chains that not only enable the production of existing goods for businesses and consumers – yet stoke the fires of innovation for the near future."

The predictions are specifically as follows:

PREDICTION 1

Supply Chain: Companies and Governments Embrace Multi-Billion-Dollar Long-Term Plans to Strengthen Global Semiconductor Fabrication and Packaging

- In the past, many companies focused on consolidating manufacturing activities in one or two countries. Looking ahead, the global semiconductor supply chain will work towards developing a substantial US presence in both engineering design and manufacturing. In the USA, this means embracing a national strategic semiconductor policy — rather than politically convenient.
- The CHIPS and Science Act of 2022 is expected to catalyze the geographic diversification of the semiconductor industry in the USA during the next four years. The substantial economic muscle in the form of $52.7bn in grants, loans and tax credits will drive investment in design, foundry and fabrication facilities. Large chip manufacturers will receive as much as $2.5–3bn for each new fabrication facility they build in the USA.
- To accelerate next-generation chip design and production, the broad investment program within the European Union (EU) Chips Act will focus on increasing production capacities and improving the ability to identify and respond to the semiconductor supply crises. Above all, the EU Chips Act aims to strengthen Europe's research and technology leadership, which consists of the capabilities, capacities and controls necessary to act on long-term economic and societal objectives.
- Semiconductor packaging will be addressed in the shorter term, with factory additions in Vietnam and India. A large portion of semiconductor wafer fabrication will remain in Taiwan (68% of all semiconductors and 90% of advanced chips). This will continue to expose the semiconductor industry to regional 'single source' vulnerability as fabrication expansion in Europe, Canada and the USA builds out over several years.

PREDICTION 2

Sustainability: The Motivation for Energy Efficiency and Natural Resource Conservation Meets the Political Imperative of Energy Independence

● Sustainability and profitability will be dual drivers of business success. For example, using GaN semiconductors will concurrently increase revenue through greater data density in data centers and mitigate the environmental impact (e.g. meet aggressive ESG goals). Additionally, meeting sustainability metrics for products and operations will be as necessary as meeting performance and cost requirements.

● Pressures will increase for mass rollouts of technology for large-scale renewable energy collection, storage and use. More energy-efficient power inverters, DC–DC converters, and energy-dense storage will be needed in on-demand solar power systems. GaN technology will be at the center of this solution.

● In 2023 and beyond, there will be a natural acceleration of GaN demand to ensure a more sustainable future. The technology has been found to optimize power designs to decrease the carbon footprint of high-frequency devices and systems. GaN is uniquely positioned to enable a greener, more carbon-neutral future for the electronics industry. GaN power semiconductors aim to conserve energy and miniaturize devices by capitalizing on high switching speeds and low ON resistance.

PREDICTION 3

Data Centers – Profitability Meet Sustainability Initiatives in the Move to Greater GaN Technology Adoption

● As data centers refresh hardware every three to five years, compounded with the EU Eco-design Lot 9 efficiency regulatory requirements in effect, there will be a significant opportunity for GaN to replace silicon in both rackmount power supplies and the individual redundant power supplies in servers. This upgrade of servers and build-out of server racks using GaN power supplies will be led by the innovative work from OEMs such as Intel and HP. More server and rack power supply companies will follow, adopting GaN and making GaN 'the standard' for the industry.

● New standards from tech giants will accelerate change to higher efficiency and smaller form factors for power supplies. The Open Computer Project (OCP) defines a new standard form factor, M-CRPS, for a server's power supply that decreases the size by 30%. Legacy transistor technology, namely silicon MOSFETs, will struggle to deliver on this standard while GaN excels here. Additionally, OCP designs, many targeted for hyperscale computing, have increasing demands for very high energy efficiency, a characteristic best delivered by GaN.

● The demands on power supplies will increase the use of GaN:
(1) to increase efficiency via its properties of lower switching and conduction losses,
(2) to increase power density via operating at higher frequencies than the ability of alternative technologies, and
(3) smaller and more highly efficient GaN-based power supplies directly lower a data center's power bills and indirectly reduce cooling system costs.

PREDICTION 4

Electric Vehicles: Pressures Intensify to Accelerate the Move to EVs from Both the Moral Motivations of Climate Change and the realities of Energy Economics

● Automotive OEMs and their tier 1 suppliers will continue to make decisions about their power transistor choices through the four lenses of performance, reliability, cost and capacity. High-performance GaN solutions in the design stage in 2022–2023 will be mainstream in 2025–2026, delivering lower cost and more energy-efficient power solutions.

● OEMs are increasingly moving into production with GaN, which will accelerate in 2023. GaN semiconductor companies will begin to see their share of EV designs increase as more 400V system designs rise in importance, multi-level GaN solutions for 800V systems are validated, and silicon carbide (SiC) experiences continued material shortages, yield challenges and cost concerns.

PREDICTION 5

Consumer Electronics: GaN Becomes Mainstream in Multiple Consumer Markets

● GaN will increase its share in chargers from the popular 45W and 65W chargers to the growing market for higher-power 100-180W chargers with both single and multiple port variations, delivering ultrafast and multi-device charging experiences to consumers.

● For audio, GaN will enable mainstream brands to fulfill consumers' mobile and voice-activated lifestyle demands with more compact form factors that deliver the same volume and audio quality of much larger devices.

● New Class D audio systems design will accelerate with the adoption of 'building blocks' for GaN products that enable audio systems designers across markets to mix and match designs and maximize performance for their specific applications.

● Growth in new application areas, such as home appliances, large-screen TVs, E-bikes and power tools, will result from companies' acknowledgment of GaN's mainstream position and value in consumer electronics and their validation of GaN-based system designs. Innovative GaN-powered products in these markets will hit the consumer market in 2023–2024.

"As global companies continue to face pressure to drive both profitability and sustainability, GaN technology takes on an even higher level of importance," says GaN Systems' CEO Jim Witham. "Despite significant global economic and geopolitical headwinds of the last three years, GaN is now recognized as a widely adopted technology estimated to reach $2bn by 2027, driven by rising use in consumer electronics, automotive applications, data centers, and industrial and electric vehicles. As such, companies will continue to accelerate their commitment to greater energy efficiency, and we'll see profitability and sustainability drive $6bn GaN growth."

www.gansystems.com

Transphorm releases compact 240W power adapter reference design with TO-220 GaN FETs

CCM boost PFC + half-bridge LLC topology delivers over 96% peak power efficiency with power density up to 30W/in^3

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion —has announced the availability of its new 240W power adapter reference design. The TDAIO-TPH-ON-240W-RD deploys a continuous-conduction mode (CCM) boost PFC + half-bridge LLC topology to deliver a peak power efficiency of over 96% with a power density up to 30W/in^3.

Transphorm's design uses three SuperGaN FETs (TP65H150G4PS) each with an on-resistance of 150mΩ. The GaN FET comes as a 3-lead TO-220, a well-known and long-trusted transistor package that offers superior thermals at lowline for higher-current power systems running power factor correction (PFC) configurations.

The reference design is intended to simplify and quicken power system development for applications such as high-power-density AC-to-DC power supplies, fast chargers, IoT devices, laptops, medical power supplies, and power tools.

Key specifications and features

As a 240W 24V 10A AC-to-DC power adapter reference design, the TDAIO-TPH-ON-240W-RD pairs the TP65H150G4PS GaN FETs with onsemi's off-the-shelf NCP1654 CCM PFC controller and NCP1399 LLC controller. The design uses a 25mm heatsink that produces a power density of over 24W/in^3. The power density can increase by about 25% to 30W/in^3, depending on the heatsink design.

The high power density and efficiency range is primarily due to the FET's packaging, as Transphorm offers what is claimed to be the only high-voltage GaN devices in a TO-220 currently available. Power adapters, along with all universal AC-to-DC power supplies, require high current at lowline (i.e. 90V$_{ac}$) which can require paralleling two PQFN packages (as typically seen with e-mode GaN) to achieve the desired power output. This method reduces a power supply's power density while requiring 2x part count. Transphorm's TO-220 packages mitigate this, providing what is claimed to be unparalleled power density at a lower cost — a result not currently possible with e-mode GaN, the firm adds.

Other specifications and features include:

- operation over a universal input voltage of 90V$_{ac}$ to 264V$_{ac}$;
- over 96% peak efficiency and flat efficiency curve across line and load;
- tight switching frequency regulation for improved input EMI filter utilization;
- over 180kHz switching frequency operation for compact implementation.

The new reference design joins a broad portfolio of adapter/fast charger design tools that currently includes five open frame USB-C PD reference designs ranging from 45W to 100W, as well as two open frame USB-C PD/PPS reference designs for 65W and 140W adapters.

www.transphormusa.com/en/reference-design/tdaio-tph-on-240w-rd

Mitsubishi Electric extends GaN HEMT range with 70W 12.75–13.25GHz low-Ku-band products

Increased data capacity and smaller earth stations for SATCOMs

Tokyo-based Mitsubishi Electric Corp is adding two new 12.75–13.25GHz (low-Ku-band) 70W (48.3dBm) gallium nitride high-electron-mobility transistors (GaN HEMTs) to its lineup of GaN HEMTs for satellite communication (SATCOM) earth stations.

On sale from 15 January, two products — one for multi-carrier communications and the other for single-carrier communications — support increased data-transmission capacity and smaller earth stations even in the low-Ku-band.

Ku-band satellite communication systems are increasingly being deployed for emergency communications during natural disasters as well as for satellite news gathering (SNG) by TV broadcasters in rural areas where fiber and/or cable networks are not available.

For SATCOM earth stations, existing mainstream systems use a 14GHz band, but in the near future they are expected to use the low-Ku (13GHz) band as well as the Ka (28GHz) band to address needs for increased data-transmission capacity.

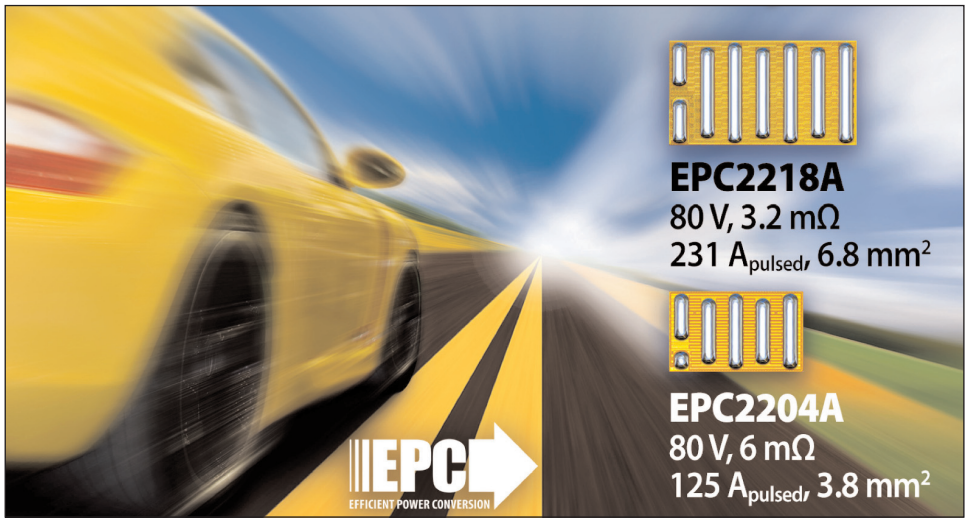
Up to now, Mitsubishi Electric has offered a lineup of seven GaN HEMTs for multi-carrier and single-carrier SATCOM earth stations. The two new 70W GaN HEMTs that have now been introduced will also support emergency communications and satellite news gathering in the low-Ku-band.

www.MitsubishiElectric.com/semiconductors

EPC launches 80V AEC-Q101-qualified GaN FETs for vehicle electronics and advanced autonomy

Smaller and more efficient solutions for automotive 48V–12V DC–DC conversion, infotainment, and LiDAR for autonomous driving

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has expanded its range of automotive, off-the-shelf gallium nitride transistors by introducing the 80V, 6mΩ EPC2204A (which delivers 125A pulsed current in a 2.5mm x 1.5mm footprint) and the 80V, 3.2mΩ EPC2218A (which delivers 231A pulsed current in a 3.5mm x 1.95mm footprint), offering designers significantly smaller and more efficient devices than silicon MOSFETs for automotive DC–DC for 48V–12V conversion, infotainment, and light detection & ranging (LiDAR) for autonomous driving.



The EPC2204A and EPC2218A are suitable for applications with demanding requirements for high power density including 48V–12V bidirectional converters for mild hybrid cars, 24V–48V DC–DC in cars and trucks, and for infotainment, lighting, and advanced driver assistance systems (ADAS) applications.

Lower gate charges (Q_{GD}), and zero reverse recovery losses allow high-frequency operation at 1MHz and beyond. Combined with high efficiency in a tiny footprint, these factors enable state-of-the-art power density, it is claimed.

As an example, for 2–4kW 48V–12V converters, GaN devices allow five times the frequency of silicon MOSFET solutions. Also, with a quarter of the inductance, inductor size and losses are reduced, allowing 40% higher current per phase and up to half of the phases for lower system cost and half of the size. Despite the smaller size, efficiency rises to up to 98%, more than 2% higher than MOSFET solutions.

For lower-power DC–DC, such as those used for infotainment applications in the vehicle, GaN allows for operations at 2MHz and above to avoid interference and enable the smallest solution size.

The fast-switching speed of GaN, with sub-nanosecond transitions and the capability to generate high-current pulses in less than 3ns, allows for longer range and higher resolution in LiDAR for autonomous driving, parking, and collision avoidance.

For automotive LiDAR and 48V DC–DC, the 80V EPC2204A and EPC2218A switch devices improve performance and cost for highly efficiency vehicle electrification and advanced autonomy applications, says EPC's co-founder & CEO Alex Lidow. "EPC is committed to the automotive market with devices ranging from 15V–100V shipping in volume, and many more are planned for release," he adds.

The EPC2204A is priced at $1.55 and the EPC2218A at $3.01 each, respectively, in 1000-unit quantities.

www.epc-co.com/epc/products/gan-fets-and-ics/epc2218a

Richtek and EPC collaborate to create small 140W fast-charging solution

Reference design exceeds 98% efficiency using RT6190 buck-boost controller and EPC2204 GaN FETs

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits for power management applications — and power management analog IC company Richtek Technology Corp of Hsinchu, Taiwan have announced the availability of a 4-switch bidirectional buck-boost controller reference design board that converts an input voltage of 12V–24V to a regulated 5V–20V output voltage and delivers up to 5A continuous current and 6.5A maximum current.

The combination of the new Richtek RT6190 controller with EPC2204 GaN FETs shrinks the solution size by more than 20% compared with traditional solutions for high-power-density applications, it is reckoned. The solution achieves greater than 98% efficiency for 20V and 12V output voltage and can operate without a heat-sink with maximum rise temperature below 15°C for 20V to 5V, and 55°C for 12V to 20V, at 5A continuous current.

The high power density makes this solution suitable for buck-boost converters with an input of 4V–36V and output of 3V–36V such as those used for 5V–36V battery chargers, battery stabilizers to 5V–36V and USB PD 3.1 charging (5V, 20V, 28V, 36V support). GaN FETs provide the fast switching, high efficiency and small size that can meet the stringent power density requirements of these leading-edge applications.

The reference design uses the EPC2204 100V enhancement-mode EPC GaN FET and the RT6190 4-switch buck-boost controller with integrated GaN drivers.

The RT6190 is a 4-switch bidirectional buck-boost controller with I2C interface using peak current mode control. The input voltage ranges between 4V and 36V and the output voltage is programmable between 3V and 36V and supports dynamic voltage scaling. The switching frequency reaches up to 1MHz for high power density and the device offers a power saving mode for high light load efficiency. Output current, voltage and soft start can be precisely programmed, and the device is fully protected and offers OCP, UVLO, OVP, OTP, cycle-by-cycle current limit, and PGOOD in a package measuring just 5mm by 5mm.

The EPC2204 is a 100V GaN FET with 6mΩ (maximum) $R_{DS(on)}$, 5.7nC$_{QG}$, 0.8nC$_{QGD}$, 1.8nC$_{QGS}$ and zero Q_{RR} in a super small 2.5mm x 1.5mm footprint and can deliver up to 29A continuous current and 125A peak current. The dynamic parameters allow very small switching losses at 500kHz–1MHz switching frequency, especially in hard-switching applications like buck-boost converters. Higher switching frequency enables a reduction in the inductor value, size and DC resistance (DCR) and in the capacitor count for less losses and higher power density.

"GaN FETs are required to achieve the maximum power density for DC–DC converters," notes EPC's CEO Alex Lidow. "We are delighted to work with Richtek to combine the benefits of their advanced controllers with the performance of GaN to provide customers with the highest-power-density and low-component-count solution that increases the efficiency, increases power density, and reduces system cost," he adds.

"The Richtek Device's RT6190 is designed to fully exploit the high performance of EPC's eGaN FETs for high-power-density solutions," says Eason Chen, senior application marketing manager at Richtek, "The RT6190 offers higher switching frequency and integrates all protection features and functionality required for a 4-switch buck-boost controller for battery chargers and battery management/stabilizers to a fixed voltage, very common for consumer USB applications for PC and smartphone, e-bike, e-scooter, battery-operated appliances and power tools, medical, industrial and solar applications. With these new controllers, customers can take advantage of the very fast switching of GaN for the highest power density."

Both the Richtek RT6190 and the EPC2204 are in mass production now.

www.epc-co.com
www.richtek.com

EPC shipping lowest on-resistance 150V and 200V GaN FETs on market

Higher performance and smaller size and cost for DC–DC conversion, AC/DC SMPS and chargers, solar optimizers and micro-inverters, and motor drives

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits for power management applications — has launched the 150V, 3mΩ EPC2305 and the 200V, 5mΩ EPC2304 GaN FETs in a thermally enhanced QFN package with exposed top and a small 3mm x 5mm footprint.

The devices are claimed to be the lowest-$R_{DS(on)}$ (on-resistance) FETs in the market at 150V and 200V in a size that is 15 times smaller than alternative silicon MOSFETs. In addition to offering devices with half the on-resistance and 15 times smaller, Q_G, Q_{GD}, Q_{OSS} are more than three times smaller than silicon MOSFETs, and the reverse recovery charge (Q_{RR}) is zero. These characteristics result in switching losses that are six times smaller in both hard switching and soft switching applications. The driver losses are three times less than silicon solutions, and ringing and overshoot are both significantly reduced.

For sinusoidal brushless DC (BLDC) motor drives, the devices enable <20ns deadtime and higher frequency to reduce noise, minimize size to allow for integration with the motor, reduce the input filter and eliminate the electrolytic capacitors, and increase motor + driver efficiency more than 8% by eliminating vibrations and distortions. This makes them suitable for forklift, e-scooter, e-Mobility, robots, and power tool motor drives.

For DC–DC conversion operating from 80V to 20V, the EPC2304 and EPC2305 enable higher switching frequency and up to five times higher density, and higher efficiency to simplify cooling.

The devices also provide higher efficiency, reduced size and weight, and robust reliability that are required for solar optimizers and micro-inverters.

The new devices are footprint compatible with the previously released 100V 1.8mΩ EPC2302, the 100V 3.8mΩ EPC2306, and the 150V 4.9mΩ EPC2308 for the maximum design flexibility.

"The EPC2304 and EPC2305 expand our family of easy-to-assemble and thermally enhanced QFN packaged devices to 150V and 200V," says co-founder & CEO Alex Lidow. "Designers can use this family of products for smaller and lighter-weight BLDC motor drives, smaller and more efficient DC–DC converters, solar optimizers and micro-inverters, and higher-power-density USB chargers and power supplies. The footprint compatibility allows for optimization of performance and cost without redesigning the board."

The EPC90140 development board is a half-bridge featuring the EPC2304 GaN FET and the EPC90143 development board is a half-bridge featuring the EPC2305 GaN FET. Their purpose is to simplify the evaluation process and speed time to market. The 2" x 2" (50.8mm x 50.8mm) boards are designed for optimal switching performance and contain all critical components for easy evaluation.

The EPC2304 is priced at $5.25 each and the EPC2305 is priced at $4.95 each in 1000-unit volumes. The EPC90140 and EPC90143 development boards are $200 each.

www.epc-co.com/epc/products/gan-fets-and-ics/epc2304
www.epc-co.com/epc/products/gan-fets-and-ics/epc2305

Aehr receives follow-on production order from second major SiC customer

FOX-XP multi-wafer test & burn-in system with integrated automated WaferPak Aligner to ship in March quarter

Semiconductor production test and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has received a follow-on production order from its second major silicon carbide (SiC) customer for an additional production FOX-XP multi-wafer test & burn-in system configured with Aehr's fully integrated and automated WaferPak Aligner (to ship in Aehr's fiscal fourth-quarter 2023, beginning 1 March).

The FOX-XP system is configured with Bipolar Voltage Channel Module (BVCM) and Very High Voltage Channel Module (VHVCM) options that enable new advanced test and burn-in capabilities for silicon carbide power semiconductors using Aehr's proprietary WaferPak full-wafer contactors. This customer serves several significant markets including the electric vehicle (EV) industry as well as other industrial applications.

"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," says president & CEO Gayn Erickson.

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

"The FOX-XP with integrated WaferPak Aligner uses our proprietary WaferPak full-wafer contactors and supports 100mm, 150mm, 200mm and 300mm wafer 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," Erickson continues.

"The FOX-XP configured with the integrated and automated WaferPak Aligner has a number of additional very valuable 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."

"Forecasts from William Blair estimate that the silicon carbide market for devices in electric vehicles alone, such as traction inverters and on-board chargers, is expected to grow from 119,000 6-inch-equivalent SiC wafers for electric vehicles in 2021 to more than 4.1 million 6-inch equivalent wafers in 2030, representing a compound annual growth rate (CAGR) of 48.4%. Total 6-inch-equivalent SiC wafers for all current addressable markets are expected to grow to nearly seven million 6-inch-equivalent SiC wafers in 2030," Erickson says.

"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," adds 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

CVD Equipment receives extra order for ten PVT-150 systems for SiC growth

Systems to grow 150mm monocrystalline silicon carbide boules

CVD Equipment Corp of Central Islip, NY, USA (a designer and maker of chemical vapor deposition, gas control and other equipment and process solutions for developing and manufacturing materials and coatings) has received an additional order for ten high-performance PVT-150 systems. For delivery in first-half 2023, the systems will be used to grow 150mm-diameter monocrystalline silicon carbide (SiC) boules, for processing into SiC wafers used in power electronics.

Physical vapor transport (PVT) is the main method for growing SiC boules for wafer production. As the demand for SiC devices for high-power electronics continues to increase for electric vehicles, energy, and industrial applications, CVD Equipment has engineered PVT systems to support the production of high-quality SiC boules for high-yield SiC wafers. Presently offering 150mm crystal growth systems, the firm says that it is committed to supporting the critical high-volume production needs for the industry and further supporting the evolution to systems of 200mm and above.

"CVD Equipment Corporation is ramping up our commercialization of the PVT systems to meet the growing needs of the high-power electronics industry," says president & CEO Emmanuel Lakios. "Our 40 year legacy of developing process equipment and our vertical integration has positioned us as a leading manufacturer of high-quality SiC PVT systems. Our sights are set to facilitate the industry's growth and electrification."

www.cvdequipment.com

k-Space launches XRF thin-film metrology tool

kSA x-ray fluorescence tool measures film thickness below 100nm

k-Space Associates Inc of Dexter, MI, USA — which was founded in 1992 and produces thin-film metrology instrumentation and software for research and manufacturing of microelectronic, optoelectronic and photovoltaic devices — has launched the kSA XRF x-ray fluorescence thin-film metrology tool, which measures film thickness for materials that are too thin for reliable optical measurements.

The kSA XRF uses an x-ray source, detector and proprietary software to measure the x-ray emission spectrum, which is then used to calculate film thickness in real-time. It measures the appropriate atomic species based on the customer's unique coating formula and measurement needs. This technique has been proven to measure semiconductor and dielectric layers on glass panels, wafers and susceptors for applications in solar, power, and other thin-film devices.

"We developed the kSA XRF while helping one of our existing customers measure dielectric coatings that couldn't be measured using traditional optical methods," says CEO Darryl Barlett. "The XRF measures dielectric coatings below 100nm and can be used by makers of glass panels, solar panels, MOCVD [metal-organic chemical vapor deposition] carriers and other products," he adds. "It's a superior and more scalable option than existing tools and is easily installed into conveyor lines."

The kSA XRF, which can be configured for a standalone benchtop setup or over a conveyor for in-line inspection and manufacturing process control (as here)

The kSA XRF can be configured for a standalone benchtop setup or over a conveyor for in-line inspection and manufacturing process control.

"The kSA XRF allows users to characterize and monitor their thin-film coatings during production, thereby increasing yield and reducing costs," notes Barlett.

www.k-space.com

III–V Lab chooses Riber MBE 412 to expand opto and microelectronic manufacturing platform

France Relance funding InPERIUM opto project

Under France's economic stimulus package 'Plan France Relance' (administered by the nation's Ministry of the Economy and Finance), III–V Lab of Palaiseau, France (the joint Alcatel-Lucent, Thales and CEA-Leti industrial research laboratory) is being supported by the Government to adapt and modernize its R&D and production tool. III–V Lab has hence chosen to rely on epitaxy equipment from Riber S.A. of Bezons, France – which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources – whose set up realized during first-half 2023 will expand III–V Lab's optoelectronic and microelectronic semiconductors manufacturing platform.

"InPERIUM (InP for optoelectronic with Molecular Beam Epitaxy) is a project implemented in the framework of the French recovery plan that allows us to increase our manufacturing capacity of wafers, components and optoelectronic and microelectronic modules for our strategic sectors," says III–V Lab's president Jean-Pierre Hamaide.

"The MBE 412 convinced us thanks to its reliability and its great modularity," comments Olivier Delorme, researcher in epitaxy at III–V Lab. '"Thanks to our understanding of physics of materials, combined with the versatility of the epitaxy reactor, we explore many combinations of III–V semiconductors in order to develop high-performance components."

Operating under ultra-vacuum, the cluster robot automatically transports wafers between different modules connected to the eight available ports of the system. In particular, a preparation module, equipped with a hydrogen plasma source, has been installed, improving the performance of components by providing optimum surface morphology.

Finally, the in-situ characterization instrument EZ-CURVE from Riber will be integrated and adapted for precise and continuous control of the growth process, contributing to better control of the epitaxy processes, allowing improvement in the electronic or photonic performance and ultimately increasing component manufacturing efficiency.

"Our MBE system cluster allows both product development and production," notes Riber's chairman Michel Picault. "Our deposition reactor easily integrates various control instruments needed for the development of new materials. The modularity of the cluster design offers the opportunity to add additional reactors for pre/post process and analysis steps, or multiplying reactors to optimize product development and/or increase production efficiency," he adds. "Our platform is fully automated and is driven by our software Crystal XE."

www.riber.com
www.3-5lab.fr

III–V Epi appoints Neil Gerrard as director of epitaxy

III–V expert to help meet customers' MBE and MOCVD epi manufacturing, support and R&D requirements

III–V Epi Ltd of Glasgow, Scotland, UK — which provides a fast-turn-around molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) service for custom compound semiconductor wafer design, manufacturing, test and characterization — has appointed Dr Neil Gerrard as director of epitaxy, with the role of helping to meet the MBE and MOCVD III–V epitaxial manufacturing, support and R&D requirements of III–V Epi's customers. These range from universities, development departments and start-ups through to defence and smaller datacoms and telecoms companies.

In over 30 years of industrial experience, Gerrard's prior III–V compound semiconductor manufacturing experience has included technology direction; new product development; and wafer fab and epitaxy operations. His roles have ranged from technical marketing director at Aixtron UK Ltd (Thomas Swan); UK managing director at LayTec UK; to engineering lead in start-ups KUBOS and Optical Reference Systems. Gerrard helped to set up and run the wafer fab at multi-billion-dollar firm Nortel Networks, and to introduce the MOCVD facility at Sivers.

Gerrard first worked with fellow III–V Epi director professor Richard Hogg while he was director of operations & business development for the UK Engineering and Physical Sciences Research Council (EPSRC). Between them, they helped to set up the UK's National Centre for III-V Technologies at The University of Sheffield.

Gerrard has a PhD from the University of Manchester, Institute of Science and Technology (UMIST). He followed this with post-doctoral research at Bell Labs, where he first began honing his MOCVD skills.

www.iii-vepi.com

Riber deploys MBE technology for quantum computing materials development

EPICENTRE joint lab with LAAS-CNRS to speed progress towards larger-scale quantum chip manufacturing

Riber S.A. of Bezons, France — which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources — has further strengthened its development of quantum processor materials.

Through EPICENTRE — a joint laboratory established in June 2021 with the French National Centre for Scientific Research's Laboratory for Analysis and Architecture of Systems (LAAS-CNRS) in Toulouse — Riber has started to deploy the technologies making it possible to build the core components of future-generation quantum computers. These are based on the physical phenomenon of quantum entanglement, which occurs when two elementary particles — two electrons or two photons — share identical parameters even though they are very far apart. This requires stringent conditions for their production environment, which must be ultra-pure, ultra-controlled and ultra-cold, with single-atom precision.

The technologies available to deliver these performance levels include MBE. That is why Riber is part of a joint quantum computers laboratory program to develop the technological components enabling them to be built.

To produce electrons or photons, it is possible to use quantum dots, developed and controlled using MBE. To transport them, superconductor metals can be used with ultra-precise (atomic scale) dimensions, within which the electrons flow undisrupted. MBE technology can deposit these superconducting materials in an ultra-pure environment with atomic-layer-controlled thickness.

These quantum dots and superconductors need to be perfectly insulated from their environment, which is achieved by depositing dedicated oxide materials.

The various stages for developing the quantum dots, superconductors and insulators require various deposition chambers which must have an ultra-high – or almost perfect – vacuum in order to avoid any contamination. Vacuum quality is part of the excellence provided by Riber's technology for these MBE machines.

An MBE machine for quantum computers will therefore include several deposition chambers connected together by robots under ultra-high-vacuum conditions. It may include three to five chambers linked by two or three robots under ultra-high-vacuum conditions, controlled by software that manages the sample movements and material deposition process.

Because of the complexity of this type of equipment due to the number of chambers and the ultra-purity, ultra-control and ultra-cold performance levels, the technology has a market value of several million euros per machine, says Riber.

This is illustrated by the order worth several million euros (announced on 25 October) for research equipment, including several chambers and items of equipment, in order to provide a new European research laboratory with the flexibility and versatility of MBE to use materials for future quantum computer components.

"Quantum technology is very promising, but it still needs to overcome some significant development challenges to build specific chips," comments Michel Picault, chairman of Riber's executive board. "Riber's MBE technology will make it possible to accelerate progress towards manufacturing quantum chips on a larger scale," he adds. "Our joint laboratory with LAAS-CNRS will help us reach this higher level of technological maturity more quickly".

www.riber.com

Camtek receives $18m order from compound semiconductor manufacturer

Multiple Eagle systems to be shipped from Q2 through early 2024

Camtek Ltd of Migdal Haemek, Israel has received a multi-system order worth $18m from a "leading global compound semiconductor manufacturer".

Due to be delivered starting from second-quarter 2023 through early 2024, the order is for Camtek's latest Eagle model of inspection & metrology tool, designed with advanced capabilities developed specifically for this market segment.

"This is an excellent start to 2023," comments CEO Rafi Amit. "The compound semiconductor market is expected to present strong growth in the coming years, fueled by the automotive industry and other applications," he adds. "This order demonstrates our competitive position and technology leadership in this segment."

www.camtek.com

3D-Micromac's CEO presents at mini- & micro-LED display conference

'Laser technologies for the production of micro-LEDs' highlighted

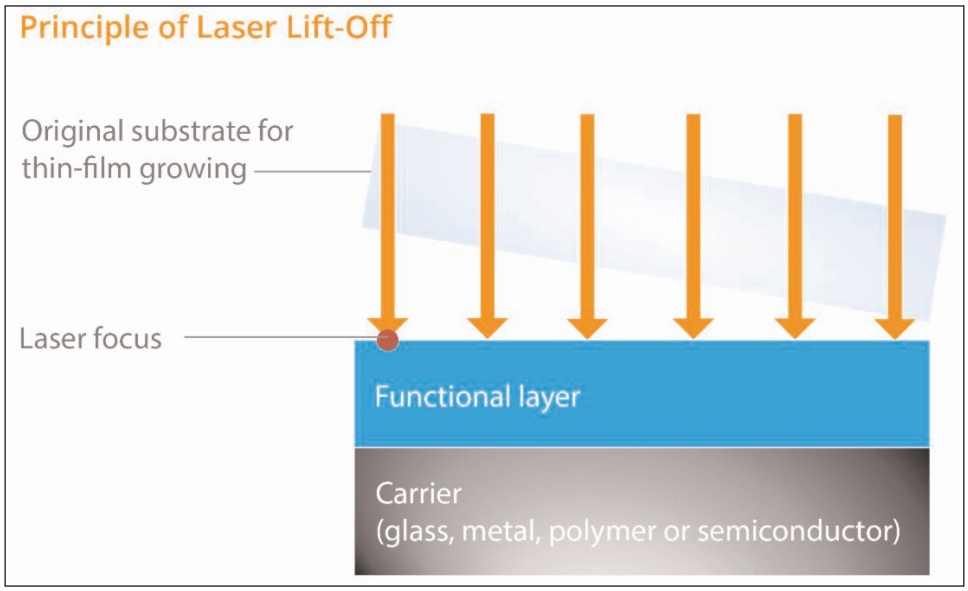
3D-Micromac AG of Chemnitz, Germany (which provides laser micromachining and roll-to-roll laser systems for semiconductor, photovoltaic, glass and display applications) says that, at the Tech-Blick 'Mini- & Micro-LED Displays: Markets, Manufacturing Innovations, Applications, Promising Start-ups' event (being held virtually) its CEO Uwe Wagner is presenting 'Laser technologies for the production of micro-LEDs' on 1 December highlighting laser-based system solutions for various manufacturing steps for micro-LEDs, including the use of integrated process control and monitoring to assure stable and reliable operation to ensure high throughput and low yield losses.

3D-Micromac says that, although micro-LEDs have tremendous potential for future displays, several technical challenges must be overcome in the fabrication process prior to widespread deployment in the marketplace. One key hurdle is developing a process to release the dies from the sapphire growth wafer. Another is developing a process to transfer these dies to the display substrate with micron-level precision and reliability.

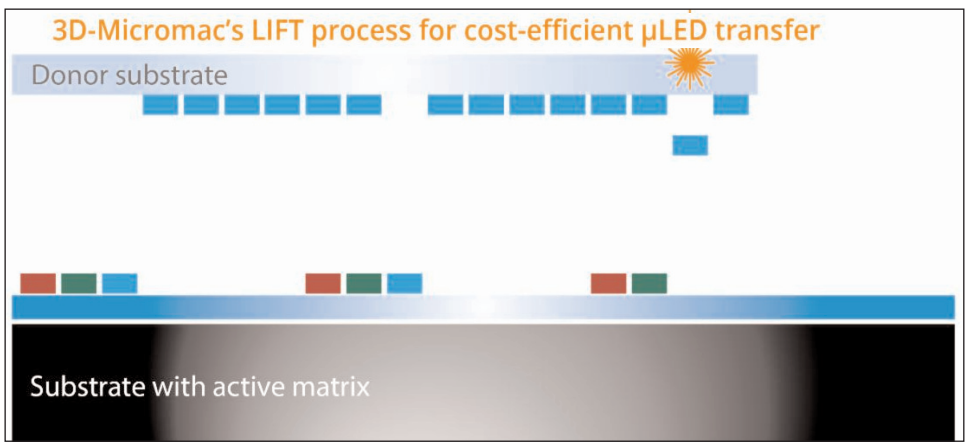
3D-Micromac addresses these challenges with its laser processing solutions, including its microMIRA Laser Lift-Off (LLO) system for separating the finished micro-LEDs from the sapphire growth wafer, and its microCETI Laser-Induced Forward Transfer (LIFT) system for moving the devices from the donor substrate to the display substrate. To date, 3D-Micromac has sold more than 10 laser processing systems for micro-LED applications, including a recent order for multiple microMIRA systems from a leading optical solutions provider.

3D-Micromac is also a founding member of the MicroLED Association, which was established earlier this year to accelerate the adoption of micro-LED display technologies by bringing together companies, researchers and organizations active in the micro-LED industry and providing a forum for solving common technology issues, fostering cooperation and sharing relevant information, resources and tools. 3D-Micromac sees the MicroLED Association as an important body to help establish close networking and cooperation between customers and technology providers for further market development, and sees group efforts around topics like standardization as key to boosting market entry and paving the way for new display technologies.

www.techblick.com/events-agenda
https://3d-micromac.com/



3D-Micromac's Laser Lift-Off process, available on both the microCETI and microMIRA laser micromachining platforms, selectively detaches one material from another without causing damage to the carrier or base material. It separate micro-LED chips from the sapphire growth substrate for testing, and separate transparent and absorbing flexible substrates from glass substrates.



3D-Micromac's Laser-Induced Forward Transfer (LIFT) process, available on the microCETI laser micromachining platform, provides high-throughput and cost-efficient transfer of micro-LED chips from the carrier substrate to the display substrate. The laser on the microCETI platform is highly selective, enabling single or multiple micro-LED chips to be separated and transferred.

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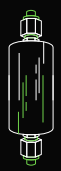

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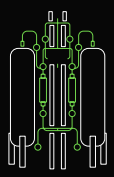

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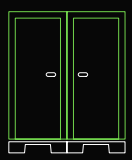

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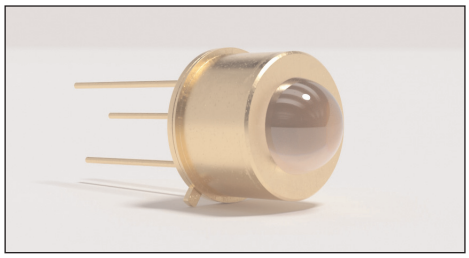
Silanna UV introduces TO-can package for SF1 235nm- and SN3 255nm-series UV-C LEDs

High-performance, hermetically sealed TO-39 packages suit sensing

UV-C LED maker Silanna UV of Brisbane, Australia has released two new products in its SF1 235nm and SN3 255nm series of UV-C LEDs: the SF1-3T9B5L1 and the SN3-5T9B5L1.

Silanna UV's new UV-C LEDs feature the transistor outline (TO-can) package format, consisting of a header and a cap forming a hermetically sealed package to protect sensitive semiconductor components within the package. The header supplies power to the encapsulated components, while the cap enables the transmission of optical signals. The strong weld between the cap and the header provides hermetic protection to the die, and the ball lens offers a narrow viewing angle for the high irradiance required in most sensing applications.



Using a steel header with a gold coating and an industrial-standard TO-39 footprint, the devices have ESD protection and contain no mercury. The TO-39 package has an 18º viewing angle, enhancing radiant intensity and measurement resolution.

The SF1-3T9B5L1 is a far UV-C emitting device with a peak wavelength of 235nm, making it effective for water quality detection of nitrate (NO_3) and nitrite (NO_2), gas detection of carbon dioxide (CO_2) and liquid chromatography.

The SN3-5T9B5L1 is a powerful deep UV-C LED with a peak wavelength of 255nm, making it effective for water quality detection of COD (chemical oxygen demand) and TOC (total organic carbon), as well as gas detection for ozone (O_3) and medical analyzers. It has a high optical output power, making it suitable for a range of applications including chemical and biological analysis, water quality monitoring, gas sensing and liquid chromatography.

Both the SF1-3T9B5L1 and SN3-5T9B5L1 offer what is claimed to be excellent stability and performance, with less than 0.5% drift and fluctuation in a steady state. They are also compatible with off-the-shelf optical systems, making them a convenient and reliable choice for sensing applications.

www.silannauv.com/products

Cree LED releases Pro9 versions of XLamp LEDs

90 and 95 CRI LEDs with up to 15% higher efficacy, matching standard 80 CRI LEDs at 2700–4000K CCTs

Cree LED Inc of Durham, NC, USA (a company of SMART Global Holdings of Milpitas, CA) has launched XLamp Pro9 LEDs, which deliver up to 15% higher efficacy for 90 and 95 color-rendering index (CRI) LEDs without sacrificing color rendering quality. With this performance improvement, Pro9 versions of XLamp LEDs provide 90 CRI light quality with the same efficacy as standard 80 CRI LEDs at a correlated color temperature (CCT) of 2700–4000K. The LEDs are said to improve the output, efficacy and size of LED luminaires in commercial applications needing high-quality light.

"With the availability of our new Pro9 LEDs, lighting manufacturers are now able to achieve excellent

color quality for indoor lighting applications with increased efficiency," says David Peoples, VP of marketing.

Unlike other high-efficacy LED solutions, Pro9 LEDs feature what is claimed to be the industry's highest operating temperature rating of 105°C and the same maximum current as the standard versions.

Pro9 LEDs share the mechanical and electrical characteristics of the standard versions, enabling lighting manufacturers to quickly upgrade their products to higher CRI with no change in performance and minimal redesign effort.

The LEDs are available with CCTs of 2700–4000K at minimum 90 and 95 CRIs. Pro9 versions of XLamp CXB and CMA family chip-on-board (COB) LEDs are available immediately, with product samples available now and production quantities available with standard lead times. Pro9 versions of XLamp CMB, CHA and CMU family COB LEDs plus XLamp XD16 Premium White and XHP35.2 LEDs will be available first-quarter 2023.

www.cree-led.com/Pro9

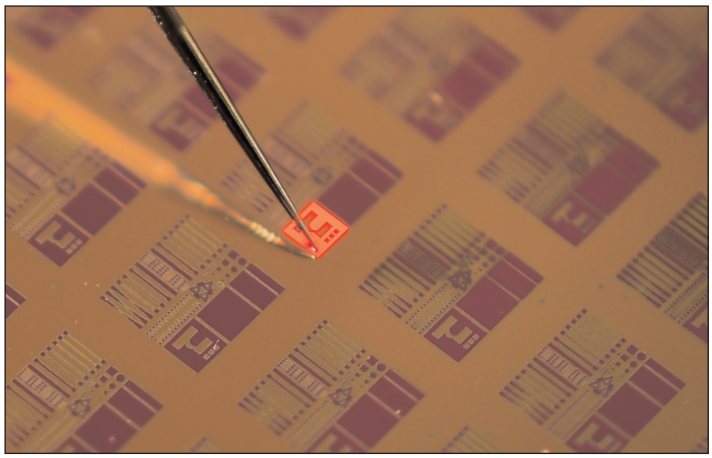
MICLEDI demos red AlInGaP micro-LEDs at CES, completing portfolio of RGB micro-LEDs

Red AlInGaP validated in CMOS-foundry-compatible process and composition

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 produced its first demonstration units of red µLEDs on aluminium indium gallium phosphide (AlInGaP) starting material. The newest addition to its portfolio of R, G and B µLEDs follows the firm's strategy of optimized display module performance and is manufactured in a CMOS-compatible flow, free of arsenide. Demonstration units of both red gallium nitride (GaN) and red AlInGaP were shown in MICLEDI's booth at the Consumer Electronics Show (CES 2023) in Las Vegas.

MICLEDI's strategy is to enable true consumer AR glasses by making the best individual color-performing µLEDs which, when coupled with the firm's proprietary micro-lenses, can be integrated into the highest-performing full-color 3-panel µLED display module. Different applications (true consumer, industrial, automotive, and others) require different optimal performance parameters. "There is no one-size-fits-all solution for AR glasses," notes CEO Sean Lord. "This achievement, with our previously announced blue, green and red GaN µLEDs, opens the door to a broader offering of display module performance parameters which enables MICLEDI to serve customers developing AR glasses from medium to high resolution and medium to high brightness," he adds.

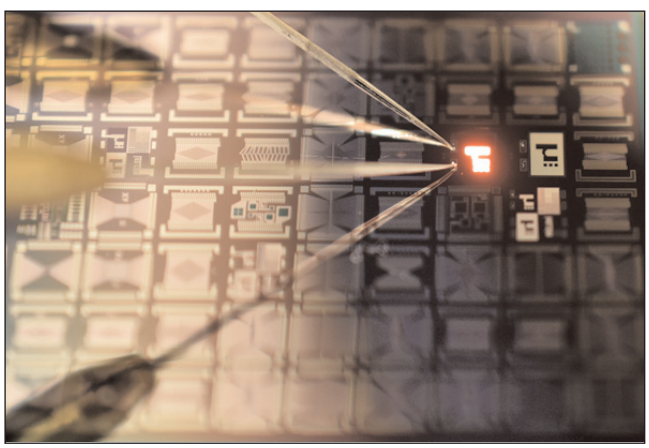
"Using advanced photolithography available in world-class 300mm wafer fabs assures that µLEDs made by MICLEDI will achieve lowest defectivity, highest process control and repeatability, and capitalizes on the symbiosis in manufacturing that comes from building our µLEDs in the same fabs and fab processes that advanced ASICs for µLED control and driving are made," says co-founder & chief technology officer Dr Soeren Steudel. "Through partnerships with world-leading developers of starting materials and our healthy collaboration with IMEC and other fab partners, we will demonstrate at CES µLEDs with excellent color performance across the full range of drive currents for many different types of AR glasses appliances in blue, green and two optimized versions of red."



MICLEDI's new red AlInGaP is Ferrari-red, free of arsenide, CMOS compatible, and designed with a new structure compared with standard GaN micro-LEDs.

MICLEDI's first red on GaN is solidly in the red range with wavelength centered at 620nm and good full-width half-maximum (FWHM) of <50nm. This newest announcement of red on AlInGaP achieves 653nm wavelength at extremely narrow FWHM of <9nm. MICLEDI's newest addition to its portfolio of colors is Ferrari-red, free of arsenide, CMOS compatible, and designed with a new structure compared with standard GaN micro-LEDs.

MICLEDI says that its 3-panel approach to µLED full-color displays is uniquely positioned to achieve the highest performance standards in AR glasses. AR glasses for indoor or semi-darkened light settings can be less efficient, less bright, and deliver less overall performance compared with outdoor sunlight settings. Best-in-class AR glasses with transparent lenses, for use all the way from low indoor light to bright outdoor sunlight, is a must before high-volume consumer adoption of AR glasses will commence, says the firm. By optimizing the chemistry and physics of each individual color, MICLEDI says that it enables the highest brightness of any of the alternative solutions in the market currently.



Demo units of red GaN and red AlInGaP were shown at MICLEDI's booth at CES.

www.micledi.com

SmartKem creates first monolithic micro-LED display using organic thin-film transistors

Semiconductor inks allow low-temperature processing of organic TFTs directly on micro-LEDs

UK-based electronics materials and process technology firm SmartKem claims that it has created the first monolithic micro-LED display using organic thin-film transistors (OTFTs).

The new method of processing a thin-film transistor backplane on top of gallium nitride LEDs has the potential to accelerate the commercialization of micro-LED displays, it is reckoned.

Consumer electronics companies are actively developing micro-LED displays since they promise higher brightness, lower power consumption and longer lifetime. This is particularly important for portable powered displays such as smartwatches and augmented-reality/virtual-reality (AR/VR) displays which cannot accommodate large batteries.

Existing VR and AR headsets use liquid-crystal displays (LCD) and organic light-emitting diode (OLED) displays, which lack brightness, resolution, power efficiency and lifetime. Efforts to establish micro-LED manufacturing use physical transfer of LEDs from the wafer upon which they are manufactured to the TFT display backplane, where they must be laser welded to the contact pad of the transistor to make an electrical connection.

For high-resolution displays, millions of tiny LEDs need to be transferred from one place to another, so the potential for placement error is large. If a 99.9% placement yield is achieved, then a full-HD color display will have over 6000 faulty sub-pixel LEDs that would need to be identified, removed and re-attached. Once the 6000 faulty LEDs have been replaced, a 99.9% yield will still mean six of these will be faulty, so the task of manufacturing a perfect display is not yet finished. It is the process of seeking out the faults and then replacing them one by one which is slowing down commercialization of this new type of display.

SmartKem says that its patented core chemistry allows its semiconductor inks to be processed at the low temperature of 80°C. With its lower temperature, transistors can be processed directly on top of the micro-LEDs. This eliminates the mass transfer and laser welding processes, and the fabrication of OTFTs can use existing low-cost manufacturing tools currently used for LCD backplane manufacturing. This approach cannot be carried out with other types of thin-film transistors as they are processed at the much higher temperature of 300°C, which damages the micro-LEDs, and which is why you need to make them separately and then laboriously join them together one by one, notes SmartKem.

www.smartkem.com

Luminus releases MP-7070 mid-power LEDs

Sulfur-resistant coating yields long lumen maintenance in outdoor and industrial environments

Luminus Devices Inc of Sunnyvale, CA, USA — which designs and makes LEDs and solid-state technology (SST) light sources for illumination markets — has announced the launch and immediate availability of a new high-efficacy family of 7070 mid-power LEDs designed for high performance and long-term reliability.

The new MP-7070 LEDs are available in both a 12V (MP-7070-4600 series) and 36V (MP 7070-T200 series) and are made with sulfur-resistance coating technology for long lumen maintenance in outdoor and industrial environments. While nominal drive conditions operate the device around 8W, customers can use these products in a range from 5W to 15W to maximize the lumen/Watt or lumen/$ values, respectively.

In a square 7mm x 7mm package, with a 6.3mm-diameter round light-emitting surface (LES), the MP-7070 delivers what is claimed to be excellent optical performance in both narrow-beam and wide-beam flood light applications. While competitors' 7070 products have a square LES, Luminus' round LES delivers higher optical efficiency and attractive beam shape, especially in narrow-beam optical systems. In addition, they are compatible with both automatic placement equipment and infrared reflow solder processes, and are RoHs and REACH compliant.

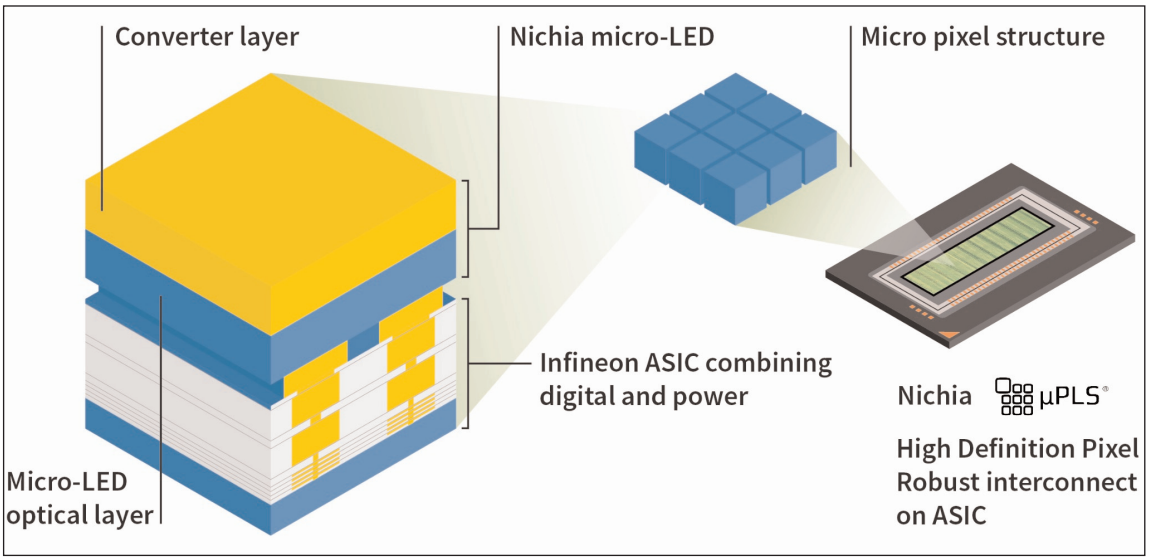
"Customers have been asking for a powerful, robust SMT emitter with high efficacy, reliability, affordability and Luminus' outstanding quality of light," says Tom Jory, VP of illumination marketing. "Our engineers have delivered on all of these requests and further differentiated from the competition by packing it all into a 6.3mm-diameter round LES, which delights optical engineers with a small source size for optimal efficiency in narrow-beam directional optical systems."

www.luminus.com/products/standardmidpower

Nichia and Infineon launch first fully integrated micro-LED light engine for HD adaptive driving beams

16,384-pixel µPLS micro-Pixelated Light Solution combines Nichia's micro-LED technology with integrated LED driver IC from Infineon

Three years ago Nichia Corp of Anan City, Tokushima, Japan and Infineon Technologies AG of Munich, Germany announced the joint development of a high-definition (HD) light engine with more than 16,000 micro-LEDs for headlight applications. Now, both firms are launching what is said to be the industry's first fully integrated micro-LED light engine for HD adaptive driving beam applications. The micro-LED matrix solution will be seen in a German premium vehicle in 2023.



The new 16,384-pixel µPLS micro-Pixelated Light Solution from Nichia and Infineon.

"The new 16,384-pixel µPLS micro-Pixelated Light Solution is our latest addition to Nichia's portfolio of high-class automotive lighting solutions. It combines high-definition resolution with industry's highest light output," says Yusuke Yamazaki, head of sales and marketing Automotive, Nichia Europe GmbH. "This solution enables a new automotive lighting experience by providing four-times wider field-of-view with significantly higher light output than any other current micro-mirror-based HD matrix-light solution. For this reason, the advanced HD light can warn drivers of hazards by highlighting people or objects on or by the side of the road. It can also project markings on the road to guide the driver through a construction site or intersection. In addition, functions such as the glare-free high beam or bending light work more precisely and smoothly compared to current adaptive driving beam solutions. This takes the driver's road safety and driving comfort to a new level," he adds.

"The µPLS is industry's first fully integrated matrix LED driver capable of driving 16,384 LEDs, combining all required micro-LED driver circuitry with extensive diagnostics and high-speed video and control interfaces," says Andreas Doll, Infineon's senior VP & general manager of the Body Power business unit of Infineon's Automotive Division. "Our innovative µPLS is much more energy efficient than current HD matrix lighting solutions, contributing to saving global CO_2 emissions and extending the range of electric driven vehicles. Furthermore, we enable the vision of our customers to deploy fully digital light on the road, saving them overall system cost at a very small form factor at the size of a single semiconductor chip," he adds.

The new HD light engine uses Nichia's micro-LED technology and an integrated LED driver IC from Infineon that can drive all 16,384 micro-LEDs individually using pulse-width modulation (PWM) control. Additionally, the driver IC monitors each micro-LED separately and provides on-chip temperature monitoring, allowing for optimal thermal control. Integrated video interfaces enable high-speed transmission of the video signal from the light pattern generator unit. Unlike current HD matrix solutions, Infineon's driver IC only activates the LEDs that are actually needed for a light pattern. This dramatically increases the energy efficiency of the µPLS light engine at much smaller form factor compared with micro-mirror-based HD matrix solutions in the market, it is claimed.

This allows for smaller and slimmer headlamp designs in the future. In addition, the new HD light engine enables adjustments that can be digitally programmed at the factory or activated by the vehicle manufacturer or driver on demand. For example, the different requirements of left- and right-handed drivers can be considered, significantly increasing user-friendliness. With all these features, the new HD light significantly reduces design and production complexity for vehicle makers, it is reckoned.

www.nichia.com
www.infineon.com/cms/en/discoveries/new-mobility

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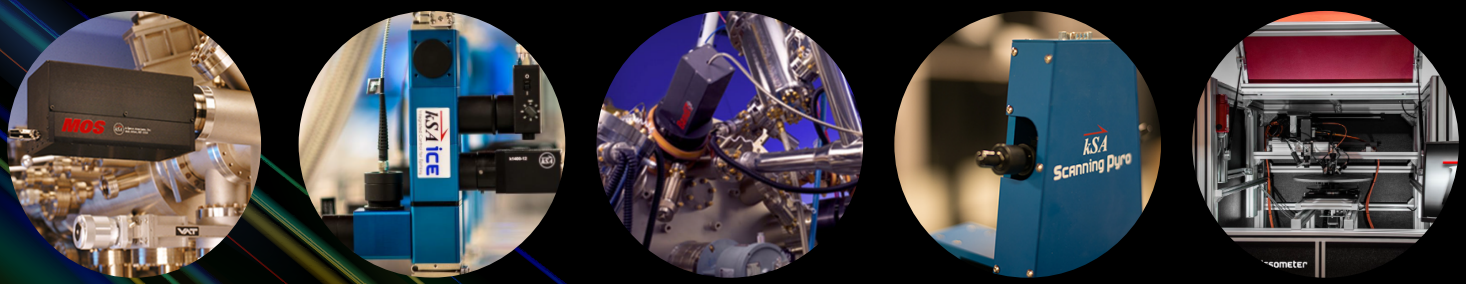

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Ganvix and BluGlass to co-develop green GaN VCSELs

Nanoporous GaN distributed Bragg mirrors to be combined with RPCVD-grown green-emitting quantum wells

Early-stage startup company Ganvix Inc of Wilmington, DE, USA – which specializes in developing nanoporous gallium nitride (NP-GaN) vertical-cavity surface-emitting lasers (VCSELs) — and BluGlass Ltd of Silverwater, Australia — which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs – have entered into a development agreement to combine their complementary technologies to create GaN VCSELs operating in the green region (515–525nm) of the optical spectrum.

GaN VCSEL devices have been long sought after but have not reached commercial maturity due to material growth and processing challenges. Two critical components of a VCSEL — the distributed Bragg mirrors (DBR) and active quantum well (QW) region — are more challenging to fabricate in GaN than for gallium arsenide (GaAs)-based VCSELs, which have seen significant commercial success operating in infrared wavelengths.

In the collaboration, Ganvix will leverage its proprietary VCSEL architecture based on nanoporous technology to facilitate the fabrication of DBRs. Ganvix has demonstrated this technology in GaN VCSEL devices operating at blue wavelengths and has completed the design and demonstrated the DBRs for green wavelengths. BluGlass will bring its expertise in RPCVD and green active QW design to grow the green QW and laser active region. The combined technology will be commercialized by Ganvix, completing a line of VCSEL products across blue to green wavelengths.

The target markets include consumer electronics, industrial, medical and life sciences, communications, and metaverse applications such as augmented reality (AR). Near-term applications include VCSEL-based light engines for laser scanning displays, lasers, and laser arrays for free-space and polymer fiber-based communications.

"We see many applications for these devices but, until now, limitations on materials have prevented commercialization," says Ganvix's CEO John Fijol. "The combination of our nanoporous materials, which we demonstrated earlier this year for blue VCSELs, and BluGlass' RPCVD-grown GaN provide a path to finally bring green GaN VCSEL to market," he adds.

"BluGlass' unique RPCVD technology provides an ideal solution to increase performance and brightness for green-wavelength lasers," comments BluGlass' president Jim Haden.

www.bluglass.com.au
www.ganvix.com

GaN lasers from BluGlass' Silicon Valley fab meeting or exceeding performance benchmarks

p-side processing transitioned from contract manufacturers to Fremont fab

BluGlass Ltd of Silverwater, Australia — which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — says that gallium nitride (GaN) laser diodes produced at its Silicon Valley production facility are now achieving or exceeding contract manufacturer performance benchmarks.

Testing of BluGlass' first lasers processed at its Fremont fab are demonstrating electrical and light-output performance in-line or better than previous iterations. These results follow the successful transition of p-side processing from contract manufacturers to its Silicon Valley fab. Reliability testing of these lasers has begun.

BluGlass continues bringing core downstream manufacturing processes in-house, with thinning, cleaving, n-metalization processes commencing, and facet coating well underway. The firm is targeting vertical integration by the end of fiscal-year 2023.

"Vertical integration is key to our commercialization strategy, enabling us to improve our laser quality, consistency and performance while significantly speeding development and reducing production costs," says president Jim Haden. "This technical milestone demonstrates the importance of operational control in accelerating development turns," he adds. "Our Silicon Valley production team has commenced work on n-side processing and facet coating capabilities, which is expected to further expedite development, production and improve laser performance and reliability."

www.bluglass.com.au/bluglass-fremont-lasers-meet-performance-benchmarks

NUBURU launches compact blue laser with third-generation light engine

New form factor accelerates high-brightness integration in industrial fabrication machines

At Photonics West 2023 in San Francisco (28 January–2 February), NUBURU Inc of Centennial, CO, USA launched the BL-series, a new compact-form-factor blue laser enabled by a third-generation light engine design.

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

The new BL-series lasers are designed as easy-to-service packages that can readily integrate with scanners and beam delivery systems. The 125W BL-125 and 250W BL-250 lasers will provide high power and brightness along with integrated power monitoring, enabling design and fabrication efficiencies across a wide variety of industries.

Advances in the new light engine build on the range of application development that NUBURU has conducted with its AO and AI product lines. The entire NUBURU product line is designed to bring the fundamental physical, economic and performance advantages of the blue industrial laser to both the electrification (energy storage, electric vehicles) and 3C (computers, communication, consumer electronics) sectors.

www.spie.org/conferences-and-exhibitions/photonics-west
www.nuburu.net

Tailwind stockholders approve NUBURU business deal

Completion of business combination targeted for first-quarter 2023

At a special meeting, shareholders of special-purpose acquisition company (SPAC) Tailwind Acquisition Corp voted to approve its business combination (announced on 8 August) with NUBURU Inc of Centennial, CO, USA, as well as other proposals related to the business combination.

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

Tailwind is a blank-check company formed for the purpose of effecting a merger, capital stock exchange, asset acquisition, stock purchase, reorganization or similar business combination with one or more businesses. Tailwind seeks to capitalize on the decades of combined investment experience of its management team, board of directors and advisors who are both technology entrepreneurs as well as technology-oriented investors with a shared vision of identifying and investing in technology companies.

www.nuburu.net

TRUMPF expands portfolio of polarization-stable multi-mode VCSELs to improve illumination quality in 3D applications

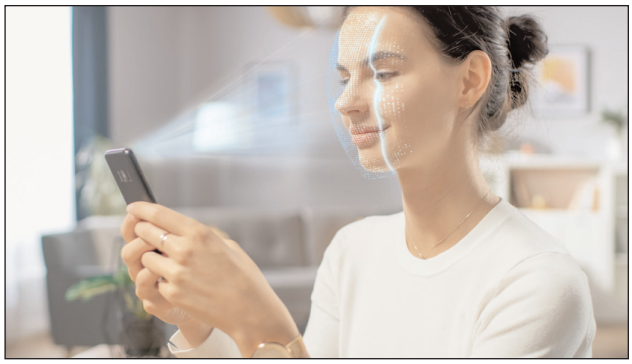
High-power dual-polarization multi-mode VCSEL and single-mode polarization-controlled VCSEL planned for 2023

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets — has released a new multi-mode VCSEL with stable polarization to support the increasing demand for advanced VCSEL sources.

By integrating additional functionalities such as linear polarization, VCSEL technology is becoming smarter and illumination quality is increasing, notes the firm. "It's great to see the VCSEL technology evolving and to tap into new application fields for VCSELs by integrating additional features," says Ralph Gudde, VP marketing & sales. "With the market release of our new multi-mode VCSEL with stable polarization, we serve application demands with optimal illumination quality, like in smartphones," he adds.

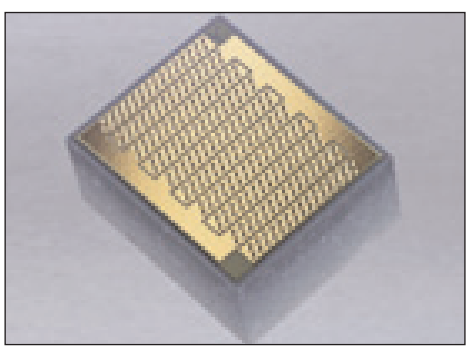
The new 940nm multi-mode VCSEL with controllable polarization is entering mass production and comes with high yield. The proprietary surface grating is directly etched into the gallium arsenide (GaAs). With the two emission zones, the new VCSEL generates optical power of 8mW. Applications in consumer electronic devices and smartphones benefit from this optimum efficiency in optical power, as the VCSEL technology combines high laser efficiency and slope efficiency of 1W/A with full polarization control.

Measurements confirm that the electro-optical properties of VCSELs with integrated grating and stabilizing linear polarization are the same as VCSELs without grating. "Thanks to the polarization feature, controlled laser light improves the quality of the overall sensing system, enabling a positive user experience and power savings," says Gudde.



Better illumination quality for smartphones, AR and VR

The smartphone and consumer electronics industries are constantly looking for smarter components for their devices, all while increasing illumination quality. VCSELs with polarization-controlled light address these demanding 3D illumination applications not only in smartphones but also in OLED screens or in virtual-reality (VR) and augmented-reality (AR) applications. The illumination quality is greatly increased, as polarized light helps to eliminate optical losses. VCSELs with stable polarization also avoid disturbing reflections and enable innovative optical concepts like a collinear arrangement of transceiver and receiver optics. This is supported by TRUMPF's own designs and processes, which enable high quality and perform without any losses.



VCSEL with dual polarization.

Two in one: switchable polarization on its way

TRUMPF has also announced its next products with polarization features, which will be released later in 2023.

One is a multi-mode VCSEL with dual polarization that is now ready for customer sampling. Here, one single VCSEL chip can individually address two polarization directions, which significantly reduces the form factor and the optical system complexity. This supports further miniaturization demands in smartphone applications and consumer electronics. In the actual concept, two VCSEL arrays at 0° and 90° linear polarization are combined and interlaced on one VCSEL chip, using orthogonal surface gratings. The two polarization directions are individually addressable, each yielding about 1.35W of output power. Combined with polarization-selective optics, this results in a reduction in the number of components, as only one VCSEL chip is needed to create both flood illumination and dot patterns. "Dual-polarization VCSELs will revolutionize the consumer electronics business," believes Gudde. "Device manufacturers will get one component that functions as a dual-pattern projector," he adds.

The second release will be a large polarization-controlled single emitter, single-mode VCSEL component with 2mW output power. This serves industrial sensing applications like industrial optical encoders and spectroscopy. Evaluation samples will be available from June onwards, and mass production is scheduled for the end of 2023.

www.trumpf.com/s/VCSEL-solutions

TRUMPF and RSP partner to miniaturize non-invasive wrist-worn blood glucose sensor

VCSELs to enable needle-free monitoring for diabetes patients

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which makes vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for consumer electronics, datacoms, industrial sensing, heating and automotive markets — and medical device company RSP Systems A/S of Odense, Denmark have partnered to create a sensor that will allow RSP's non-invasive technology to be miniaturized to a wearable format. The aim to make life easier for people with diabetes. Instead of having to prick with a needle or wear an implant, in the future a wrist-worn device will read their glucose with a mini-laser.

TRUMPF brings its expertise in VCSELs. "With our knowledge of the mechanisms of photonics, we can soon enable people with diabetes to measure their blood glucose levels more easily, more cheaply and entirely without pain," says TRUMPF Photonic Components' CEO Berthold Schmidt. "This partnership once again shows the innovation potential of VCSEL technology."

RSP Systems already has portable, optical sensor-based devices that can measure glucose levels – but in the size of a paperback book. "Touch glucose monitoring has been an ambition for device developers over the last three decades due to the vast implications for hundreds of millions of people, needing to keep an eye on their glucose levels," says RSP Systems' CEO Anders Weber. "Together with TRUMPF Photonic Components, we will realize a wrist-worn device, aimed to cover all uses from people on insulin therapy to people at risk for developing diabetes, literally hundreds of millions of people," he adds. "Over the past 10 years, the company has developed an accurate, factory-calibrated and clinically proven glucose monitor that provides accurate glucose readings just by touching the skin and with no need for calibration."

Measuring blood glucose with laser diodes

Diabetes has caused worldwide at least $966bn in healthcare expenditures to date. If the disease is not treated or is treated incorrectly, there is a risk of secondary diseases such as blindness, kidney failure or heart attack, according to the World Health Organization (WHO). According to the International Diabetes Federation, about 540 million adults worldwide live with the metabolic disease diabetes, half of whom have not yet been diagnosed. The number of people affected is expected to rise to 643 million by 2030 and to 783 million by 2045. "If we are successful together, we will improve the lives of hundreds of millions of people," says Schmidt.

TRUMPF Photonic Components' lasers are already used in smartphones, smartwatches, digital data transmission and sensors for autonomous driving. "VCSEL lasers are clearing the way for a glucose sensor for your wrist — people with diabetes can thus keep an eye on their glucose levels at all times," says Weber.

www.rspsystems.com
www.trumpf.com
/s/VCSEL-solutions

Coherent launches first commercially available 50W pump laser diodes for fiber lasers

Materials, networking and laser technology firm Coherent Corp has launched its next-generation pump laser diodes, which achieve output power of 50W from a single chip (40% more than that of the existing product), enabling high-power industrial fiber laser designs with fewer pump laser diodes.

The deployment of fiber lasers for materials processing applications such as cutting, welding, marking and additive manufacturing is accelerating, driving the demand for key components that lower the cost per watt of output power.

"This is the first commercially available pump laser diode in the industry to achieve 50W of output power," believes Dr Karlheinz Gulden, senior VP, Laser Components and Subsystems business unit. "We continue to break new industry records in semiconductor laser diode output power, based on our gallium arsenide technology platform that has decades of field-proven reliability."

The new 50W laser diodes are available at 915nm and 976nm. The output facet width of the chips is available from 150µm to 350µm, enabling optimal coupling efficiency and output powers for a wide range of fiber laser designs. The chips include Coherent's proprietary E2 front mirror passivation that prevents catastrophic damage to the laser, even at extremely high output.

Coherent offers pump laser diodes as bare dies, chips on ceramic submounts, and in fiber-coupled multi-emitter modules. The firm's broad portfolio of components for fiber lasers includes seed lasers, acousto-optic modulators, fiber Bragg gratings, kilowatt pump and signal combiners, as well as IBS-coated laser optics and micro-optics for high-power isolators.

www.Coherent.com

Dutch consortium invests €3.5m in LioniX

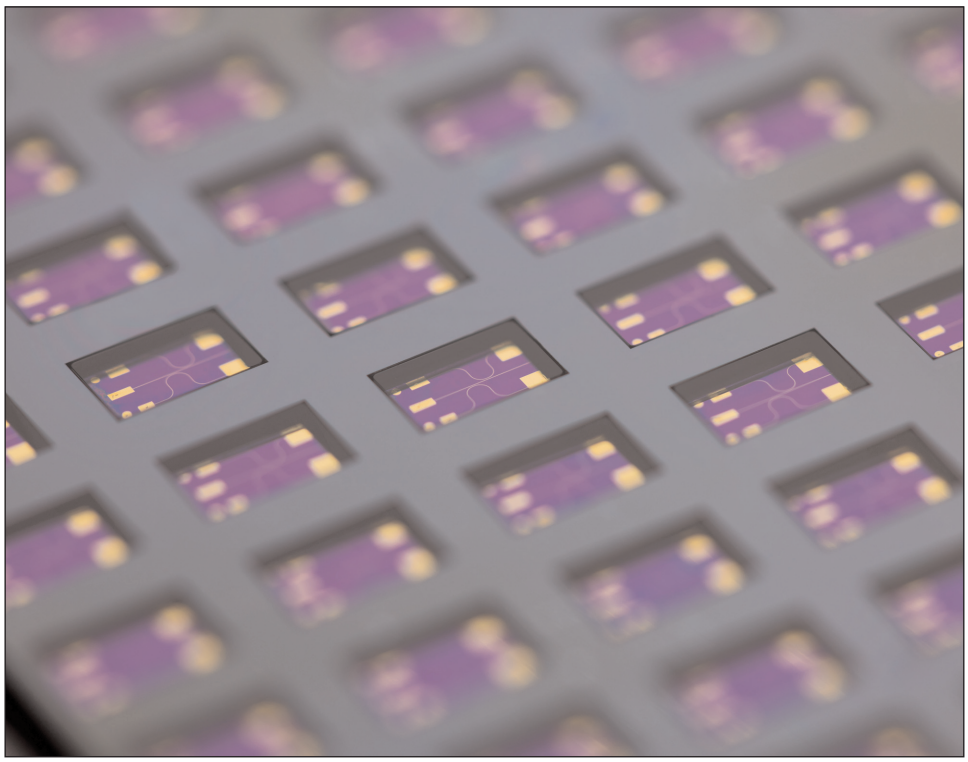
Consortium led by Invest-NL and FORWARD.one, and including Universiteit Twente Holding, Oost NL and PhotonDelta

A Dutch consortium led by Invest-NL and FORWARD.one, and further consisting of Universiteit Twente Holding, Oost NL and Netherlands-based PhotonDelta, has invested €3.5m in LioniX International BV (LXI) of Enschede, The Netherlands, which designs and produces customized integrated microsystems, photonics, sensing and micro-electro-mechanical systems (MEMS) for OEMs and system integrators. The consortium sees investment in LioniX International as an illustration of its commitment to further strengthening the Dutch deep-tech ecosystem and ChipTech Twente in particular.

LioniX has developed the proprietary TriPleX photonic integrated circuit (PIC) platform, which is based on stoichiometric silicon nitride (SiN) proprietary waveguide technology realized by low-pressure chemical vapor deposition (LPCVD). This enables the development of applications ranging from augmented reality/virtual reality (AR/VR), (bio)sensing and telecom to photonic quantum computing. Its solutions are critical for the advancement of technologies for a range of industries including healthcare, aerospace, defense and telecoms.

As a vertically integrated player within the Dutch deep-tech ecosystem, LioniX offers full module product development and production for its OEM customers with services including microfabrication, packaging & assembly, prototyping, testing & characterization, and engineering design. This module development is based on an extensive library of validated building blocks from which customized modules are built.

"This set of investors enables further growth for LioniX International," says CEO Arne Leinse. "We are excited to continue developing and delivering cutting-edge microsystem solutions to our current, and new clients around the globe," he adds.



Wafer with RGB light engine chips for AR-VR glasses.

"This investment is an exciting step forward for both LioniX International and the Dutch tech industry as a whole," comments Leo Holwerda, director capital at Invest-NL. "It fits perfectly with the ambitions of our Deep Tech Fund, which aims to invest in knowledge-intensive start- and scale-ups that have the potential to bring innovation in the Netherlands to the next level," he adds.

"LioniX has developed a technology that is a leader in the field of photonics with numerous potential applications," comments Paul Pruijmboom, general partner at FORWARD.one. "As a high-quality Dutch deep-tech company, LioniX exemplifies the innovative potential of the Netherlands," he adds.

"With this investment in LioniX we strengthen our position in chip technology in East Netherlands," says Chimwemwe de Gaay Fortman, director capital at Oost NL. "Together we built a strong Dutch photonics cluster with global impact."

"This investment in LioniX International is a further enhancement of the tech ecosystem in Twente, and will help to further establish Twente as one of the key photonics and quantum technology hubs in Europe," believes Ellen Velthuis, chief financial officer at University of Twente Holding.

The Ministry of Economic Affairs and Climate Policy of the Netherlands and Invest-NL launched their Deep Tech Fund (DTF) in early 2022. The DTF aims to invest in companies with innovative, complex technologies, like LioniX. These investments are reckoned to be crucial for the future of the Dutch economy and, more specifically, contribute to the aim to strengthen knowledge and innovation within the Netherlands and the European Union.

www.lionix-international.com
www.photondelta.com

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NIST and AIM Photonics collaborating to boost photonic chip designs to 110GHz

Electrical calibration structures to be incorporated into updated PDK

The US Department of Commerce's National Institute of Standards and Technology (NIST) has entered into a cooperative research and development agreement with AIM Photonics that will give chip developers a critical new tool for designing faster integrated photonic circuits, as key components in fiber-optic networks and high-performance computing facilities as well as laser-guided missiles, medical sensors and other advanced technologies.

As a Manufacturing USA institute, AIM Photonics (the American Institute for Manufacturing Integrated Photonics) is an industry-driven, public-private United States Department of Defense (DoD)-sponsored engineering technology consortium, spearheaded by the State University of New York Polytechnic Institute (SUNY Poly). Its aim is to accelerate the commercialization of new technologies for manufacturing photonic chips. The institute provides small- and medium-sized businesses and academic and government researchers access to expertise and fabrication facilities during all phases of the photonics development cycle, from design to fabrication and packaging.

As part of the new collaboration, NIST will design electrical calibration structures that can be used to measure and test the electronic performance of the chips. This will result in improved designs for photonic chips that operate at speeds up to 110GHz. Most existing photonic chips operate at about 25GHz.

Cleanroom technicians at the AIM Photonics' NanoTech chip fabrication facility in Albany, New York. Credit: SUNY Polytechnic Institute.

"This effort will leverage NIST's expertise in chip measurements, calibration and integrated device modeling," says Under Secretary of Commerce for Standards and Technology and NIST director Laurie E. Locascio. Also, while planning for this effort began before the passage of the CHIPS Act, it aligns with the act's goals. "This shows how government and industry can work together to drive innovation and restore US global leadership in semiconductor manufacturing," Locascio adds.

In addition, AIM Photonics will incorporate these calibration structures into its process design kit (PDK) for engineers designing new chips for fabrication at AIM's facilities.

"Accurate measurements are key to advancing high-speed communications," says David Harame, AIM Photonics' chief operating officer. "These enhancements will give our members and customers the tools they need to design the next generation of advanced photonic chips."

Experts from both organizations are already working to integrate the new measurement structures into AIM Photonics' foundry process, and an updated PDK with the calibration structures should be available to users in about a year.

www.aimphotonics.com
www.nist.gov

OpenLight appoints Adam Carter as CEO

Industry veteran to lead growth with integrated laser open-foundry business

OpenLight of Santa Barbara, CA, USA, the first open silicon photonics technology with integrated lasers, has appointed Dr Adam Carter as CEO. Carter has over 25 years of experience in the semiconductor industry, including roles in sales, marketing and general management in networking, optical communication system, optical component and module markets.

"The company has a unique and innovative business model and a world-class engineering team that will enable our customers with access to our intellectual property, design services and photonic integrated components to accelerate the use of PICs in a wide variety of markets and applications," says Carter. "I look forward to guiding the team through future growth as we scale our open-foundry business."

Previously, Carter was chief commercial officer at Foxconn Interconnect and Oclaro. At Oclaro, he served as a member of the senior executive team from July 2014 to December 2018, when it was acquired by Lumentum Holdings for $1.85bn. Prior to that, he was senior director & general manager of the Transceiver Module Group at Cisco from February 2007 to July 2014, where he was instrumental in the acquisition of silicon photonics start-up Lightwire, and released the first internally designed CPAK 100G transceiver family utilizing a silicon photonics optical engine.

CEO Adam Carter.

Our proven ability to integrate lasers, amplifiers as well as passive components on a single chip has already provided our customers with scalable, high-performance, cost-effective solutions while driving operational efficiency

"Since our launch last year, our proven ability to integrate lasers, amplifiers as well as passive components on a single chip has already provided our customers with scalable, high-performance, cost-effective solutions while driving operational efficiency," says OpenLight's chief operating officer Dr Thomas Mader. "As we begin a new year, we are delighted to have Dr Carter join the company and lead our efforts in driving this new era of open silicon photonics with integrated lasers and our company growth."

Carter holds a B.Sc. (Honors) in Applied Physics from the UK's Portsmouth University and received a PhD from the University of Wales, Cardiff, for his research on reactive ion etching of III–V semiconductor materials.

OpenLight says that it is currently engaged with many customers to design and deliver new levels of performance and scalability across applications, including but not limited to datacom, automotive, artificial intelligence (AI), machine learning (ML), high-performance computing (HPC), and sensing applications.

www.openlightphotonics.com

Vector Photonics appoints factory applications engineer

Peter Linton to drive PCSEL design-in with global NEM customers

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK says that Peter Linton has joined it as factory applications engineer, providing a technical interface between global network equipment manufacturer (NEM) customers and its research & development team in Glasgow. This will involve establishing each NEM customer's next-generation 800Gb/s interconnect requirements as they develop devices for hyperscale and cloud data-center applications. The firm says that the role is essential to the ongoing commercialization of its unique, all-semiconductor PCSEL technology.

Peter Linton.

"Peter will bring important direction to the ongoing development and commercialization of Vector Photonics' PCSELs," says sales & marketing director Euan Livingston. "He will drive the 'design-in' of PCSELs in each NEM's device development to inform PCSEL design, manufacture, characterization, and systems qualification."

Linton joins Vector Photonics from spectroscopy instrumentation product manufacturer Edinburgh Instruments, where he was product engineer, responsible for validation testing, product integration, customer support, continuous design improvement, training and after-sales support.

Linton has a Masters degree in Physics from the University of Strathclyde, specializing in Solid State Physics and Nanoscience.

www.vectorphotonics.co.uk

Coherent appoints Beck Mason as executive VP, Telecommunications

Mason to lead Telecoms business unit within Networking Segment

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA says that Dr Beck Mason has joined the firm as executive VP, Telecommunications, leading the Telecommunications business unit within the Networking Segment.

"Mason will identify the technology vision for Coherent's telecom product offerings, play an integral role in defining the company's technology platforms and strategic investments, and drive the profitable growth of the telecom business in the communications markets that we serve," says chair & CEO Dr Vincent D. Mattera Jr.

Mason will have oversight of Coherent's broad technology and product portfolio for optical communications in transport and access networks, from components to integrated modules and disaggregated subsystems. The telecom product portfolio includes wavelength-tunable pluggable transceivers, high-speed coherent pluggable transceivers, wavelength-selective switch (WSS) modules, pump lasers, optical amplifiers, optical monitoring, and reconfigurable optical add-drop multiplexer (ROADM) solutions.

Beck Mason.

Mason joins Coherent from Lumentum, where he was senior VP & general manager of the Telecom Transmission business, helping to guide their technology strategy for the last four years. He joined Lumentum in 2018 through the acquisition of Oclaro, where he was president of the Integrated Photonics business. Previously, he had leadership roles at JDSU, Collinear, Finisar, Agere Systems, and Lucent Technologies Bell Labs. He has a bachelor's degree in Engineering from the University of Waterloo in Canada, a master's in Aerospace Engineering from the University of Toronto, and a Ph.D. in Electrical and Computer Engineering from the University of California at Santa Barbara (UCSB).

Coherent launches 905nm triple-junction edge-emitting lasers for industrial LiDAR

Up to 100W at 40A (pulsed) enables direct ToF LiDAR applications

Coherent has introduced its 905nm triple-junction edge-emitting semiconductor lasers for light detection and ranging (LiDAR) in industrial applications.

Range-finding devices embedded in binoculars and increasingly in autonomous robots that accomplish complex tasks, such as handling, sorting, mapping and navigating, are accelerating the demand for LiDAR-based depth sensing using components that perform efficiently and reliably, even in the most extreme environments. The new 905nm lasers feature a triple-junction design that enables them to efficiently emit up to 100W of optical power in nanosecond pulses. The lasers are qualified to the stringent JEDEC JESD22-A10x standard for industrial applications.

"We will be able to achieve significant economies of scale by migrating manufacturing of this new laser diode platform to our existing 6-inch gallium arsenide platform," says Dr Karlheinz Gulden, senior VP, Laser Components & Subsystems business unit. "It is the only technology platform of its kind to have pushed the frontiers of both manufacturing scale and field reliability, underpinning semiconductor lasers for high-volume consumer electronics and industrial devices, as well as for optical communications equipment deployed undersea."

Built in a robust and hermetically sealed TO-56 package, the triple-junction lasers emit three times the optical power per chip area compared with single-junction devices, resulting in powers of up to 100W at 40A pulsed operation. They enable direct time-of-flight (ToF) LiDAR systems in a wide variety of mission-critical robots exposed to challenging environments. Applications include warehouse logistics, consumer appliances, last-mile delivery, crop harvesting, land surveying, and safety monitoring.

Coherent offers a broad portfolio of active and passive products for LiDAR designs. Active devices include vertical-cavity surface-emitting lasers (VCSELs), edge-emitters, laser bars, frequency-modulated continuous wave (FMCW) sources, and pulsed fiber-based sources. Passive devices includes laser optics, polygons, galvo mirrors, lenses, ultra-narrowband filters, wide-incidence-angle mirrors, gratings, and thermoelectrics.

Coherent showcased its solutions for life sciences, precision manufacturing, and sensing at BiOS and Photonics West in San Francisco (28 January to 2 February).

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

Lumentum names Caroline Pan as senior VP & chief marketing officer

Pan to lead strategic marketing, corporate marketing and communications, and Lumentum Ventures

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has appointed Caroline Pan as senior VP & chief marketing officer, reporting to president & CEO Alan Lowe. Pan will be responsible for leading strategic marketing, corporate marketing and communications, and Lumentum Ventures, a company-wide initiative to drive market expansion through breakthrough innovation.

"Given expanding opportunities outside of Lumentum's core customers and end-markets, Caroline's diverse portfolio of global experience, deep domain knowledge across industry sectors, and proven track record of delivering high-impact business results make her an important and timely addition to our executive leadership team," comments Lowe.

Caroline Pan.

"I could not be more pleased to have the opportunity to join Lumentum as their chief marketing officer at this particular inflection point in the company's evolution," says Pan. "I am looking forward to working closely with Alan and the rest of the organization to unlock and unleash our internal innovation efforts and reposition the company for unprecedented growth ahead."

Pan has nearly 30 years of experience across the high-tech, industrial and automotive sectors. Before joining Lumentum, she was the chief marketing officer for Bright Machines, a venture-backed software and robotics company that provides intelligent automation solutions for discrete manufacturing.

Prior to Bright Machines, Pan was a vice president at Honeywell International, where she last led strategy, innovation and ventures for its $7bn Safety & Productivity Solutions business. She also established Honeywell's first corporate marketing function and led strategy & marketing for their Global High Growth Regions organization.

Pan also served as global VP of emerging markets for Hewlett-Packard's PC and Printing division, and spent 11 years with Intel Corp, where she held leadership roles in their core product groups and corporate functions. She began her career as a design engineer and product line manager at Ford Motor Company.

Pan holds a Bachelor of Science degree in Mechanical Engineering from the Massachusetts Institute of Technology and an MBA from Harvard Business School.

www.lumentum.com

Lumentum listed among America's Most Responsible Companies for 2023

Newsweek ranks Lumentum third in Software and Telecommunications Industry

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) has been named by Newsweek as one of America's Most Responsible Companies for a second consecutive year.

In partnership with global research and data firm Statista Inc, global digital news organization Newsweek Inc assessed the top 2000 publicly listed US-headquartered companies and ranked the most responsible companies according to the three key pillars of ESG: environment, social, and corporate governance. Scoring was determined by two metrics: publicly available key performance indicators derived from corporate social responsibility (CSR) reports and an independent survey on the perception of companies' CSR activities among U.S residents.

Lumentum's ranking improved significantly from 2022 to 2023 – moving to 31st in the overall rankings and third within the Software and Telecommunications sector, versus 122nd and 8th, respectively. The company earned an ESG score of 85.03 out of 100, including an Environmental score of 93.08.

"This recognition validates Lumentum's outstanding progress toward its CSR goals as we strive to reduce our environmental impact, improve the lives of others, and shape a culture that prioritizes a brighter future for the world," comments president & CEO Alan Lowe.

POET collaborates with ADVA on highly integrated 4x100G solutions

Multi-engine transmit and receive chips pack functionality of four 100Gbit/s interfaces into QSFP-DD housing

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center, telecom and artificial intelligence (AI) markets — has developed multi-engine 100G CWDM4 and 100G LR4 chip-on-board solutions for its lead customer ADVA Optical Networking SE of Munich, Germany. ADVA will use POET's multi-engine transmit and receive chips in an innovative pluggable solution that packs the functionality of four independent 100Gbit/s interfaces into a single QSFP-DD housing.

"ADVA's MicroMux Quattro brings the industry's smallest aggregation technology all the way to the network core," says Ross Saunders, general manager of Optical Engines, ADVA. Engineered as a standard-compliant plug-in a QSFP-DD form factor, it fits into a 400Gbit/s socket, enabling it to meet legacy needs. "This innovative pluggable solution packs the functionality of four independent 100Gbit/s interfaces or two independent 200Gbit/s interfaces into a single QSFP-DD housing. POET's unique design of its optical engines with hybrid integration of optical chips and monolithically integrated MUX and DMUX enables us to deliver industry-leading products in a small form factor that is scalable to high-volume production as well as to higher data rates, such as 1.6Tbit/s and 3.2Tbit/s, thereby enabling much higher bandwidth in a pluggable form factor," he adds.

"POET's Optical Interposer platform provides a high level of photonic integration to provide unique solutions in miniature form factors," says POET's president & general manager Vivek Rajgarhia. "Our wafer-scale integration platform provides ADVA with compelling solutions that are well aligned with their current and future products."

POET's multi-engine chips incorporate multiple instances of industry-standard 100GBASE-CWDM4 (for 2km applications) and 100GBASE-LR4 (for 10km applications) transmit and receive functionalities on a single optical engine. The firm's 100GBASE-LR4 optical engines are reckoned to be the industry's first implementation of chip-on-board solutions for the 100G LR4 market. The hybrid integration of lasers and photodiodes, monolithic integration of optical MUX and DMUX and the passive alignment of components on POET's Optical Interposer platform provides a unique solution to enable high-density network connectivity.

POET has demonstrated 10km operation of 100G LR4 optical engines in its Shenzhen Lab and plans to ship beta samples to ADVA in first-quarter 2023, with production targeted in second-half 2023.

According to LightCounting's April 2022 report, the market opportunity for 100G CWDM4 and LR4 pluggable transceivers will continue to remain strong, at an average size of $700m annually from 2023 to 2027.

www.adva.com

Production release of POET's optical engines for 100G, 200G & 400G telecom and data-center markets

Commercialization milestone for products built with proprietary wafer-level chip-scale packaging technology

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center, telecom and artificial intelligence markets — has advanced its commercialization goals by releasing to production four optical engines. The small-form-factor optical engines with integrated directly modulated lasers (DMLs), optical multiplexer, high-speed photodiodes and optical demultiplexer enable low-power, cost-efficient and highly scalable 100G CWDM4, 200G FR4 and 400G FR4 pluggable transceivers for telecom and data-center markets.

POET reached its production release milestones while working with Super Photonics, the joint venture company formed with Sanan IC of Xiamen, China. POET and Super Photonics have jointly completed design verification testing and reliability testing of the optical engines per relevant industry standards. The next step in the commercialization process is for POET's customers to qualify the products internally with their clients. Purchase orders are expected to follow.

"We have worked closely with our customers to engineer the optical engines to their requirements. So far, everyone involved in the process is very satisfied with the results. The release of POET's optical engines to production sets the stage for high-volume deployment and widespread acceptance of our technology," said Vivek Rajgarhia, president & general manager of POET. "Our customers can realize the immense value of POET's Optical Interposer platform when they move to high-volume production and achieve a cost-effective solution with simplified transceiver design, fewer active alignments, and reduced OpEx and CapEx spending."

The 100G CWDM4 transmit optical engine consists of four high-speed DMLs, monitor photodiodes and an optical multiplexer. The receive optical engines for 100G CWDM4, 200G FR4 and 400G FR4 have four high-speed photodiodes and an optical demultiplexer integrated in a compact form factor. Customers can opt to procure the engines with an integrated fiber array unit (FAU), which provides an even more complete solution for next-generation data-center interconnects.

Super Photonics has received an order from a customer for transceiver prototype builds for end-customer qualification. Super Photonics and POET are actively working with at least four other customers to complete transceiver-level design and qualification of the optical engines and expect to ramp to high volume in second-half 2023. POET expects to release more products to production in first-half 2023.

POET amends terms of share purchase warrants

Exercise price reduced, expiry extended, acceleration clause amended

POET says that, further to its announcement on 22 December, it has completed the amendment to the terms of 1,764,720 common share purchase warrants that were issued pursuant to a private placement that closed on 11 February 2021.

The warrants previously had an exercise price of C$11.50 per common share and were due to expire on 11 February 2023. As a result of the amendments, the warrants are now exercisable to acquire one common share at an exercise price of C$4.25 each until 5pm (Toronto time) on 11 May.

In accordance with the policies of the TSX Venture Exchange, the expiry date of the warrants may be accelerated to 30 calendar days if, for any 10 consecutive trading days during the unexpired term of the warrants, the closing price of the common shares on the exchange is equal to or greater than C$4.89 each. All other terms and conditions of the warrants remain the same.

www.poet-technologies.com

Fraunhofer ISE advancing perovskite–silicon tandem cell and module technology to industrial maturity

Efficiency of 22.5% achieved for 100 square centimetre cell with industrial screen-printing metallization

Compared with a pure silicon solar cell, stacking a solar cell made of perovskite material on top of a conventional silicon solar cell enables more effective use of the solar spectrum. Scientists around the world are presently researching these perovskite–silicon solar cells, focusing on stability, durability and industrial manufacturing processes.

Between 2020 and 2022, researchers at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany, together with industry partners, developed technologies for the production of perovskite–silicon full-format photovoltaic (PV) modules in the joint project SWiTch. At the cell level, the research teams in the Fraunhofer lighthouse project MaNiTU and in the project PrEs-to, funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK), succeeded in scaling up perovskite–silicon tandem solar cells from laboratory cell size to wafer size. Within the framework of a recent collaboration agreement with Meyer Burger, Fraunhofer ISE will further intensify its activities in tandem solar cells and modules.

Perovskite–silicon tandem solar cells represent a further development of the conventional silicon wafer-based solar cell technology. Here a perovskite solar cell with a wider bandgap is stacked on top of the silicon solar cell to make better use of sunlight. "Efficiencies of over 35% are possible with these tandem solar cells," says professor Andreas Bett, institute director at Fraunhofer ISE. "Laboratory-scale perovskite–silicon tandem solar cells have already overcome the silicon cell's theoretical upper efficiency limit of 29.4%, showing promise for even more efficient solar cells in the future."

Processing perovskite–silicon tandem solar cells at Fraunhofer ISE. The lab infrastructure comprises evaporation chambers for perovskite absorbers, selective contacts and metals, and the atomic layer deposition of metal

Scaling of laboratory cells to wafer size

On a laboratory scale, the best published efficiency of a perovskite–silicon solar cell is currently 31.3%. However, these laboratory solar cells have a small cell area of about 1cm^2, and most of the manufacturing processes used in the laboratory to date cannot be used for industrial production. "We are therefore very pleased that we have succeeded in achieving a certified efficiency of 22.5% for a perovskite–silicon solar cell with an area of more than 100 square centimeters and with industrial screen-printing metallization," says Dr Patricia Schulze, solar cell scientist working in the MaNiTU project at Fraunhofer ISE. "Our aim is now to realize the high efficiencies of our small laboratory cells on large-area cells using scalable fabrication methods," she adds. In particular, the Fraunhofer researchers are working on a hybrid deposition process based on two established manufacturing processes to produce perovskite solar cells on double-sided textured silicon solar cells.

First full-format modules built

In the project SwiTch, Fraunhofer ISE — together with project partners — developed interconnection and encapsulation solutions for tandem solar cells. "The interconnection and lamination processes had to be understood and adapted in such a way that the perovskite–silicon cells can be integrated into the module without damage, at low cost and with long-term stability," says Dr Holger Neuhaus, department head of Photo-voltaic Modules at Fraunhofer ISE. First module prototypes with an output of 430W peak have already been produced. The development was accompanied by a detailed analysis of cell-to-module losses and work on the long-term stability of the tandem PV modules. As part of the joint project SALTO, Fraunhofer ISE was able to establish Meyer Burger's patented SmartWire interconnection technology (SWTC) for full-format modules at Fraunhofer ISE. This low-temperature technology is suitable for interconnecting silicon–perovskite cells, in contrast to conventional soldering processes.

www.ise.fraunhofer.de

First Solar completes sale of 141MW Luz del Norte power plant to asset manager Toesca

Sale and purchase agreement terms completed in December

First Solar Inc of Tempe, AZ, USA — which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) and provides engineering, procurement & construction (EPC) services — has completed the sale of Luz del Norte (a 141MW_{AC} utility-scale solar power plant in Copiapó) to independent asset manager Toesca of Las Condes, Chile.

First Solar previously disclosed that it had signed a sale and purchase agreement for the facility on its third-quarter 2022 earnings call. The terms of the transaction, which was completed in December, were not disclosed.

www.firstsolar.com

Ascent Solar launches options trading

Turnaround continues after relisting on Nasdaq, reforming board, and new executive leadership

Ascent Solar Technologies Inc of Thornton, CO, USA — which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) modules that can be integrated into consumer products, off-grid applications and aerospace applications — has introduced options trading of its stock, via all US options exchanges.

Nasdaq approved ASTI options for trading on 17 November. Four options chains are available to the public: December 2022 and January, February and May 2023. The American-style ASTI options expire monthly.

"This is another step in our comprehensive turnaround that began in early 2022 with the relisting of ASTI on Nasdaq, reforming our board of directors, and installing new executive leadership," says CEO Jeffrey Max.

www.AscentSolar.com

Mini-LED-backlit automotive display module shipments to grow from 140,000 in 2022 to 450,000 for 2023

Late adopters will boost shipments to almost 1 million in 2024, says TrendForce.

Because of their use by European, Chinese and US carmakers, shipments of mini-LED-backlit display modules are estimated to total about 140,000 units in 2022, which can be considered to be the inaugural year for their adoption in the automotive industry, says TrendForce. In 2023, European and US carmakers such as Ford and Jeep are expected to gradually introduce the display technology to more of their models, driving shipments to 450,000 units, it forecasts. However, 2024 will be the year when shipments take off even more dramatically. By then, the further technological maturation of mini-LED backlights will attract the late adopters among carmakers, it is reckoned. Shipments are thus forecasted to reach almost 1 million units in 2024.

TrendForce lists four factors that are attracting carmakers to mini-LED-backlit displays. First, mini-LED backlights offers multiple dimming zones that can raise the brightness of a display above 1000 nits. High brightness is especially important for automotive applications because it helps to minimize glare from the outside environment. For instance, the strong light reflected from snow or emanating from the sun can interfere with the driver's viewing of various displays inside a vehicle, creating safety risks. Increasing display brightness mitigates this problem.

Second, a direct-lit backlight solution featuring mini-LEDs can turn individual sections of a screen on or off selectively in accordance with the distribution of the light and dark parts of an image. With the traditional edge-lit solution, the entire screen is lit all the time. Carmakers can thus leverage mini-LED backlights to meet their energy-saving requirements, as a display system can consume about 10% less power by incorporating this technology.

Third, the development of automotive interior displays is trending towards larger sizes and integration. Direct-lit mini-LED solutions support not only the ongoing increase in display size but also the optical performance enabled by highly curved displays. Compared with the traditional edge-lit solutions, direct-lit mini-LED solutions offer better performance for curved automotive displays and are suitable for a wide range of automotive interior displays that differ in size and design.

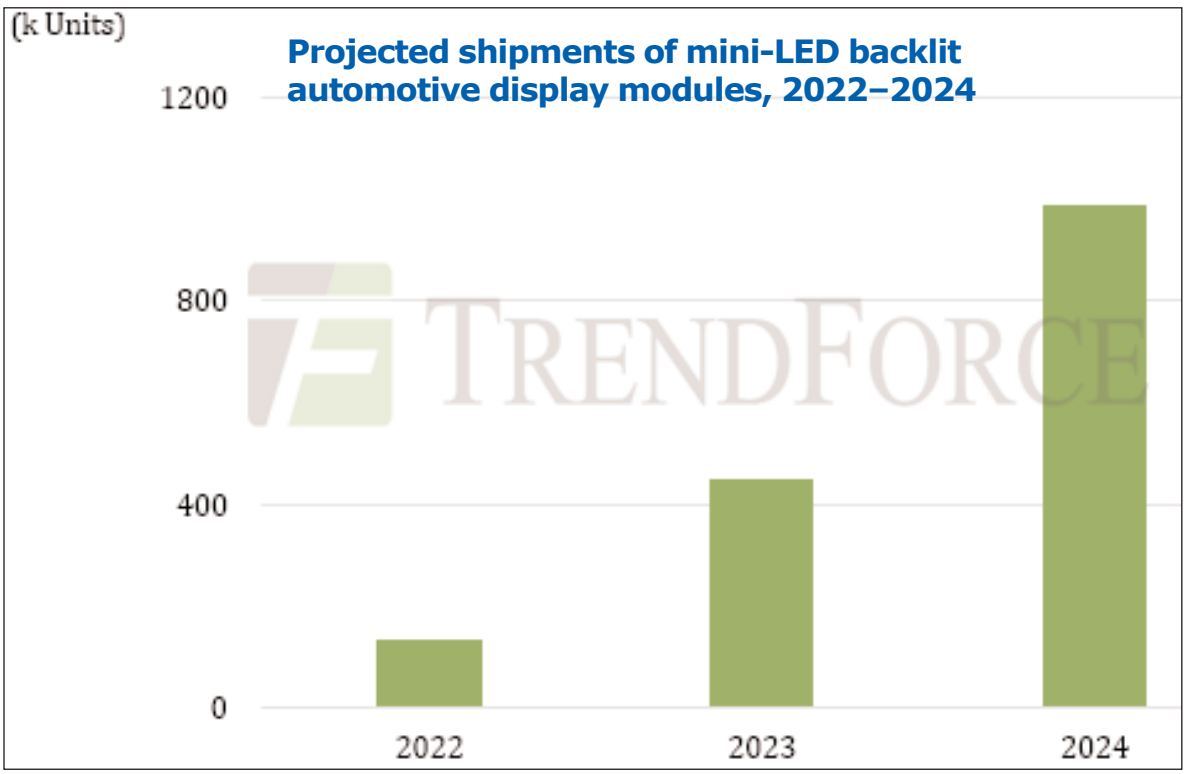

Table 1: Comparison of Display Technologies

Technology	OLED	LCD + Traditional LED BLU	LCD + Mini LED BLU
Brightness	★★	★★	★★★
Contrast	★★	★★	★★★
Reliability	★★	★★★	★★★
Power Consumption	★★★	★★★	★★
Curved	★★★	★	★★
Cost	★	★★★	★★

Competitiveness Indicator: ★★★ High; ★★ Middle; ★ Low

Lastly, mini-LEDs are as highly reliable as conventional LEDs. Hence, they are expected to be the first choice for display backlight among carmakers.

As mentioned above, the advantages of direct-lit mini-LED solutions over edge-lit solutions include overall brightness, contrast, power consumption, support for the optical performance of a curved display, etc. Apart from these performance gains, mini-LED backlit displays are also much more reliable than organic light-emitting diode (OLED) displays for automotive applications. Priced between traditional edge-lit displays and OLED displays, mini-LED backlit displays deliver superior cost-to-performance ratio. Taking account of these benefits, carmakers are expected to be much more enthusiastic about using mini-LED backlit displays in the future.

Among carmakers, China's Nio and Roewe have adopted mini-LED backlit display this year. They applied this solution first to the dashboard display (which places great demand on performance). Then, they applied it to the central information display (CID) and panel for air-conditioning (A/C) and volume controls. US-based carmaker General Motors (GM) has offered a 33.4-inch automotive display system with a mini-LED backlight. This system reflects the trend towards larger sizes and integration as it combines the dashboard display and CID.

Looking at the supply chain for mini-LED backlit automotive displays, Chinese carmakers have adopted automotive display systems that comprise mini-LED backlit display modules from BOE. European and US carmakers use mini-LED backlit display modules from AUO and Innolux. Regardless of suppliers, display modules are delivered to tier-1 integrators such as Bosch and CarUx so they can be assembled into display systems. Then, display systems are sent to car assembly plants for vehicle installation. ■

www.trendforce.com

Table 2: Carmakers That Have Adopted Mini LED Backlight and Targeted Automotive Display Applications

Launch Year	Carmaker	Application	Display Size (in Inches)
2022	Nio	Dashboard	10.1"
2022	Nio	Control Panel	6.63"
2022	GM	Dashboard+CID	33.4"
2022	Roewe	Dashboard	10.25"
2022	Roewe	Entertainment Display	12.3"
2023	GM	Dashboard+CID	35"
2023	GM	Entertainment Display	20"
2023	GM	Control Panel	10.2"
2023	Ford	Dashboard+CID	23.6"
2023	Jeep	Dashboard	12.3"
2023	Jeep	CID	14.5"

High-temperature GaN memory and sequential logic

Delay flip-flops achieve stable operation at 300°C

Researchers in the USA and Bangladesh claim the highest operational temperature of 300°C for gallium nitride (GaN) delay flip-flops (DFFs), among other circuits fabricated on a GaN/silicon platform [Mengyang Yuan et al, IEEE Electron Device Letters, v43, p2053, 2022]. Previous DFF demonstrations have only been reported up to 160°C.

The team from Massachusetts Institute of Technology and Bangladesh University of Engineering and Technology also report read-only memory (ROM), static random access memory (SRAM), and data/D-latch components based on n-type field-effect transistors (n-FETs) that operated at 300°C.

The researchers see their achievement as paving the way to robust mixed-signal systems operating at high temperature (HT). They suggest applications in aerospace, automotive, oil and gas exploration. Building on previous achievements in combinational logic, the team has gone on to the next step: the sequential logic needed for storage of state information.

The GaN transistors (Figure 1) for the circuits were fabricated from 150mm GaN/Si wafers with aluminium gallium nitride (AlGaN) barrier and p-type GaN gate layers (p-GaN/AlGaN/GaN/Si), provided by Dr Kai Cheng of Enkris Semiconductor Inc. The p-GaN layer enabled fabrication of the enhancement/E-mode (normally-off at 0V gate/G potential, relative to source/S). The E-mode devices were fabricated using a self-aligned gate-first recipe with tungsten (W) providing a Schottky contact to the p-GaN.

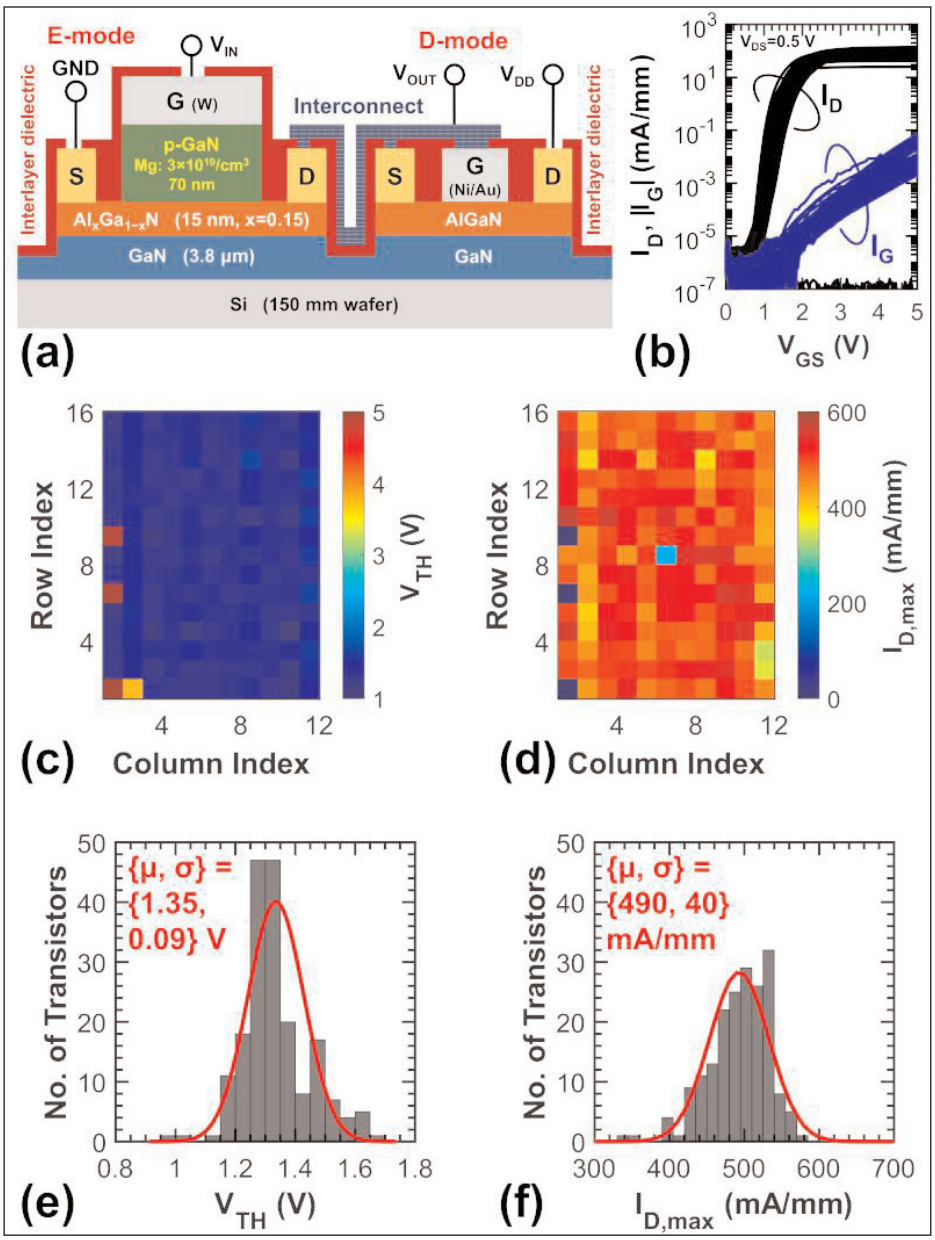

Figure 1. (a) E/D-mode transistors connected as inverter. (b) Transfer characteristics with 0.5V drain bias, (c) distribution and (e) histogram of V_{TH}, and (d) distribution and (f) histogram of $I_{D,max}$ of 192 E-mode transistors across 1.2cmx1.2cm sample at 25°C.

The researchers explain how this enables high-temperature operation: "The E-mode transistor technology of this work was optimized for HT applications through features including, (1) a refractory metal (W) gate, and (2) self-alignment of p-GaN and metal through the gate-first process, which ensures a high metal/p-GaN surface quality and reduces leakage which would become significant problems at HT."

The back-end-of-line (BEOL) fabrication began with nickel/gold (Ni/Au) for the depletion/D-mode (normally-on) Schottky gate and first layer interconnect between the devices. After adding an insulating silicon dioxide (SiO_2) interlayer dielectric, vias were

opened for titanium/gold (Ti/Au) contact pads. The Ti/Au was also used for the second layer interconnects.

Both device types featured a 2μm gate length, and 2μm G–S and G–D separations. The 12μm-wide D-mode transistors had a threshold voltage (V_{TH}) around −1V. The more difficult operation of the 36μm-wide E-mode transistors achieved a V_{TH} of +1.35V with a 0.09V standard deviation (σ). The maximum drain current ($I_{D,max}$) averaged 490mA/mm with 40mA/mm^2. The E-mode transistors served as the drivers for the various circuits fabricated.

The team notes that there is an excess of outliers at the 3σ level: 5% for V_{TH}, 3% for $I_{D,max}$. This particular measurement setup was not able to be implemented to test performance at HT.

"The circuits which incorporate transistors with significant outlying characteristics would likely not work as expected," the researchers warn. Mitigating these effects could be achieved through redundancy, but for proof-of-concept the team used circuit designs with large tolerance to transistor performance deviations.

The operating voltage (V_{DD}) of the circuits was 5V, aiming at balancing speed, noise margin and power consumption. The performance was tested in a probe station with a thermal chuck capable of heating up to 300°C.

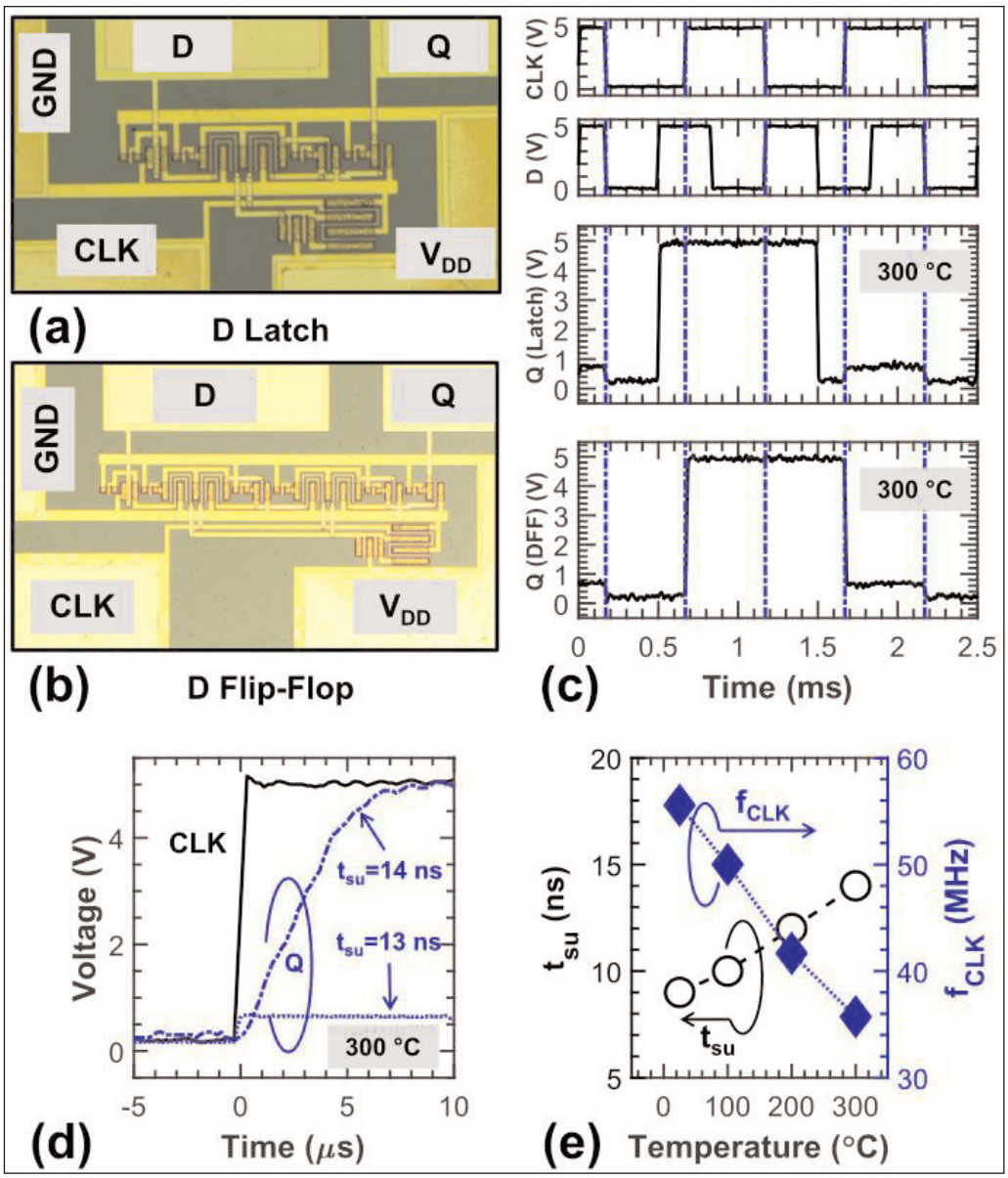

Figure 2. (a) Micrograph of negative multiplexer-based latch. (b) Micrograph of positive DFF. (c) Waveforms of CLK at 1kHz, D at 1.5kHz, and D-latch/DFF outputs (Q). (d) Example determination of tsu, using output waveform of DFF at 300°C. (e) Trend of tsu and estimated fCLK versus temperature.

The fabricated circuits included a 32bitx10bit NOR-based read-only memory (ROM), a four-transistor static random access memory (4T-SRAM), a 13T multiplexer-based negative data/D latch with input/output buffers, and a 20T positive DFF in a primary-secondary (master-slave) configuration.

The ROM was programmed with its first 10-bit word line set to [1000110001], which was read successfully at 300°C. The SRAM cell also performed stably at 300°C.

The researchers comment on the D-latch and DFF: "A large voltage swing over 4V could still be achieved for both the D latch and the DFF at 300°C due to the matched temperature behavior of the ON-resistance for both the E- and D-mode transistors."

The clock frequency (f_{CLK}) of the D-latches and DFFs were limited by the set-up time (t_{su}). This increased from 9ns to 14ns as the temperature increased from 25°C to 300°C, respectively. The maximum clock frequency therefore reduced from 55MHz to 36MHz. "The decrease in performance is mainly due to the decreased ON-current of both E- and D-mode transistors resulting from the reduction of channel mobility at higher temperatures," the team reports.

The researchers believe improvements can be sought from device scaling, reduced gate leakage, optimized circuit parasitics and chip area, a more thermally robust BEOL process, and monolithically integrated GaN complementary circuit designs. ■

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Author: Mike Cooke

Vertical GaN junction barrier Schottky diodes

Researchers in Japan have claimed record low on-resistance combined with high breakdown voltage.

Nagoya University and Toyota Central R&D Labs Inc in Japan claim a record low on-resistance (RON) for vertical gallium nitride (GaN) Schottky barrier diodes (SBDs) of between 0.57mΩ-cm^2 and 0.67mΩ-cm^2 [Maciej Matys, Appl. Phys. Lett., v121, p203507, 2022]. The breakdown voltages (BVs) of between 660V and 675V, dependent on dimensions, were 84.4% of the value expected for ideal parallel plane structures.

One target for such devices is low-loss power switching applications. Although vertical GaN pn diodes have similar performance in terms of R_{ON} and BV, the higher turn-on voltage (V_{ON}~3V for pn, compared with 0.74 for Nagoya/Toyota's SBDs) results in wasted power.

The team comments: "Compared to silicon carbide (SiC) JBS rectifiers, the GaN JBS diodes represent an early stage of development. Thus, the ability to realize high-performance vertical GaN JBS diodes can bring GaN power electronics to the next level."

The researchers used a junction barrier Schottky (JBS) diode structure (Figure 1). The 10μm drift layer of silicon (Si)-doped n-GaN was

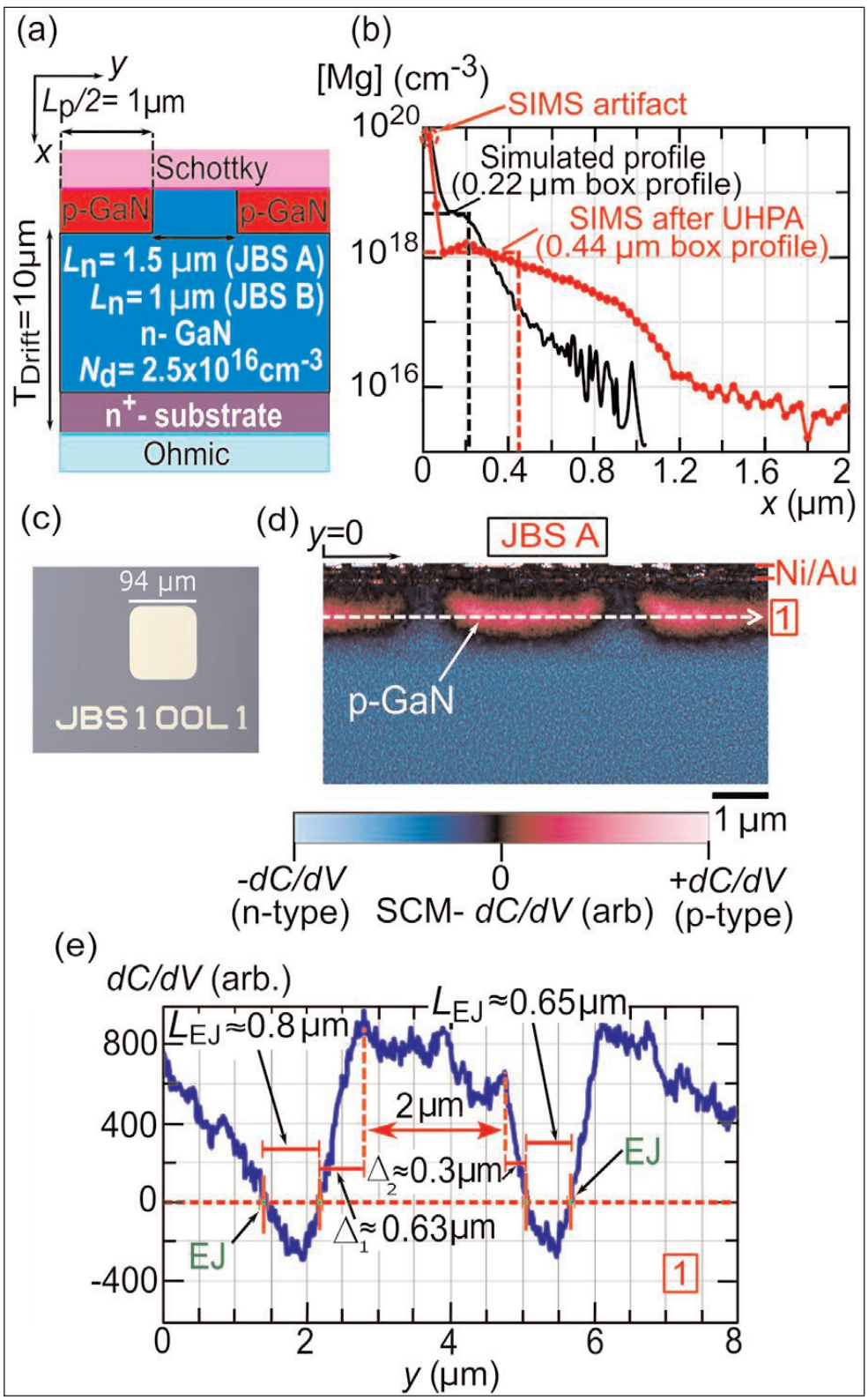

Figure 1. (a) Schematic cross section of JBS diode, (b) secondary-ion mass spectroscopy (SIMS) depth profile of [Mg] together with simulated [Mg] depth-profile, (c) optical image of fabricated JBS diode, (d) scanning capacitance microscopy (SCM) image of JBS A, and (e) linear profile of dC/dV obtained along line 1 from SCM image.

grown on freestanding heavily doped substrates by hydride vapor phase epitaxy. The threading dislocation density was of order 10^6/cm^2. The thickness of the drift layer was designed to exceed the 5μm limit for avoiding punch-through at the effective donor concentration (N_d) of $2.5x10^{16}$/cm^3.

The p-type barrier layer was achieved by magnesium ion implantation to a depth of 2μm, using a silicon dioxide (SiO_2) mask. The p-type layer was activated via 30-minute ultra-high-pressure annealing (UHPA), carried out at the Japan Ultra-High Temperature Materials Research Institute. The annealing temperature and pressure were 1300°C and 500MPa, respectively. The box profile of the $2x10^{18}$/cm^3 Mg doping was around 0.44μm, deeper than the 0.22μm simulated by Monte Carlo methods due to Mg diffusion during the UHPA.

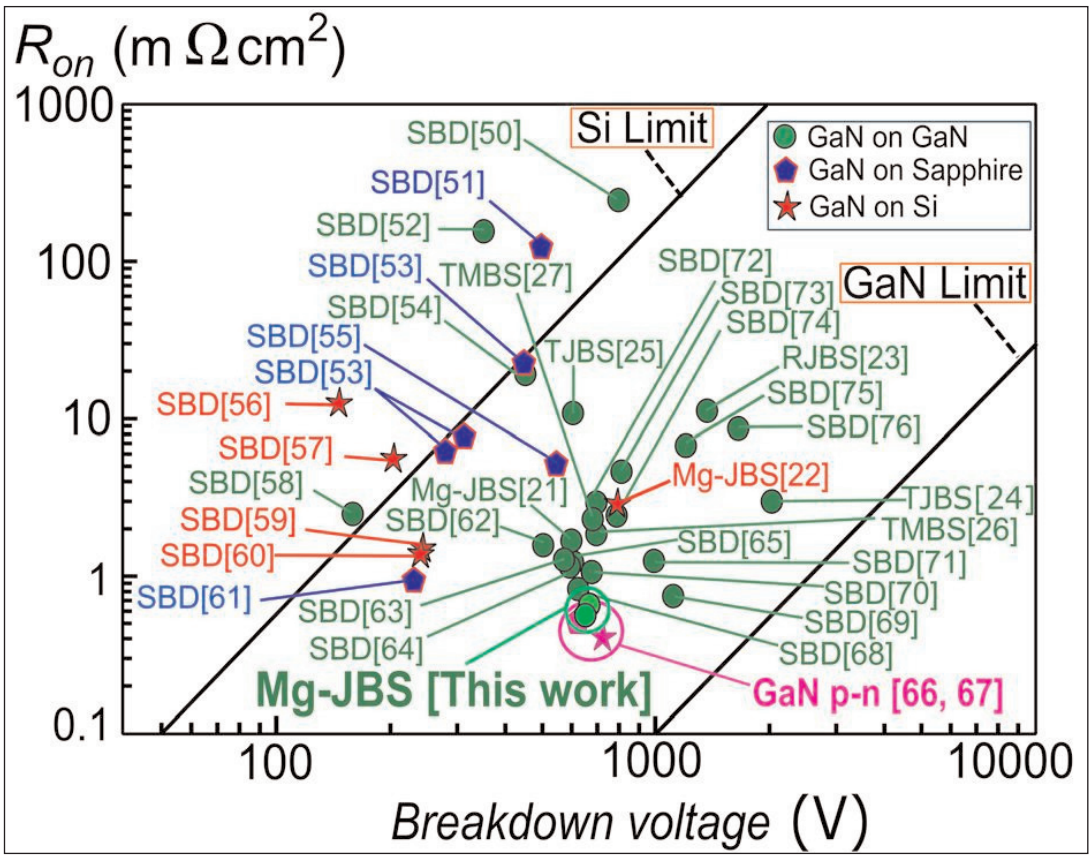

Figure 2. R_{ON}–BV benchmark comparison among GaN SBDs, Mg-implanted JBS, regrowth JBS (RJBS), trench JBS (TJBS), trench MOS barrier Schottky (TMBS), and p–n diodes (PNDs).

The channel widths (L_n) of the fabricated JBS diodes A and B were 1.5μm and 1μm, respectively. Mg diffusion reduced these values somewhat by extending the effective width of the p-type regions, according to scanning capacitance microscopy (SCM), although the shrinking of the electrical junction (EJ) in the measurements could also be partly due to AC bias of the SCM tip. Subsequent analysis of the measured R_{ON}, compared with a model, suggested this latter factor dominated.

The Schottky electrodes were nickel/gold, while the ohmic bottom contact was titanium/aluminium/nickel/gold. The JBS diodes were square with rounded corners. The active area consisted of periodic n- and p-type regions: 17 for JBS A, and 20 for JBS B.

V_{ON} was 0.74V and the ideality around 2. The minimum R_{ON} for the devices occurred in the range 1.5–1.6V. An SBD fabricated by the team had an R_{ON} of 0.51mΩ-cm^2. The forward current of the JBS diodes at 5V was more than 5.5kA/cm^2 (0.5A). Above 3V the R_{ON} of JBS B reduced to the level of the SBD, suggesting that some current flowed through the p-type regions since the turn-on voltage for vertical pn junctions is around 3V. "The reason for this issue is rather not clear at this moment," the team adds.

On the basis of the high breakdown voltage, the researchers estimate that the maximum electric field reached 2.47MV/cm, consistent with previous reports of similarly doped n-GaN. The leakage at reverse biases less than 120V was 3–4 orders of magnitude smaller than for SBDs, which broke at that point. Up to about 500V, JBS B had a lower leakage than JBS A (by about one order of magnitude up to 200V).

The team explains, based on simulations: "In the JBS B, the p-type regions are much closer than in the JBS A with more effectively depleted n-GaN channel and, thus, reduced electric field near the Schottky interface." Reducing the field decreases thermionic field emission.

The researchers were able to show that the breakdown voltage was non-destructive by repeated cycles of raising and lowering the reverse bias up to breakdown six times.

The BV^2/R_{ON} figure of merit was 0.68GW/cm^2 to 0.76GW/cm^2, "one of the highest values reported so far for GaN SBDs," according to the team (Figure 2). The low resistance values were maintained even when the termination structure was included in the normalization to give a total device area of $9.7x10^{-5c}$m^2: 0.64mΩ-cm^2 and 0.75mΩ-cm^2 for A and B, respectively. ■

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Author: Mike Cooke

Ethylene route to semi-insulating free-standing GaN

By using HVPE gallium nitride carbon-doped with ethylene, researchers claim to have achieved record high resistivities.

Researchers from China and Poland have demonstrated that halide vapor phase epitaxy (HVPE) gallium nitride (GaN) carbon-doped with ethylene (C_2H_4 or, showing the double bond, $CH_2=CH_2$) provides record high resistivity for creating semi-insulating free-standing substrates [Qiang Liu et al, Appl. Phys. Lett., v121, p172103, 2022].

The team from Peking University and Sino Nitride Semiconductor Co Ltd in China and Poland's Institute of High Pressure Physics comments: "The resistivity of the sample definitely satisfies the required value ($10^9\Omega$-cm) for commercially available semi-insulating GaN substrates. Therefore, such semi-insulating substrates achieved in this work will enable sharp current pinch-off for HEMT devices."

Such substrates allow the implementation of high-performance radio frequency (RF) and microwave power amplifier applications, based on GaN high-electron-mobility transistors (HEMTs). Presently, semi-insulating silicon carbide (SiC) is often used, but the GaN/SiC lattice mismatch introduces increased dislocation densities, impacting performance. A GaN

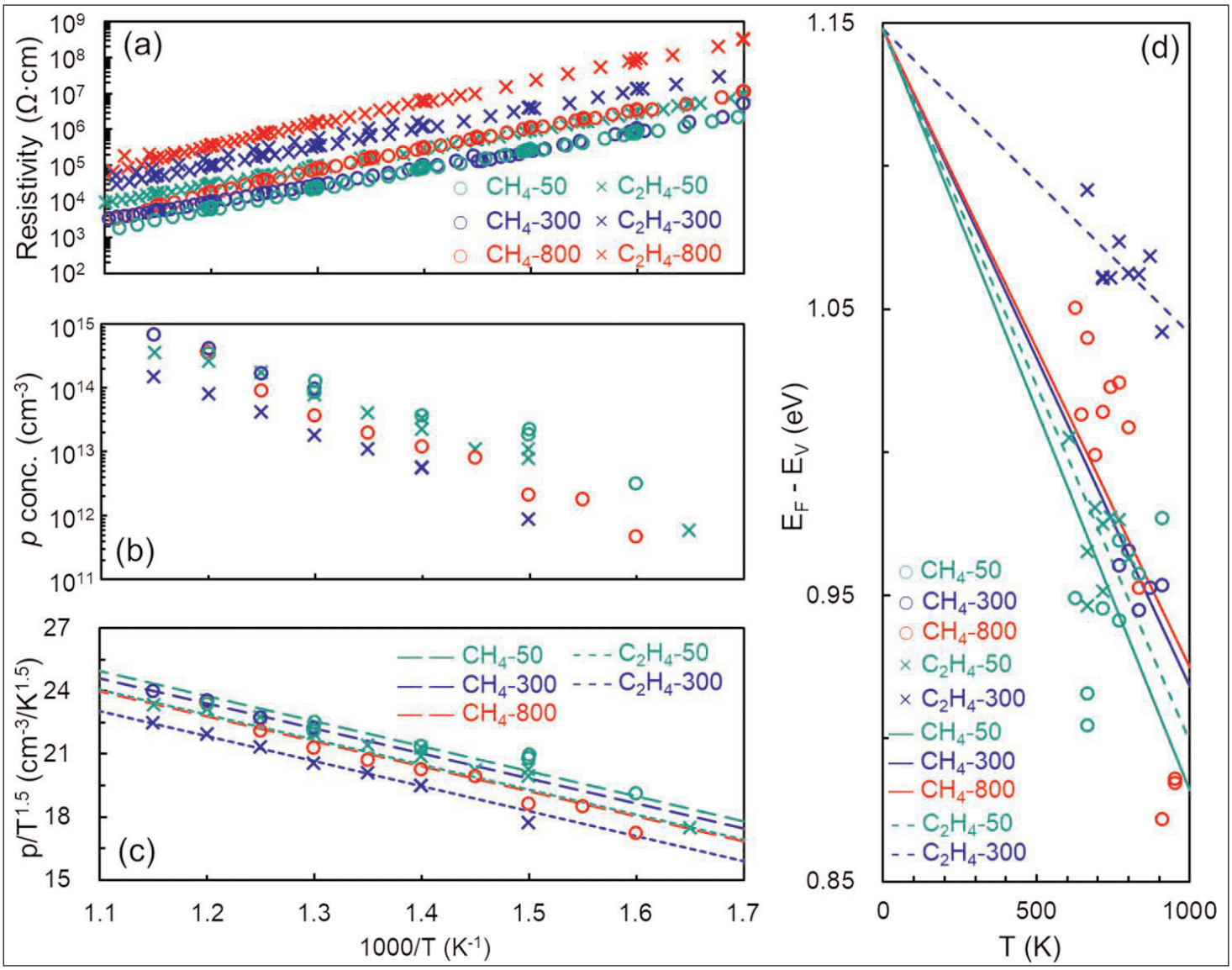

Figure 1. Temperature-dependent resistivity (a) and hole concentration (b) of all samples; (c) fitting curves for hole concentrations shown in (b); and (d) fitting curves to calculate $E_{AV}(0)$.

substrate would avoid the lattice mismatch problem. A peak power-added efficiency (PAE) of 82.8% has been reported for GaN HEMTs on free-standing GaN substrate.

The researchers point out that ethylene is an uncommon source for C-doping. However, their work showed that its use results in a 40x higher incorporation of C, relative to the more common methane (CH_4). This may be due to the ethylene tending to decompose to CH_2, breaking the double bond, before C incorporation. By contrast, methane would in the first instance dehydrogenate to CH_3 radicals, slowing C incorporation into the GaN growth front.

The substrates were grown on metal-organic vapor phase epitaxy (MOVPE) 4.5μm GaN on sapphire templates (2-inch) and then separated into free-standing material by laser lift-off. The initial HVPE growth consisted of low- and high-temperature layers of GaN (960°C/1070°C) with a V/III ratio of 60. The layer thicknesses were 100μm and 50μm, respectively. The pressure was 900Torr and the source zone of the reactor was kept at 900°C.

Carbon-doped GaN layers were grown on the separated samples with the dopant sources of CH_4 and C_2H_4 diluted by 5% nitrogen. Other factors being approximately equal, the researchers consider that the main difference in C doping from the two sources will arise from their varying chemical and physical properties.

The sample wafer ended up being 750μm thick, which was thinned down to 300μm before dicing into 10mm x 15mm test samples. The thinning was carried out from both sides, removing undoped GaN material, and double-side polishing before dicing.

The average carbon concentration in the samples, determined by secondary-ion-mass spectroscopy (SIMS), increased with dopant gas flow up to 800 standard cubic centimeters/minute (sccm): from $1.3x10^{17}/cm^3$ to $1.7x10^{18}/cm^3$ for methane, and $5.8x10^{18}/cm^3$ to $1.5x10^{20}/cm^3$ for ethylene. Silicon contamination from the quartz chamber components was below the level of $1.3x10^{17}/cm^3$ at all flow rates.

In terms of input carbon atoms relative to Ga, the team estimates that the incorporation rate of ethylene was 40x higher than for methane.

Hall-effect measurements on 5mm x 5mm testing samples showed p-type conductivity with low mobility less than $3cm^2/V\text{-}s$. Decreases in resistivity at high temperature arose from increased hole concentration (Figure 1). Between 315°C and 560°C, the hole concentration increased from $10^{12}/cm^3$ to $10^{16}/cm^3$, while the resistivity fell from $10^8\Omega$-cm to $10^4\Omega$-cm. The behavior suggests that a single impurity energy level determines the electrical properties of the sample. The team estimates the activation energy at 0K ($E_{AV}(0)$) at 1.148eV. This energy corresponds to theoretical expectations for the $C_N^{0/-}$ acceptor level. The team also found little shift in E_{AV} above 0K, unlike for other reported research by the Institute of High Pressure Physics.

In the highest 800sccm sample doped with ethylene, the p-type conductivity was almost fully self-compensated with very low carrier mobility, making Hall-effect measurements unsuccessful.

The resistivity of GaN:C using 800sccm ethylene at 1000K was $10^5\Omega$-cm, a record compared to the previous highest for C-doped GaN of 2000Ω-cm or even iron-doped GaN at $6x10^4\Omega$-cm. A problem with iron doping is diffusion to places where it is not wanted. At 833K, the GaN:C-800 had a resistivity of $6x10^5\Omega$-cm, beating a report for manganese-doped GaN of $2x10^5\Omega$-cm. ■

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Multi-dimensional wide-bandgap power devices

Researchers look forward to new capabilities from superjunction, multi-channel, finFET, and trigate architectures.

Three researchers based in the USA and the UK have reviewed the potential for applying multi-dimensional (multi-D) power device architectures with a view to suggesting more appropriate figures of merit (FOMs) compared with those applied to essentially 1D structures [Yuhao Zhang et al, Nature Electronics, v5, p723, 2022]. Such FOMs are key to assessing the performance limits and scaling capabilities of power devices.

The authors — Yuhao Zhang of Virginia Polytechnic Institute and State University (Virginia Tech), Florin Udrea of the University of Cambridge, and Han Wang of the University of Southern California — focus on multi-D structures pioneered in silicon in an effort to beat off the competition from potentially higher-power-capable but more expensive materials such as silicon carbide (SiC) and gallium nitride (GaN): superjunctions (SJs), multi-channels, fin field-effect transistor (FET), and trigate (Figure 1).

For power devices one wants high voltages to be reached before breakdown in the off-state, while having low resistance to current flow in the on-state. These features are measured as the breakdown voltage (BV) and specific on-resistance ($R_{ON,SP}$), respectively (Figure 2). In addition, one usually wants the device to be 'normally-off' at zero gate potential, reducing power consumption and for fail safety.

One attraction of the new materials, such as GaN and SiC, is the potential reduction in device size, and increase in power density. Reduced size reduces the charge capacity ('reduced parasitic capacitance'), allowing faster state changes ('switching speed'). However, increased power density has implications for thermal management and packaging requirements.

The resistance consists of contributions from the ohmic contacts with the metal electrodes, the transistor/switch channel, and the drift region. The BV is limited by the critical electric field, which tends to increase as

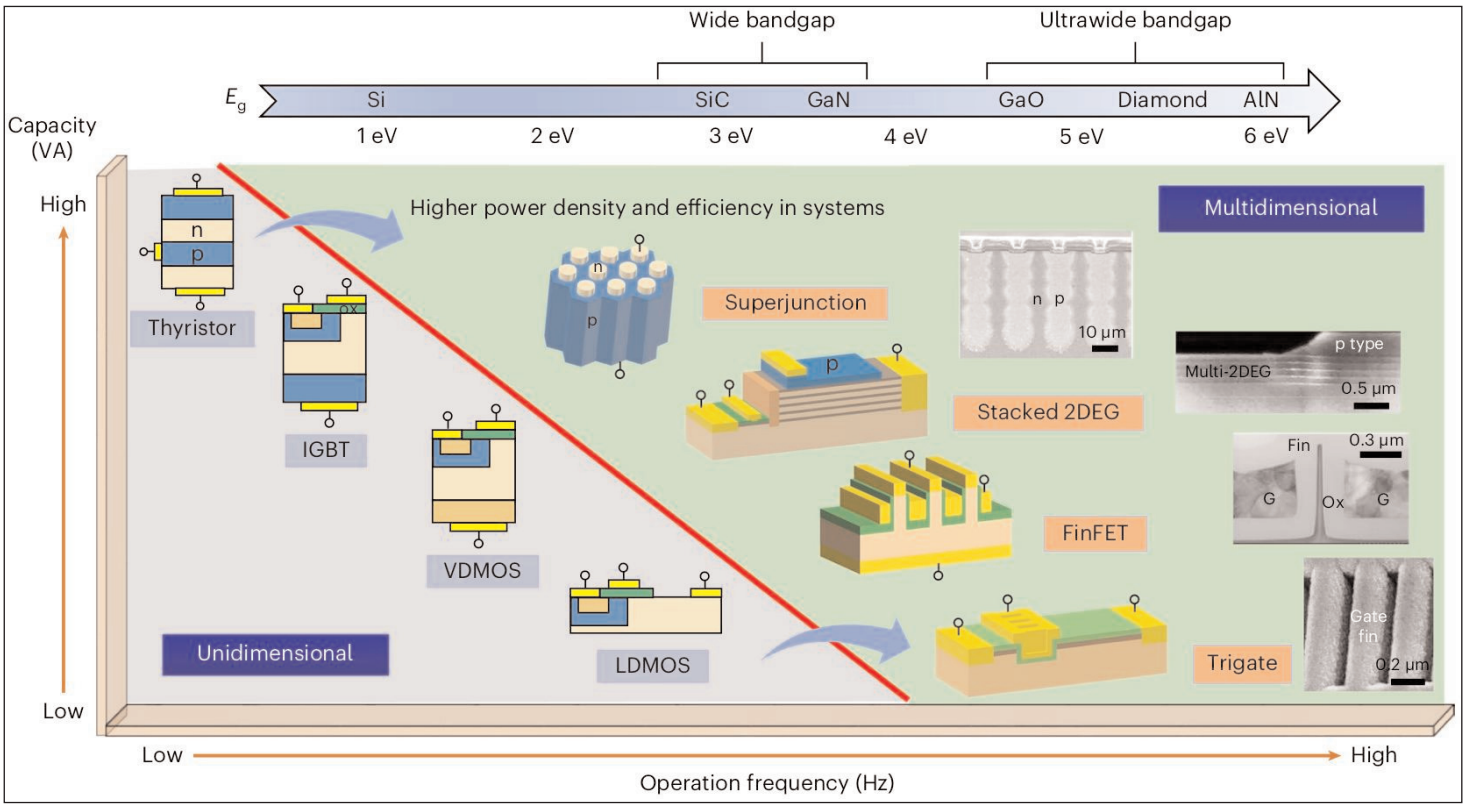


Figure 1. Power capacity and frequency trade-off of 1D and multi-D power devices: 1D — thyristor, IGBT, vertically diffused MOSFET (VDMOS) and laterally diffused MOSFET (LDMOS) — and multi-D. N- and p-type semiconductors, oxide and metal plotted in orange, blue, green and yellow, respectively. Circles represent electrodes. Included also scanning electron microscope cross-sections of multi-D devices.

the square of the bandgap energy. At lower BV, the on-resistance is dominated by the channel. In wide-bandgap (WBG) and ultrawide-bandgap (UWBG) materials, the channel resistance is higher than desired. The effective channel mobility of SiC and GaN devices is in the range 130–150cm^2/V-s, much lower than the 800–1200cm^2/V-s bulk values. For UWBG materials such as aluminium nitride (AlN), gallium oxide (Ga_2O_3) and diamond the channel mobility is even worse.

Meanwhile, drift regions need to keep the electric field below critical by ensuring the voltage drops over a sufficient distance. But the longer the distance, the higher the resistance to current flow in the on-state. Balancing the contradiction usually involves low doping. The on-resistance could be lowered with higher doping.

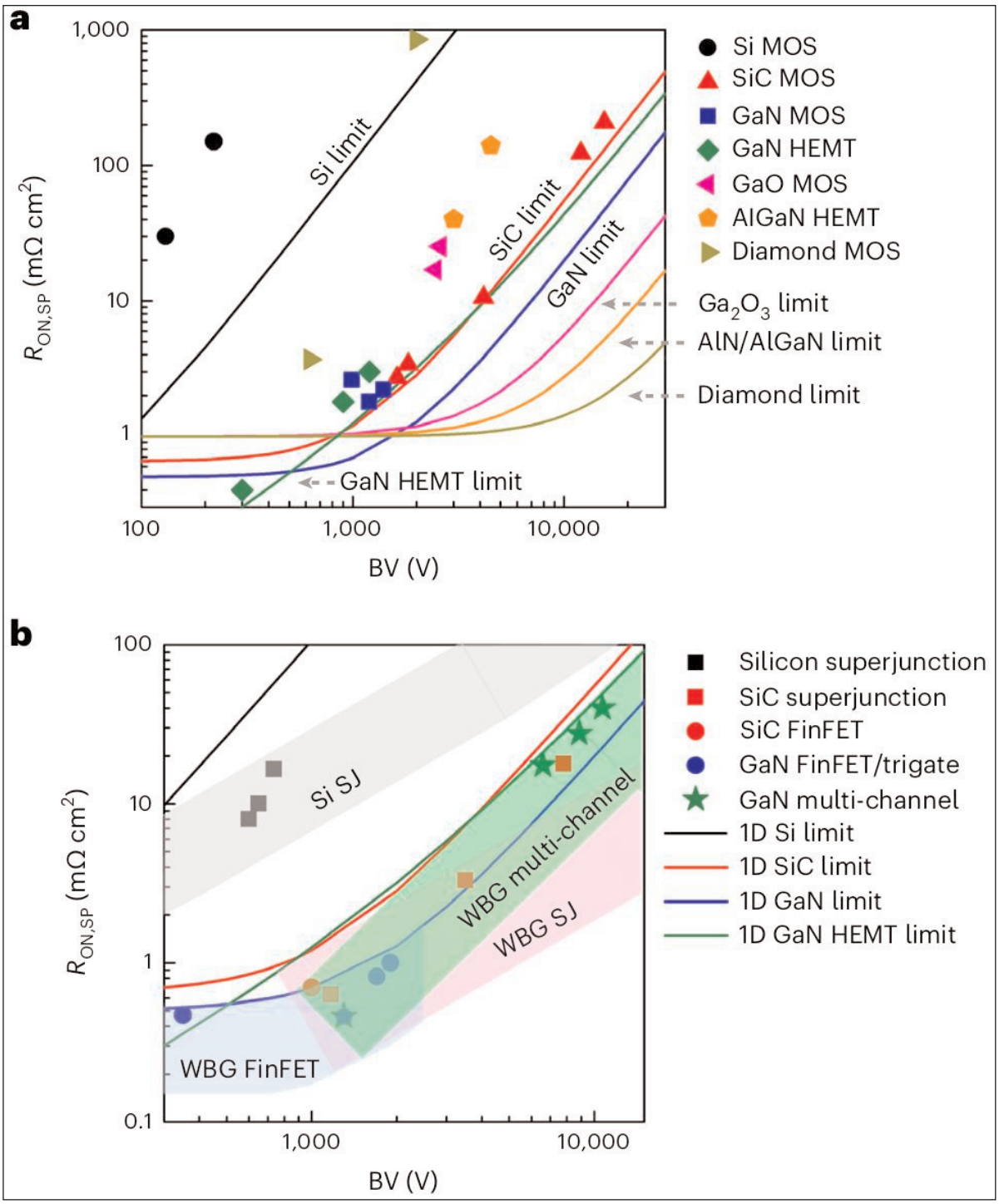


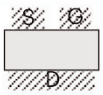
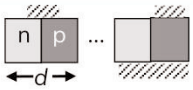
Figure 2. Specific on-resistance and breakdown voltage trade-off of reported 1D (a) and multi-D (b) power devices with theoretical limits.

Superjunction structures enable this by balancing n-regions with p-type neighbouring material. In particular, the electric field becomes more uniform over the drift region, rather than peaking at the channel–drift junction. This enables higher voltage before breakdown.

Multi-channels can be viewed as a lateral form of the superjunction, using bandgap engineering rather than doping to achieve its effect. Although this lowers on-resistance, such a structure is more difficult to switch off due to the lower electrostatic control provided by the gate to the buried layers. Such control can be enhanced by using fin gates wrapping around the buried layers.

Another approach is the multi-channel monolithic-cascode high-electron-mobility transistor (HEMT), integrating a low-voltage single-channel enhancement-mode (normally-off) transistor with a multi-channel depletion-mode (normally-on) HEMT.

Having reviewed the present state of development, the authors conclude by offering some ideas of what the relevant performance parameters might be for

Drift region design	1D	2D superjunction	3D superjunction	Multi-channel (PSJ)
Structure				
Performance limit	$R_{ON,SP} = \frac{4}{\varepsilon\mu E_C^3}BV^2$	$R_{ON,SP} = \frac{4d}{\varepsilon\mu E_C^2}BV$	$R_{ON,SP} = \frac{r}{\beta\varepsilon\mu E_C^2}BV$	$R_{ON,SP} = \frac{BV^2}{NqE_C^2 n_{2D}\sum_{e,h}\mu_{2D}}$
Scaling parameter	NA	Cell pitch (d)	Radius (r), radius ratio (β)	Channel number (N)
Scaling limit	NA	$d = \frac{50E_g}{9qE_C}$	$r = \frac{98\sqrt{2E_g\beta}}{27qE_C}$	Process and technology related
Minimum specific on-resistance	$\frac{4BV^2}{\varepsilon\mu E_C^3}$	$\frac{20E_gBV}{q\varepsilon\mu E_C^3}$	$\frac{16E_gBV}{q\varepsilon\mu E_C^3}$	–
Material FOM	$\varepsilon\mu E_C^3$	$\varepsilon\mu E_C^{2.5}$	$\varepsilon\mu E_C^{2.5}$	$E_C^2 n_{2D}\sum_{e,h}\mu_{2D}$

ε is permittivity, μ is the mobility of the major carrier, E_C is critical electric field, n_{2D} is 2DEG or 2DHG density, μ_{2D} is 2DEG or 2DHG mobility, e and h refer to the electron and hole, respectively, q is the elementary charge, and E_g is the bandgap. PSJ, polarization superjunction; NA, not available.

Figure 3. Performance limit, scaling parameter and limit, minimum specific on-resistance, and material figure of merit of 1D vertical unipolar devices, 2D and 3D superjunction devices and multi-channel lateral devices with precisely matched polarization charges.

future power devices based on multi-D superjunctions (Figure 3), and offering some complementary comments on radio frequency (RF) power amplifier devices.

For RF, one desires high-frequency, linear response in the multi-gigahertz range. The ability to reach RF is limited by parasitic capacitances. Linear response is particularly desirable for amplifiers aimed at new 5G wireless communications protocols.

The team reports: "Due to the presence of multiple channels, the transconductance (g_m) of multi-channel HEMTs was found to exhibit broad plateau characteristics, which lead to higher device linearity." ■

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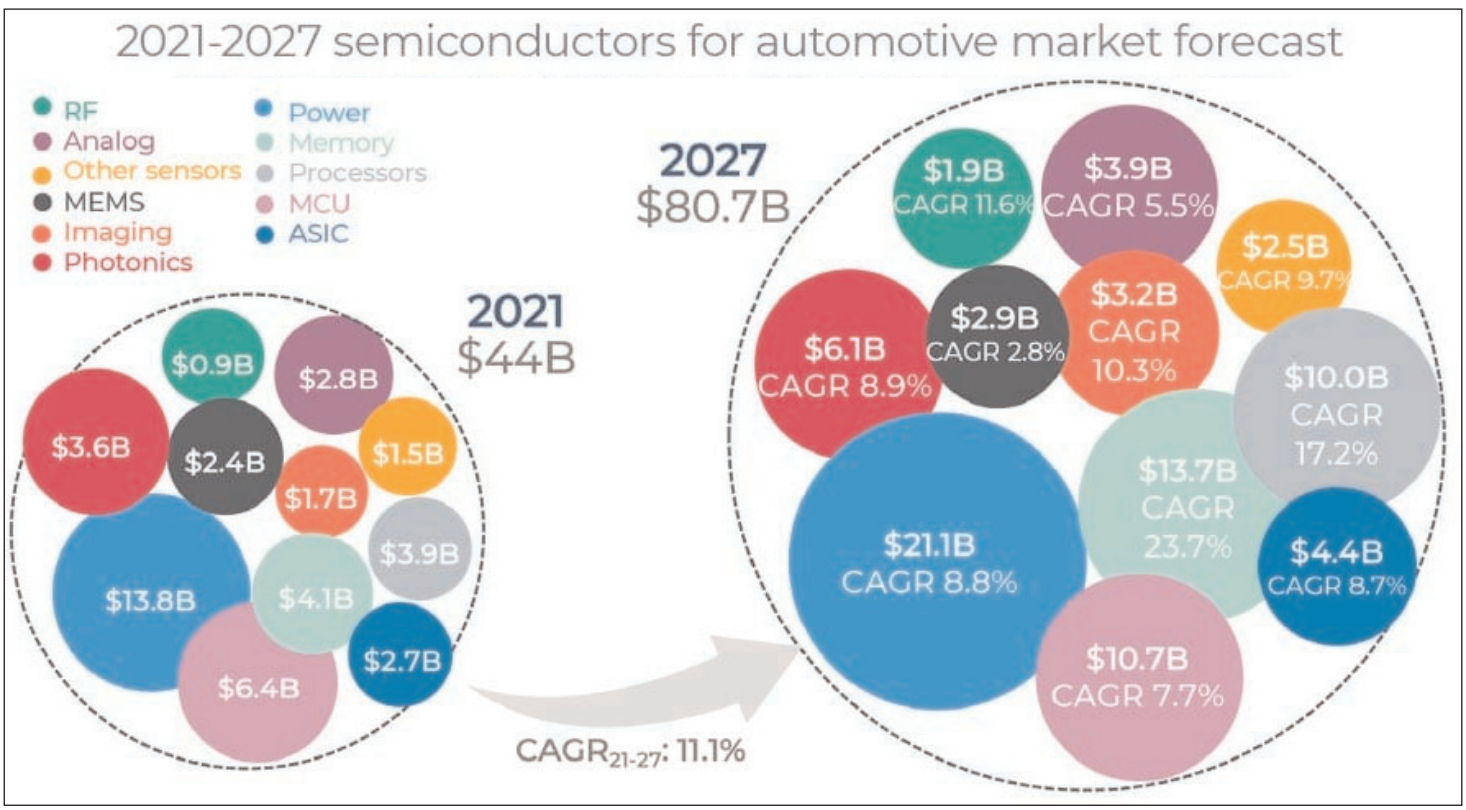
Automotive semiconductor chip market growing at 11.1% CAGR to over $80bn in 2027, due to electrification & ADAS

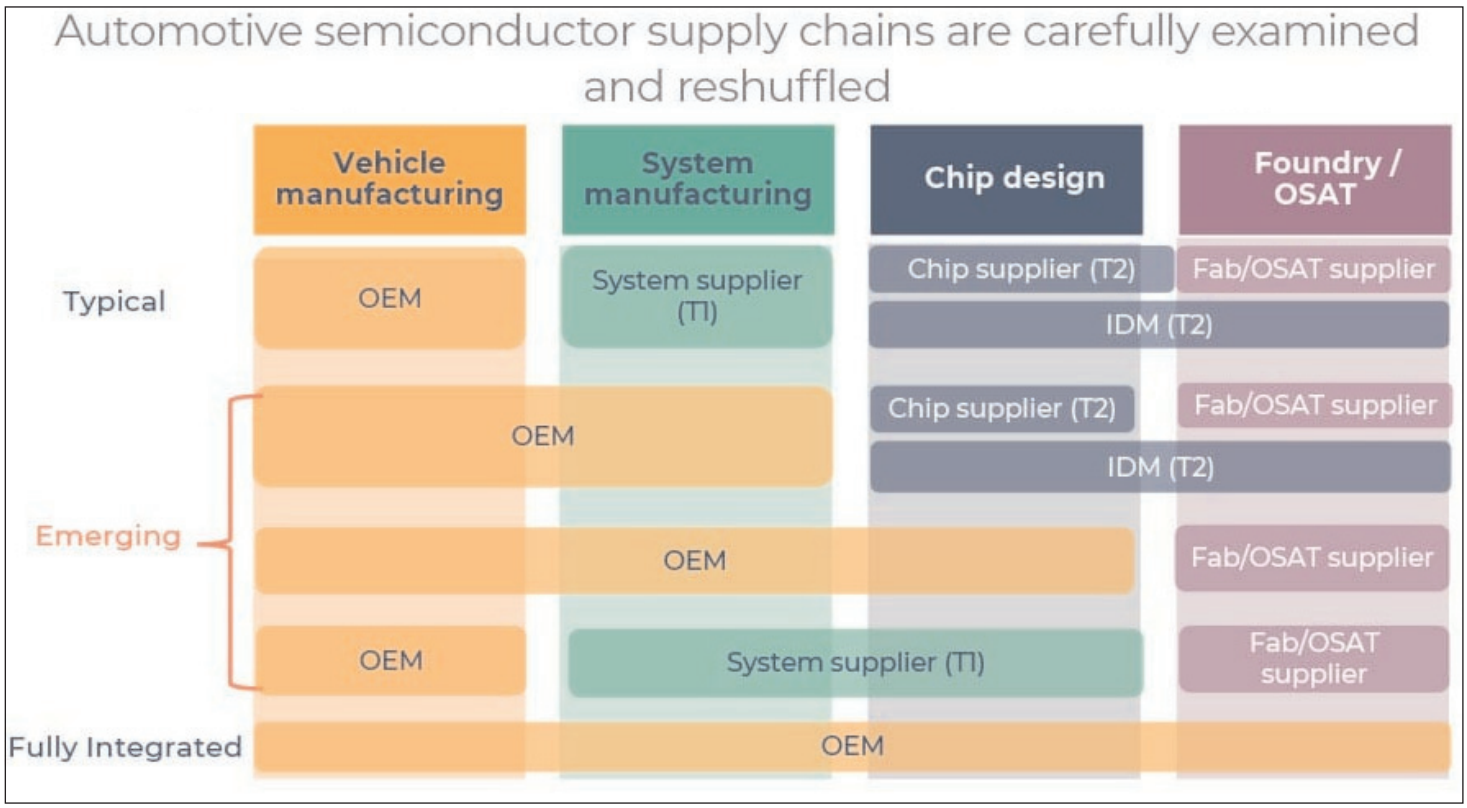
SiC substrate usage to grow faster than silicon and GaAs/sapphire, says Yole.

Despite a relatively flat market for light vehicles, the market for automotive semiconductor chips is rising at a compound annual growth rate (CAGR) of 11.1% from US$44bn in 2021 to US$80.7bn in 2027, reckons Yole Intelligence in its 'Semiconductor Trends in Automotive 2022' report. This represents the semiconductor chip value per car rising from ~US$550 to ~US$912 in 2027, while the number of chips incorporated in each car grows from ~820 to ~1100.

"The rapid increase in car electrification demands new types of substrates, such as silicon carbide (SiC) for power electronics. It is expected to represent 1130kwafers in 2027," says Pierrick Boulay, senior technology & market analyst in the Photonics and Sensing Division at Yole Intelligence. "While still low compared to the ~30,500kwafers of silicon expected for 2027, silicon carbide will grow faster than silicon and gallium arsenide (GaAs)/sapphire," he adds. "ADAS is also an important driver, and micro-controller unit (MCUs) with cutting-edge technology as low as 16nm/10nm will go into ADAS (advanced driver assistance systems), including radar and other sensor controls. Levels 4 and 5 of autonomy will drive increasing demand for more memory (DRAM) and computing power."

For electrification, vertical integration is becoming popular among OEMs. It can work out in multiple ways: full integration down to the component level, system integration and subcontracting build-to-print parts, strategic cooperation/direct investments with key component suppliers, etc. The conventional automotive supply chain needs to examine its position thoroughly and transform through joint ventures,





mergers & acquisitions (M&As), and new investments and divestments to retain its competitive edge, reckons Yole Intelligence. Although semiconductors are critical to the automotive industry in the ongoing disruptive transition, most players, both OEMs and tier-1 suppliers, do not yet have well-defined strategies for semiconductors. Specific expertise in semiconductor technologies and their supply chains, both internally and externally, is urgently needed to prepare for the future.

"Supply chain management will change as OEMs will need to negotiate directly with chip manufacturers, learn from the consumer industry, and keep 'buffer stock'," says Eric Mounier Ph.D., director of market research at Yole Intelligence. "They must work closer with chip manufacturers on volume forecasts and long-term orders," he adds. "Just-in-time manufacturing, pioneered by Toyota in the 1960s, no longer works with chip manufacturers in the current geopolitical climate." ■

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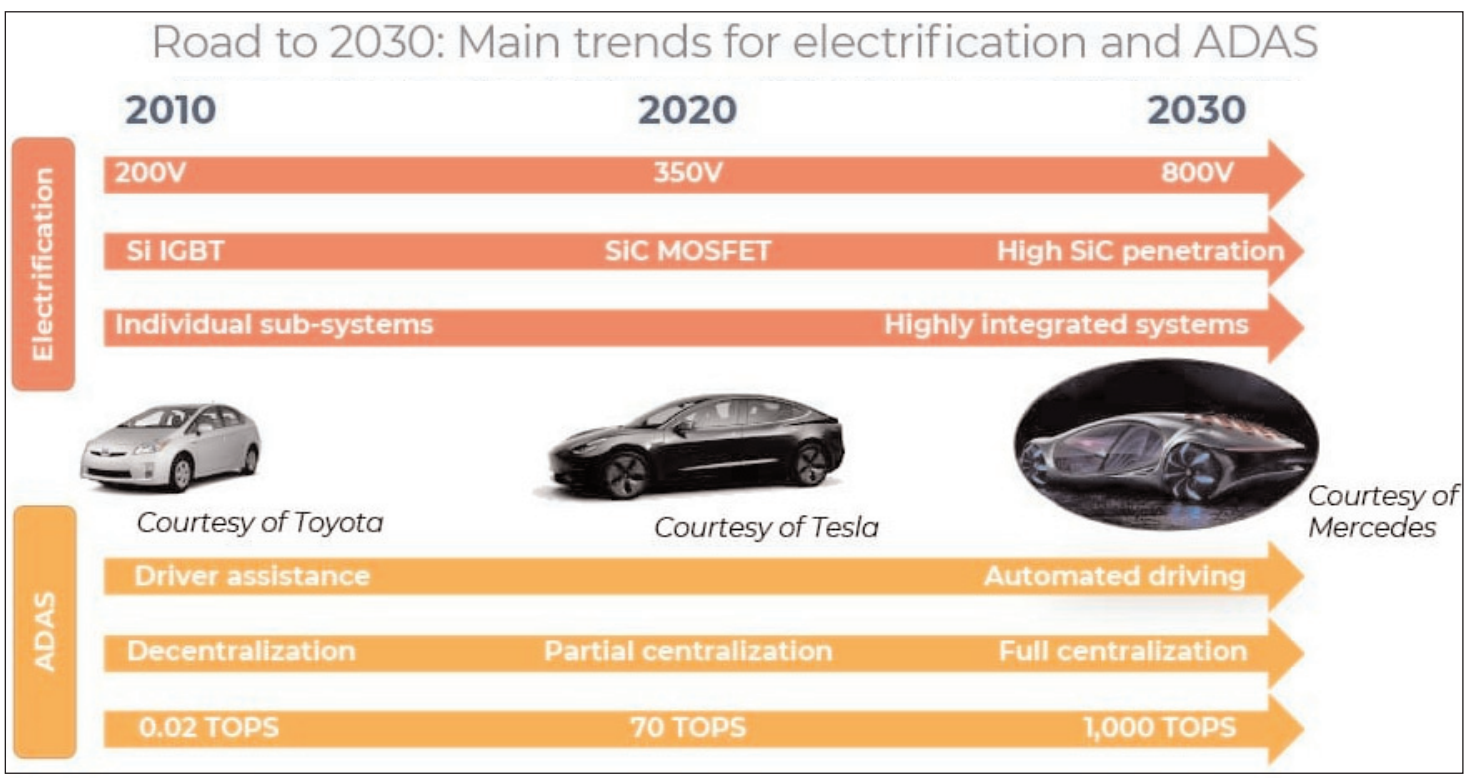


Arizona State University developing transistors made of diamond and boron nitride

Advanced Materials, Processes and Energy Devices Science and Technology Center working on project with Northrop Grumman Mission Systems.

Power transistors to regulate the flow of electrical power have traditionally been made with silicon, while more advanced transistors are made of silicon carbide (SiC) or gallium nitride (GaN). But Trevor Thornton, a professor of electrical engineering in Arizona State University's School of Electrical, Computer and Energy Engineering (part of the Ira A. Fulton Schools of Engineering), is leading a team researching the use of two new transistor materials: diamond and boron nitride (BN).

Thornton's team is conducting its research through ASU's Advanced Materials, Processes, and Energy Devices Science and Technology Center (AMPED STC). AMPED's goal is to develop materials and technologies with industry partners to support the mission of Arizona's New Economy Initiative, which aims to improve Arizona's competitiveness in developing advanced technology. AMPED specifically looks to develop technologies and materials used in the construction of batteries, solar electricity generation and power electronics.

The research team includes Thornton and other ASU faculty members including Terry Alford, a professor of materials science and engineering, Stephen Goodnick, a professor of electrical engineering, and Robert Nemanich, a Regents Professor of physics, as well as doctoral students in electrical engineering and materials science and engineering. They are working with Northrop Grumman Mission Systems as the industry partner for the project.

Diamond efficiency shines

Thornton says that diamond is under investigation as a material for transistors because of its high thermal conductivity compared with existing materials, e.g. 8–10 times greater than gallium nitride. Harnessing diamond's full potential could shrink the size of transistors by 90%, it is reckoned.

Diamond also has a high breakdown field — i.e. it can handle a high voltage relative to most materials before failure — suitable for applications that handle large amounts of power.

While diamond is the team's chosen material for the main body of a transistor, they are investigating the use of boron nitride for the transistors' electrical contacts.

Like diamond, boron nitride has a high breakdown field and high thermal conductivity. Goodnick's role is concerned primarily with computer modeling and simulation of the use of boron nitride transistors.

The team expects that, by combining their knowledge of how diamond and boron nitride work as transistor materials, they can create transistors made from both materials. The hope is that the materials complement each other and work even better together than individually.

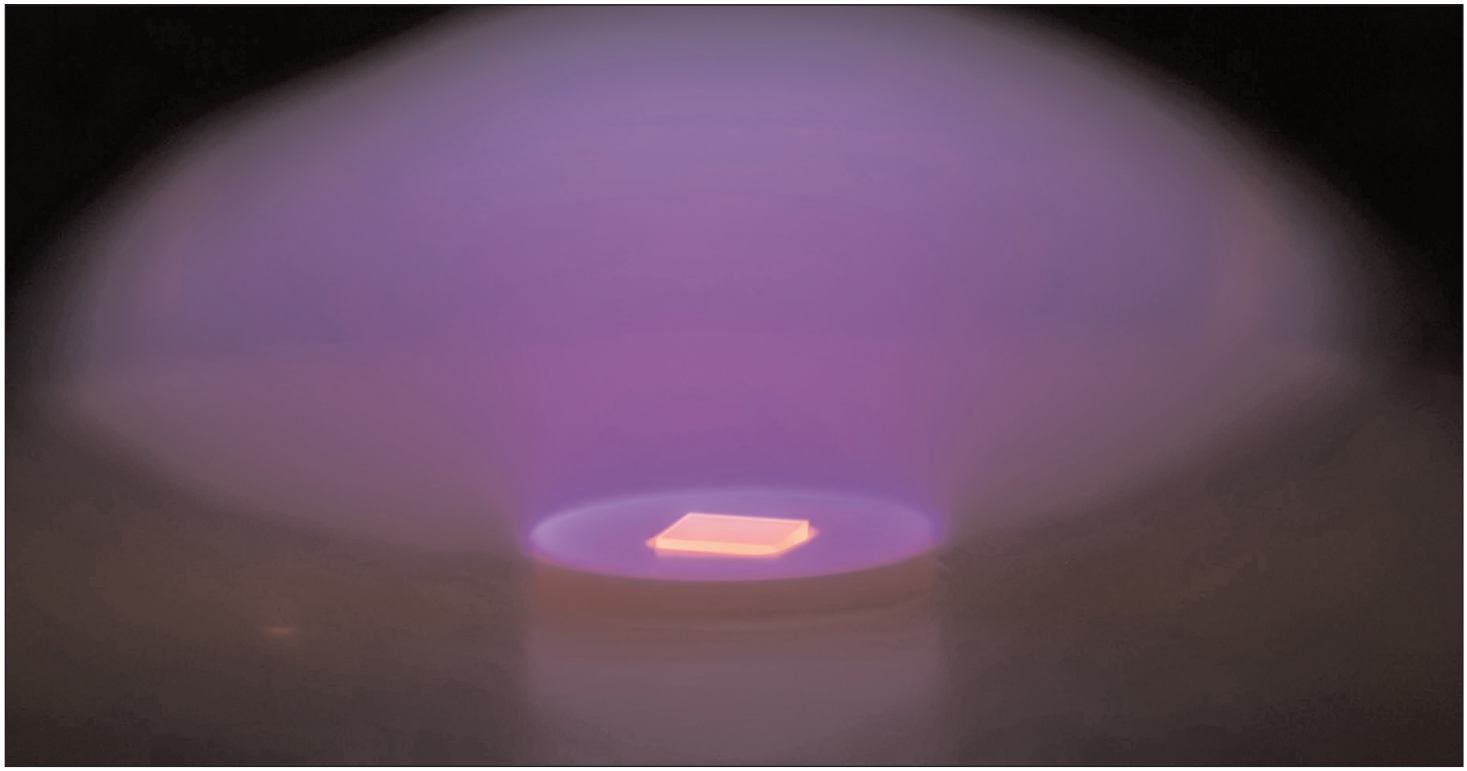
"Ultra-wide-bandgap semiconductor materials like diamond and boron nitride are expected to lead to more efficient energy conversion using less power with much smaller components," Goodnick says. "This improves the future energy grid, which is essential for the ongoing transition toward renewable energy and electrification of the transportation sector."

Better heat dissipation to improve communication

This research has applications that would be especially useful to communications technologies, says the team Many satellites run on solar power, which requires transistors to turn the electricity into a form usable by the satellite. "You can't launch a power substation into space," Thornton says. "Any improvement on size and weight in a satellite has a huge impact."

Another communications technology the transistors could improve is the cell-phone tower. Transistors convert power to the form needed to produce radio frequency waves that cell phones use.

One of the biggest challenges faced when designing and operating cell-phone towers is keeping them cool, notes Thornton. This is especially the case in a hot environment like Phoenix.



The power transistors in older cell-phone towers are typically made from silicon, while those in newer 5G systems will use gallium nitride. Thanks to its improved heat dissipation, Thornton's team expects transistors made from diamond and boron nitride to greatly reduce the cooling power needed for cell towers, making it far easier to prevent them from overheating.

Shrinking substations

While the project with Northrop Grumman Mission Systems focuses on communications technology, transistors made from diamond and boron nitride also have applications in power conversion for electrical systems and for the electricity grid. These more efficient materials could reduce the size requirements for electricity grid substations, which typically occupy an area of land the size of a building.

Nemanich, a faculty member in the ASU Department of Physics, leads the 'Ultra Materials for a Resilient, Smart Electricity Grid' (ULTRA) Energy Frontier Research Center (EFRC) conducting research on power electronics. He also leads a lab for growing artificial diamond materials, which will be used by Thornton's team in their research.

"We have been growing diamond for electronic devices for the last 10 years," Nemanich says. "Our diamond deposition lab has unique capabilities for the development of electronic materials and devices," he believes.

Interdisciplinary effort

In addition to Thornton's electrical engineering expertise and Nemanich's work with diamond as an electronic material, Alford, a faculty member in the School for Engineering of Matter, Transport and Energy (part of the Fulton Schools), provides his expertise on materials science.

Alford is working on materials characterization, analyzing the properties of the materials that the team is investigating. He also leads a part of the research looking into the use of new types of metallic electrical contacts connected to diamond as a substrate, and he co-advises a materials science and engineering doctoral student involved in the research with Thornton.

Working with Thornton's team at the AMPED STC has given Alford the chance to conduct research that differs from his normal topics. He believes that his perspective as a materials scientist can help the team to achieve its goals. "We bring to the table a desire to understand the impact of a material's defects," Alford says. "We want to be able to understand those defects and how they impact a device's performance."

Looking to the future of electronics

The transistor research project is funded for two years through the AMPED STC partnership with Northrop Grumman Mission Systems. However, to fully realize the transistors' potential for widespread applications, Thornton says it could take longer.

"We'll have breakthroughs, but I don't see it being widely adopted in the way we're talking about for five to 10 years," he says. "It's that kind of medium- to long-term research of which some applications will happen quicker, while others will be 10 years for widespread consumer applications." ■

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Tel: +1 408 734 0459
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www.samcointl.com

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

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Fax: +49 89 32007 162
www.suss.com

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1024 Ecublens,
Switzerland
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Fax +41 21 694 35 01
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2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054 ,
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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
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10 Gas and liquid handling equipment

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11 Process monitoring and control

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12 Inspection equipment

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14 Chip test equipment

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15 Assembly/packaging materials

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Wafer World Inc
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17 Assembly/packaging foundry

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18 Chip foundry

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Fax: +33 169 33 02 92
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19 Facility equipment

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20 Facility consumables

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21 Computer hardware & software

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24 Resources

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France
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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

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

4–6 April 2023
36th annual Semiconductor and Integrated Opto-Electronic (SIOE 2023)
Cardiff University, Cardiff, UK
E-mail: Future-CSHUb@cardiff.ac.uk
www.cardiff.ac.uk/conferences/sioe-conference

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

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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
ICM — Internationales Congress Center München, Munich, Germany
E-mail: info@photonics-congress.com
www.photonics-congress.com/en

29 June – 1 July 2023
SEMICON China
Shanghai New International Expo Centre (SNIEC), China
E-mail: semichina@semi.org
www.semiconchina.org

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)
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