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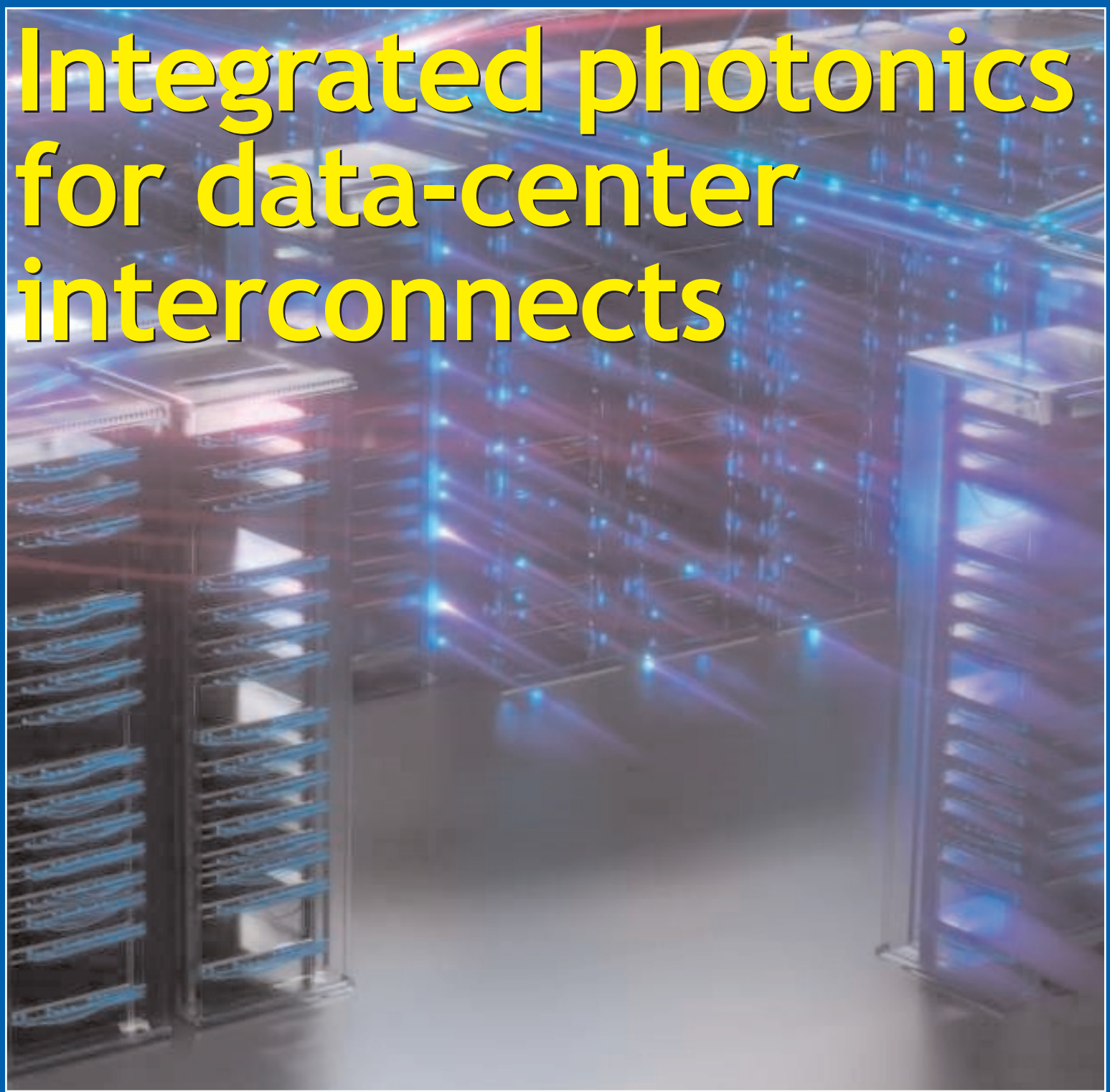
Integrated photonics for data-center interconnects



Bosch ramps SiC chip production • Voyant raises $15.4m
Navitas opens GaN IC design center for EVs • OSRAM sells Fluence

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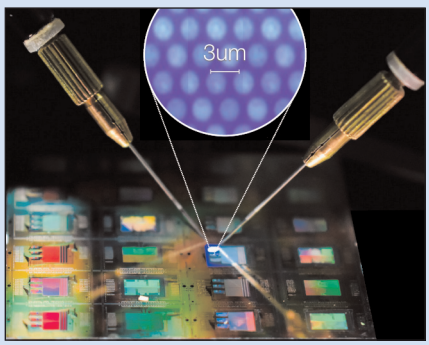
p20 Navitas has opened what is claimed to be the first GaN IC design center for electric vehicles.



p46 MICLEDI has demonstrated the first micro-LED arrays-for-AR built on a 300mm CMOS manufacturing platform.

p50 Isamu Akasaki, Shuji Nakamura, Nick Holonyak Jr, M. George Craford and Russell Dupuis have been recognised with the UK's 2021 Queen Elizabeth Prize for Engineering.

Cover: The new Intel Research Center for Integrated Photonics for Data Center Interconnects aims to accelerate optical I/O technology innovation in performance scaling and integration, with a specific focus on photonics technology and devices, CMOS circuits and link architecture, and package integration and fiber coupling. **p58**

editorial

Auto making driving compound sectors

Although automotive manufacturing continues to be constrained by the shortage in silicon chip supply, technology development continues unabated, driven by (1) the trend towards safety-oriented features such as advanced driver-assistance systems (ADAS) and ultimately autonomous vehicles (AVs) and (2) the environment-oriented migration to electric vehicles (EVs). Both are providing a stimulus to various compound semiconductor sectors.

Vertical-cavity surface-emitting lasers (VCSELs) are used for 3D sensing, for example, with over 1 billion of Lumentum's VCSEL arrays now having been deployed in mobile, consumer electronics, industrial and other applications, creating manufacturing economies of scale (page 59). The firm adds that technology advances have resulted in record optical power densities and efficiencies, making their VCSEL arrays now suitable for light detection and ranging (LiDAR) in high-performance ADAS and AV applications.

Meanwhile, US-based start-up Voyant Photonics has raised $15.4m in Series A funding to develop 3D sensing using 'chip-scale LiDAR', where silicon photonics technology developed for optical datacoms applications has been applied to machine perception by integrating a complete LiDAR system on a single photonic chip (page 57). Applications are cited as robotics, AGVs, mobility, industrial automation and security.

Regarding power electronics for EVs, after years of development, Germany's Bosch is now starting volume production of silicon carbide (SiC) power semiconductors, supplying auto makers worldwide (page 14). "Our order books are full, thanks to the boom in electro-mobility," the firm notes.

A fellow European silicon chip maker that is already well established in silicon carbide, STMicroelectronics, is already introducing its third generation of STPOWER SiC MOSFETs, intended for EV powertrains as well as other applications where power density, energy efficiency and reliability are key (page 16). "Due to the acceleration of the EV market, many car makers and automotive suppliers are now embracing 800V drive systems to achieve much faster charging and help reduce EV weight," ST notes.

Another European chip maker that currently makes silicon and gallium nitride (GaN)-based devices but is also entering volume production of SiC power electronics devices is Netherlands-based Nexperia (page 18). "SiC technology is also now advanced enough to meet the stringent requirements for mass production of devices for modern consumer and industrial products. Therefore, it is now time for Nexperia to take our next strategic step, the expansion of our portfolio to include power semiconductor devices based on silicon carbide," the firm says.

For high-volume production of SiC epitaxial wafers, Nexperia says it is using chemical vapor deposition systems made by Germany's Aixtron. Aixtron is partnering in the R&D project 'TRANSFORM – Trusted European SiC Value Chain for a greener Economy' (see page 39). Funded by the European Union and national funding authorities, the project aims to create a competitive European supply chain for power electronics based on silicon carbide (SiC) technology within the next three years.

Regarding gallium nitride, after opening a design center in Hangzhou, China, dedicated to enabling data centers to upgrade from silicon to GaN power ICs, US-based Navitas has further expanded into higher-power GaN markets by opening an EV design center in Shanghai (pages 20–21).

So, not only is the automotive industry boosting SiC production but it is also driving adoption of GaN in EVs too.

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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Automotive LED market rising 31.8% to $3.51bn in 2021

Top three suppliers remain ams-OSRAM, Nichia and Lumileds

The global penetration rate of LED headlights exceeds 60% in 2021, with penetration in new energy vehicles (NEV) exceeding 90%, according to TrendForce's '2020–2021 Global Automotive LED Product Trend and Regional Market Analysis'.

Influenced by growth momentum from increasing automotive market shipments and the rising penetration rate of LED lighting, the global automotive LED market is forecasted to grow 31.8% to $3.51bn in 2021. This demonstrates that LED headlights and automotive display LED products remain the main driving force for growth in the automotive LED market.

Although the automotive semiconductor shortage has led to manufacturing bottlenecks among some car makers, since they have asked LED producers to continue production, the purchase order status of major automotive LED makers will not be affected before the end of 2021. Among the 2021 revenue rankings of automotive LED manufacturers, the top three companies remain ams OSRAM, Nichia and Lumileds, account for as much as 71.7% market share combined.

In terms of automotive lighting, ams-OSRAM has leveraged stable product quality, excellent lighting efficiency and cost performance to make it the supplier of choice for the world's high-end cars and new energy vehicles, including high-flying Tesla among its customers. This year, ams-OSRAM's automotive LED revenue grew rapidly and has an opportunity to reach $1.304bn by year's end for an annual growth rate of about 40.9%. Samsung LED's PixCell LED has also been successfully integrated into the Tesla Model 3 and Model Y, boosting its automotive LED revenue growth to as much as $121m, with market share expected to increase to 3.4%.

In terms of automotive display backlighting (including dashboard and central console displays), not only are more and more car models equipped with automotive display products, the standard is moving towards larger displays with the current mainstream automotive panel product size at 12.3-inches. Further taking into account features popular in the current market such as HDR, local dimming and wide color gamut shows that automotive LED market demand will maintain a rapid growth trend in the next five years. This will benefit the revenue of Nichia and Stanley, with this year's market share for these two companies expected to reach 23.1% and 6.6%, respectively.

Relying on the high brightness and compact size of their WICOP product, Seoul Semiconductor's penetration rate of the automotive headlight market has reached 10%, and WICOP has been adopted by car makers including Changan Automobile, SAIC-GM-Wuling, and Nio. Revenue is forecast to reach $155m, with a market share of about 4.4%. Notably, benefiting from European customer orders, Dominant has the highest annual revenue growth out of the top ten companies in the industry, at 46.3%.

www.trendforce.com

Ranking of automotive LED manufacturers by revenue, 2020–2021 (in US$ millions).

Ranking	Company	Revenue		Market Share	
		2020	2021 (E)	2020	2021 (E)
1	ams-OSRAM	926	1,304	34.8%	37.2%
2	Nichia	647	809	24.3%	23.1%
3	Lumileds	315	401	11.8%	11.4%
4	Stanley	212	231	8.0%	6.6%
5	Dominant	136	199	5.1%	5.7%
6	Seoul Semiconductor	130	155	4.9%	4.4%
7	Samsung LED	71	121	2.7%	3.4%
8	Everlight	67	69	2.5%	2.0%
9	CREE LED	38	40	1.4%	1.1%
10	Lextar	8	35	0.3%	1.0%
	Other	110	141	4.1%	4.0%
	Total	2,660	3,506	100%	100%

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Intel unveils packaging, transistor and quantum physics developments to sustain Moore's Law beyond 2025

Intel targets >10x density improvement in packaging, 30–50% logic scaling improvements, and looks beyond classical silicon

In its pursuit of Moore's Law, Intel has unveiled key packaging, transistor and quantum physics breakthroughs that it says are fundamental to advancing and accelerating computing well into the next decade. At the 67th Annual IEEE International Electron Devices Meeting (IEDM 2021), Intel outlined its path toward more than 10x interconnect density improvement in packaging with hybrid bonding, 30–50% area improvement in transistor scaling, major breakthroughs in new power and memory technologies, and new concepts in physics that could revolutionize computing, the firm reckons.

"Our Components Research Group is sharing key research breakthroughs at IEDM 2021 in bringing revolutionary process and packaging technologies to meet the insatiable demand for powerful computing," says Robert Chau, Intel senior fellow & general manager of Components Research.

Moore's Law has been tracking innovations in computing that meet the demands of every technology generation from mainframes to mobile phones. This evolution continues as we move into a new era of computing with unlimited data and artificial intelligence (AI), says Intel.

Intel's Components Research Group is innovating across three key areas: essential scaling technologies for delivering more transistors; new silicon capabilities for power and memory gains; and exploration of new concepts in physics to revolutionize the way the world does computing. Many of the innovations that broke through previous barriers of Moore's Law and are in today's products started with the work of Component Research — including strained silicon, Hi-K metal gates, FinFET transistors, RibbonFET, and packaging innovations including EMIB and Foveros Direct.

Intel says that, at IEDM 2021, it is demonstrating that it is on track to continue the advancement and benefits of Moore's Law well beyond 2025 through three areas of pathfinding.

1. Intel is pursuing research in essential scaling technologies for delivering more transistors in future product offerings:

- Researchers have outlined solutions for the design, process and assembly challenges of hybrid bonding interconnect, envisioning a more than 10x interconnect density improvement in packaging. At the Intel Accelerated event in July, the firm announced plans to introduce Foveros Direct, enabling sub-10μm bump pitches, providing an order-of-magnitude increase in the interconnect density for 3D stacking. To enable the ecosystem to gain benefits of advanced packaging, Intel is also calling for the establishment of new industry standards and testing procedures to enable a hybrid bonding chiplet ecosystem.
- Looking beyond its gate-all-around (GAA) RibbonFET, Intel is tackling the coming post-FinFET era with an approach to stacking multiple (CMOS) transistors that aims to achieve a maximized 30–50% logic scaling improvement for the continued advancement of Moore's Law by fitting more transistors per square millimeter.
- Intel is also paving the way for Moore's Law advancement into the angstrom era with research showing how novel materials just a few atoms thick can be used to make transistors that overcome the limitations of conventional silicon channels, enabling millions more transistors per die area for ever more powerful computing in the next decade.

2. Intel is bringing new capabilities to silicon:

- More efficient power technologies are advancing through the world's first integration of gallium nitride (GaN)-based power switches with silicon-based CMOS on a 300mm wafer. This sets the stage for low-loss, high-speed power delivery to CPUs while simultaneously reducing motherboard components and space.
- Another advancement is Intel's low-latency read/write capabilities using novel ferroelectric materials for possible next-generation embedded DRAM technology that can deliver greater memory resources to address the growing complexity of compute applications, from gaming to AI.

3. Intel is pursuing massive performance with silicon transistor-based quantum computing, as well as entirely new switches for massively energy-efficient computing with novel room-temperature devices. In the future, these developments may replace classic MOSFET transistors by using entirely new concepts in physics:

- At IEDM, Intel demonstrated what is claimed to be the first experimental realization of a magnetoelectric spin-orbit (MESO) logic device at room temperature, showing the potential manufacturability for a new type of transistor based on switching nanoscale magnets.
- Intel and nanoelectronics research center IMEC of Leuven, Belgium are making progress with spintronic materials research to take device integration research close to realizing a fully functional spin-torque device.
- Intel also showcased full 300mm qubit process flows for the realization of scalable quantum computing that is compatible with CMOS manufacturing and identifies the next steps for future research.

www.intel.com

ULTRARAM memory demonstrated on silicon wafers for first time

Performance on silicon surpasses similar devices on GaAs substrates

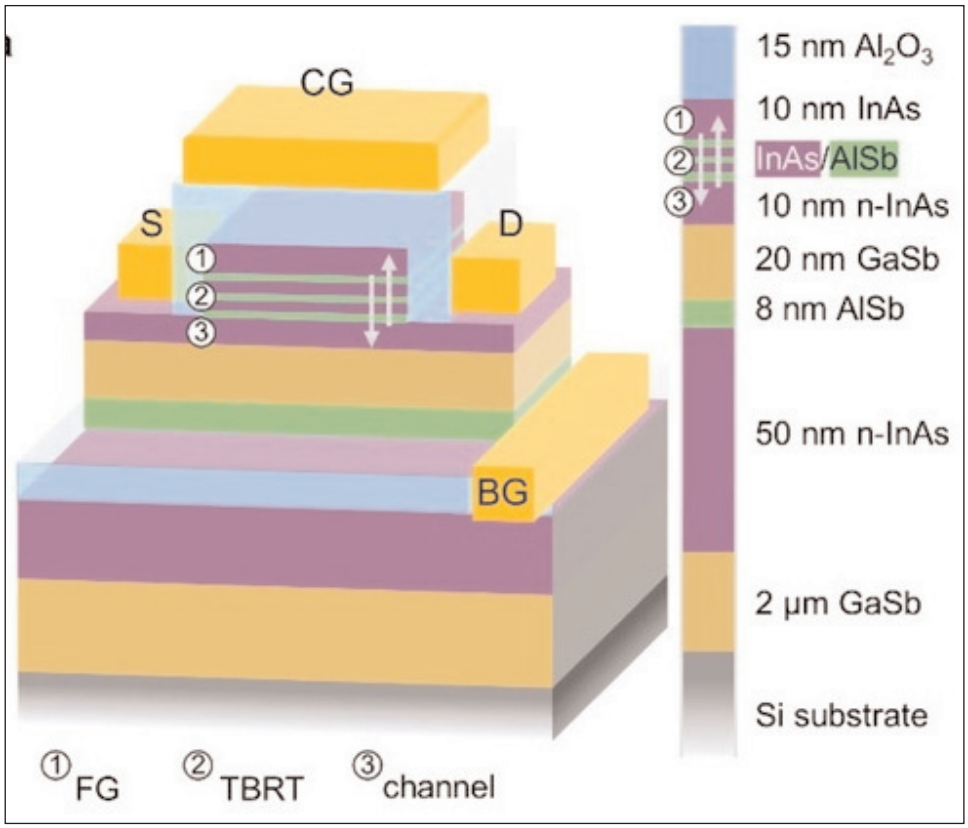
A type of patented computer memory known as ULTRARAM has been demonstrated on silicon wafers for the first time, representing a step towards its large-scale manufacture (Peter D. Hodgson et al, 'ULTRARAM: A Low-Energy, High-Endurance, Compound-Semiconductor Memory on Silicon', Advanced Electronic Materials; DOI: 10.1002/aelm.202101103).

ULTRARAM combines the non-volatility of a data storage memory like flash with the speed, energy efficiency and endurance of a working memory like dynamic random access memory (DRAM). To do this it utilizes the properties of compound semiconductors to yield a non-volatile memory with the potential to achieve fast, ultralow-energy electron storage in a floating gate accessed through a triple-barrier resonant tunneling heterostructure.

Initially patented in the USA, further patents on the technology are currently being progressed in key technology markets around the world. However, Due to the maturity of the silicon chip-making industry and the multi-billion dollar cost of building chip factories, implementation of any digital electronic technology on silicon wafers is essential for its commercialization.

Now, in a collaboration in the UK between the Physics and Engineering Departments at Lancaster University and the Department of Physics at Warwick University, ULTRARAM has been implemented on a silicon substrate for the first time (a vital step towards cost-effective mass production).

"ULTRARAM on silicon is a huge advance for our research, overcoming very significant materials challenges of large crystalline lattice mismatch, the change from elemental to compound semiconductor and differences in thermal contraction," says professor Manus Hayne of Lancaster's Department of Physics, who leads the work.



ULTRARAM device concept: schematic cross-section of a device with corresponding material layers. The floating gate (FG), triple-barrier resonant-tunneling structure (TBRT), and readout channel are highlighted. Arrows indicate the direction of electron flow during program/erase operations.

Sample growth using molecular beam epitaxy (MBE) begins with the deposition of an aluminium antimonide (AlSb) nucleation layer to seed the growth of a gallium antimonide (GaSb) buffer layer, followed by the III–V memory epilayers. Fabricated single-cell memories show clear 0/1 logic-state contrast after ≤10ms duration program/erase pulses of ≈2.5V (a remarkably fast switching speed for 10μm and 20μm devices). Furthermore, the combination of low voltage and small device capacitance per unit area results in a switching energy that is orders of magnitude lower than DRAM and flash, for a given cell size.

ULTRARAM on silicon is a huge advance for our research, overcoming very significant materials challenges of large crystalline lattice mismatch,

Extended testing of devices reveals (extrapolated) data retention (storage) times in excess of 1000 years, fast switching speed (for device size), and degradation-free program-erase cycling endurance of over 10^7 program/erase cycles (100–1000 times better than flash memory). This performance for ULTRARAM devices on silicon wafers actually surpasses very recent results for similar devices on gallium arsenide (GaAs) compound semiconductor substrates, say the researchers.

https://doi.org/10.1002/aelm.202101103

Qorvo launches first single front-end module to support 5.1–7.1GHz bands

Full-frequency support for both Wi-Fi 6 & Wi-Fi 6E enterprise solutions

Qorvo has launched the first wideband Wi-Fi front-end module (FEM) covering the 5.1–7.1GHz bands for customer premises equipment (CPE). The new wideband QPF4730 can provide full-frequency support for both Wi-Fi 6 and Wi-Fi 6E enterprise solutions.

In previous generations of Wi-Fi routers, each radio is fixed to a specific frequency, due to the narrowband nature of available solutions. To enable broadband operation, manufacturers must currently place a 5GHz front-end module, a 6GHz front-end module and switch components. The QPF4730 flexibly delivers full high-band support while reducing the board space required in Wi-Fi 6E upgrades. This improves overall system performance, capacity and flexibility, says the firm.

"Qorvo's newest FEM is optimized to operate over 5GHz, 6GHz or both, to maximize system capacity and throughput, which is not possible in existing CPE designs," says Tony Testa, director of technical marketing. "Qorvo's QPF4730 is the first in a family of new products that will address operational and architectural flexibility for Wi-Fi 6E channels and will include solutions for home gateways, routers and mesh systems."

The QPF4730 enhances efficiency in Wi-Fi 6/Wi-Fi 6E architectures and is optimized for Power over Ethernet (PoE), improving Quality of Service (QoS), range and throughput. The solution maximizes user capacity and leverages the full available spectrum. It also enables manufacturers to design smaller form factors than current gateways to meet user expectations for more compact, sleek and efficient designs. With its expanded spectrum, Wi-Fi 6E provides higher throughput while servicing more client connections in home, campus and enterprise settings, say Qorvo.

www.qorvo.com/innovation/wi-fi

Qorvo closes $500m offering of senior notes

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) has completed an offering of $500m of senior notes maturing in 2024. The notes will pay interest semi-annually at a rate of 1.750%, and mature on 15 December 2024, unless earlier redeemed in accordance with their terms.

Qorvo has used part of the net proceeds of the offering to repay all of its term loan and will use the remainder of the net proceeds for general corporate purposes.

The notes are senior unsecured obligations of Qorvo and are initially guaranteed, jointly and severally, by each of Qorvo's existing and future direct and indirect wholly owned US subsidiaries that guarantee Qorvo's obligations under its credit facility.

Altum RF announces sales rep agreement with HUTEC

Expanded sales coverage supports customers in South Korea

Altum RF of Eindhoven, The Netherlands (which designs high-performance RF to millimeter-wave solutions for commercial and industrial applications) has announces a new sales representative agreement with HUTEC Corp, covering customers in South Korea.

Founded in 1995, HUTEC has its headquarters office in Seoul, South Korea and specializes in active and passive components and modules for telecom, military, space and industrial applications.

"Adding yet another sales representative partnership highlights our view of how important it is to service our customers with top-tier talent," says Niels Kramer, Altum RF's managing director Europe & VP marketing. "HUTEC focuses not only on superior technical support but also on providing the right products to meet customers' requirements in a timely manner."

"Altum RF is an innovative and flexible company with a growing product portfolio, and we are extremely pleased to add this supplier to our catalog of products," comments HUTEC's CEO Shim.

Altum RF is an international firm, with strategic partnerships and office locations that span the globe to support its growing product portfolio.

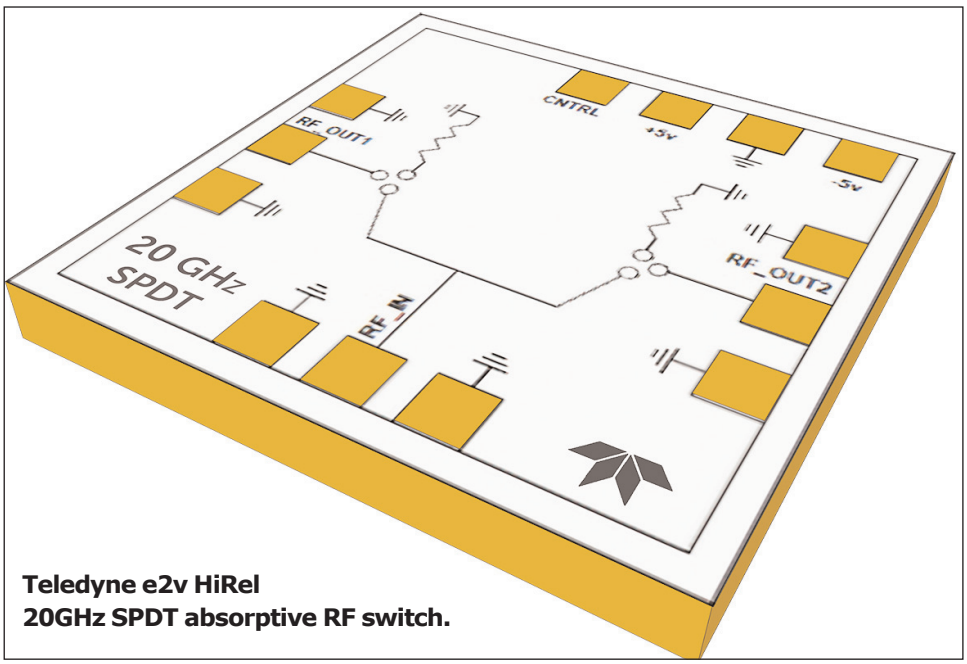
www.altumrf.com

Teledyne e2v HiRel releases catalog radiation-tolerant 20GHz SPDT absorptive RF switch

Off-the-shelf high-frequency RF switch for challenging high-rel space applications

Teledyne e2v HiRel Electronics of Milpitas, CA, USA (part of the Teledyne Defense Electronics Group that provides solutions, sub-systems and components to the space, transportation, defense and industrial markets) has made available the TDSW020A2T radiation-tolerant 20GHz single-pole double-throw (SPDT) absorptive RF switch, suitable for demanding high-reliability space and defense applications, and now available with qualified material off-the-shelf. The new RF switch, developed on 0.15μm indium gallium arsenide (InGaAs) pseudomorphic high-electron-mobility transistor (pHEMT) technology, will be available as die and is qualified per MIL-PRF-38534 Class K-equivalent for space applications.

The TDSW020A2T leverages monolithic microwave integrated circuit (MMIC) design techniques that deliver superior performance in the Ku and K microwave and millimeter-wave bands. The switch delivers low insertion loss, high isolation, fast switching times, and high linearity across a wide frequency band from DC to 20GHz and attains an input power 1dB compression of 28dBm (typical). Class K-equivalent element evaluation is performed per wafer.



Teledyne e2v HiRel 20GHz SPDT absorptive RF switch.

"We continue to expand our portfolio of high-reliability RF products for Ku and K bands and beyond," says Mont Taylor, VP & business development manager at Teledyne e2v HiRel. "This new product is the first 20GHz switch qualified to 100krad, and joins our growing product lines of amplifiers, low-noise amplifiers, power amplifiers, DVGAs, digital step attenuators, limiters, mixers, pre-scalers, phase-locked loops, and switches."

The TDSW020A2T is TID radiation tolerant to 100krad (Si), making it suitable for satellites and other high-altitude, high-reliability applications.

Devices are available for ordering and shipment today, from Teledyne e2v HiRel or an authorized distributor, with the option of Classes H- or K-equivalent screening. They are shipped from the firm's DoD Trusted Facility in Milpitas, CA, USA.

www.tdehirel.com

AmpliTech completes acquisition of Spectrum Semiconductor Materials

Acquisition provides a near quadrupling of revenue base and expanded distribution reach and growth potential

AmpliTech Group Inc of Bohemia, NY, USA – which designs and makes signal-processing radio frequency components for satellite communications, telecoms (5G & IoT), space, defense and quantum computing markets – has completed the purchase of the assets and operations of Spectrum Semiconductor Materials Inc of San Jose, CA, a global distributor of components (packages and lids) for integrated circuit (IC) assembly in prototyping, testing and production.

The acquisition is expected to deliver significant strategic and top- and bottom-line benefits while also building on AmpliTech's technical and management expertise and distribution reach. Spectrum's unaudited 2021 revenue is expected to be $13m ($2m higher than previously announced), with pre-tax net income margin of about 25% of revenue. AmpliTech's revenue for the past four quarters was $3.5m. AmpliTech and Spectrum have current order backlogs of $3.8m and $7.6m, respectively, for a record consolidated backlog for AmpliTech Group of $11.4m in orders expected to ship in first-half 2022.

AmpliTech says that Spectrum has achieved solid growth and attractive net margins by building strong customer relationships across a range of niche markets and supporting their specific needs by stocking a wide variety of specialty products, unmatched by larger competitors, it is claimed. Further, Spectrum leverages digital inventory practices to optimize its operating efficiency and to enhance its ability to meet customer needs.

The purchase price was $8m in cash plus $1.5m to be held in escrow through December 2022 (to fund any adjustments) plus the issuance of 188,442 restricted shares of AmpliTech common stock. The parties agreed to a purchase price adjustment of 25% of Spectrum's cumulative net revenue above or below $20m in sales for calendar years 2021 and 2022 combined. Post-closing, AmpliTech had about $17m in cash, cash equivalents and marketable securities, and no long-term debt. AmpliTech says that it is well funded to execute on the growth opportunities of the combined business.

Spectrum has been building its radio frequency (RF)-focused semiconductor revenue base and is expected to provide a powerful distribution platform in the USA, Europe and Asia for AmpliTech's new line of monolithic microwave integrated circuit (MMIC) chip designs. Spectrum is positioned to package these and future designs for high-volume applications.

AmpliTech's MMIC chip designs integrate its low-noise signal amplification (LNA), signal filter and signal attenuator technologies into a much smaller and more flexible chip form factor. Foundry production of initial MMIC wafers has been completed, and they are now undergoing initial testing. MMIC chipsets remain on schedule for commercial availability and sampling during first-quarter 2022.

Spectrum has been building its RF-focused semiconductor revenue base and is expected to provide a powerful distribution platform in the USA, Europe and Asia for AmpliTech's new line of MMIC chip designs

"Through the Spectrum acquisition we have substantially increased our revenue base with a well-managed, growing business known for high quality and excellent customer service," says AmpliTech's CEO Fawad Maqbool. "This transaction will allow us to more than triple our current annual revenue run rate, while also being immediately accretive to our bottom line," he adds.

"Of equal importance, Spectrum brings us a highly satisfied, long-term and global customer base with excellent penetration in our core end markets of aerospace, defense, automotive and computing, along with a deep Silicon Valley presence [building on AmpliTech's existing East Coast and Texas teams], to support the launch of MMIC chip solutions [that] we plan to bring to market by the end of first-quarter 2022," Maqbool continues. "We expect AmpliTech and Spectrum will play a key role in improving the speed and efficiency of communications systems around the world in high-growth applications such as 5G cellular, medium earth orbit (MEO) and low earth orbit (LEO) satellites, quantum computing and autonomous vehicles.

It is reckoned that each company brings proven sales personnel and relationships that complement each other in addressing an expanded market opportunity. "We are already focused on several joint business development opportunities that should expand the reach and value of our respective solutions and total market opportunity," says Spectrum's president Steve Ochoa.

Joining forces with AmpliTech provides "a broader base of opportunity and exciting growth potential as we collaborate to bring AmpliTech's premier MMIC chip solutions to market," comments Spectrum's CEO Robert Larson.

www.spectrum-semi.com
www.amplitechinc.com

A*STAR's IME and Soitec to co-develop silicon carbide for EVs and high-voltage electronics

Smart Cut and IME's pilot production line to create 200mm SiC

The Institute of Microelectronics (IME) at Singapore's Agency for Science, Technology and Research (A*STAR) and engineered substrate manufacturer Soitec of Bernin, near Grenoble, France have announced a research collaboration to develop silicon carbide (SiC) devices to power electric vehicles (EVs) and advanced high-voltage electronic devices. Specifically, Soitec's proprietary technologies such as Smart Cut and IME's pilot production line will be leveraged to create 200mm-diameter SiC substrates.

The joint research aims to contribute towards developing a holistic SiC ecosystem and boosting semiconductor manufacturing capabilities in Singapore and the region. The research collaboration is planned to run until mid-2024, and aims to achieve the following outcomes:

- develop SiC epitaxy and metal–oxide–semiconductor field-effect transistor (MOSFET) fabrication processes for Smart Cut SiC substrates to produce higher-quality microchip transistors with ewer defects and enhanced yield during the manufacturing process;
- establish a benchmark for SiC power MOSFET devices fabricated on Smart Cut SiC substrates and demonstrate the advantages of the process with conventional bulk substrates.

"This joint research between A*STAR's Institute of Microelectronics and Soitec to develop next-generation semiconductor devices using innovative technologies is made possible by both organizations' deep capabilities in R&D," says IME's executive director Terence Gan. "We look forward to working together with Soitec to add value to the local R&D ecosystem and the growing pool of silicon carbide players in the semiconductor industry," he adds.

"This is a great opportunity for us to partner with Singapore's Institute of Microelectronics and demonstrate SmartSiC substrate's scalability to 200mm," says Christophe Maleville, chief technology officer & senior executive VP at Soitec. "The collaboration paves the way for the development of advanced epitaxy solutions to produce higher-quality SiC wafers with energy-efficient characteristics, given the exciting potential of this material. As the main beneficiaries of this new process, the semiconductor ecosystem in Singapore will be given the opportunity to validate the superior energy efficiency of the SiC wafers produced through our collaboration."

www.soitec.com

Bosch starting volume production of silicon carbide chips

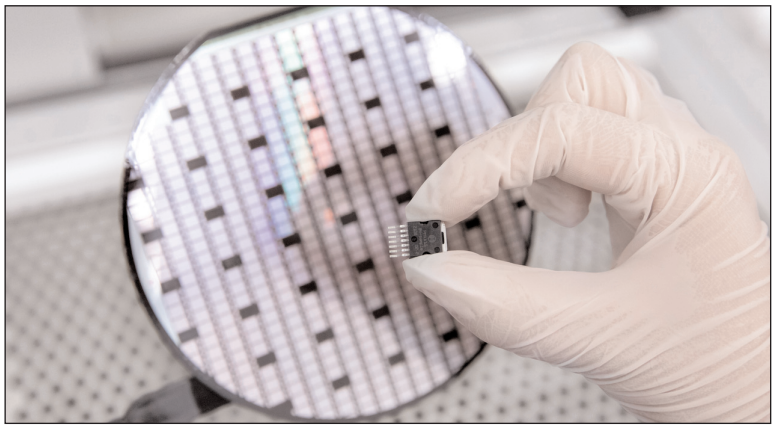
Extra 1000m² cleanroom space added in 2021 to be followed by another 3000m² by end-2023

After several years of development, Bosch is now starting volume production of silicon carbide (SiC) power semiconductors, supplying automotive manufacturers worldwide. In the future, more and more production vehicles will feature these chips.

"We want to become a global leader in the production of SiC chips for electro-mobility," says Harald Kroeger, member of the board of management of Robert Bosch GmbH of Reutlingen, Germany. Two years ago, the technology and service provider announced that it would push ahead with the development of SiC chips and enter production. For this, Bosch has developed its own manufacturing processes, which it has been using to produce SiC chips since the beginning of 2021 — initially as samples for customer validation. "Our order books are full, thanks to the boom in electro-mobility," Kroeger says.

In the future, Bosch intends to expand its production capacity for SiC power semiconductors to a unit volume running into the hundreds of millions. The firm has hence already started expanding the cleanroom space at its Reutlingen plant. In parallel, work is also being done on the second generation of SiC chips, which will be even more efficient and should be ready for volume production in 2022.

Bosch is receiving support for the development of these for SiC manufacturing processes from the German Federal Ministry for Economic Affairs and Energy (BMWi) as part of the 'Important Project of Common European Interest (IPCEI) Microelectronics' program. "For several years now, we have been providing support to help establish semiconductor production in Germany," says Peter Altmaier, Germany's Federal Minister for Economic Affairs. "Bosch's highly innovative semiconductor production strengthens the microelectronics ecosystem in Europe and is a further step toward greater independence in this key field of digitalization."



Demand for silicon carbide power semiconductors is rising. A forecast by market research and consulting firm Yole Developpement indicates that, between now and 2025, the SiC market as a whole will grow on average by 30% per year to over $2.5bn. At about $1.5bn, the automotive SiC market is expected to account for the majority.

"Silicon carbide power semiconductors make particularly efficient use of energy. This material's advantages really come to the fore in energy-intensive applications such as electro-mobility," Kroeger says. In the power electronics of electric vehicles, silicon carbide chips ensure that drivers can drive significantly further on one battery charge — on average about 6% further than with their pure silicon counterparts.

"We want to become a global leader in the production of SiC chips for electro-mobility," says board member Harald Kroeger

To meet steadily increasing demand for SiC, an extra 1000m² has already been added to the cleanroom space at the Bosch wafer fab in Reutlingen in 2021. Another 3000m² will be added by the end of 2023. The new space will house production facilities for SiC manufacturing using processes developed in-house, building on decades of expertise in chip manufacturing.

In the future, the company (the only automotive supplier to produce its own SiC chips) plans to manufacture silicon carbide chips on 200mm wafers, which will deliver sizeable economies of scale compared with existing 150mm wafers. "By producing on larger wafers, we can manufacture significantly more chips in one production run and thus supply more customers," Kroeger says.

www.bosch.com

Microchip providing SiC MOSFETs and digital gate drivers to Mersen

150kVA three-phase SiC Power Stack Reference Design precludes need for individual device sourcing, testing and qualification

Since e-mobility and renewable energy systems require power management solutions that drive performance and cost efficiencies in addition to speeding up development time, Microchip Technology Inc of Chandler, AZ, USA is collaborating with Mersen of Courbevoie, France (a global provider of power management solutions for industrial sectors including e-mobility and energy storage) on its 150kVA three-phase silicon carbide (SiC) Power Stack Reference Design.

Mersen's three-phase SiC Power Stack Reference Design provides system designers with a complete, compact, high-power silicon carbide solution without the need for individual device sourcing, testing and qualification. The Power Stack Reference Design includes Microchip's silicon carbide power modules and digital gate drivers and Mersen's bus bar, fuses, capacitors and thermal management, optimally designed together in a single high-performance stack reference design. With Microchip's 1200V MSCSM120AM042CD3AG SiC MOSFET and AgileSwitch 2ASC-12A1HP digital gate driver, the Power Stack Reference Design is said to enable engineers to rapidly develop high-voltage systems using kits pre-designed for their applications — reducing time to market by up to six months.

"Microchip customers will benefit from our collaboration with Mersen to provide silicon carbide MOSFETs and digital gate driver solutions," says Leon Gross, VP of Microchip's discrete product business unit. "When power inverter designers can source a proven solution, they can avoid sourcing individual parts and reduce risk through reliability — and that helps avoid downtime. Designers now have an all-in-one evaluation system."

The Power Stack Reference Design provides 16kW per liter (kW/l) of power density and up to 130°C junction temperature (T_j), peak efficiency at 98%, with up to 20kHz switching frequency. Utilizing Microchip's rugged SiC MOSFETs and AgileSwitch family of configurable digital gate drivers, the reference design enables engineers to select from 700V and 1200V options in currents up to 750A. Microchip also provides a choice in module construction including baseplate material, direct bonding copper (DBC) ceramic material and die-attach method.

"We worked closely with Microchip on the design and development of this silicon carbide Power Stack Reference Design given the availability of highly robust silicon carbide MOSFETs and compatible digital gate drivers from a single source," says Philippe Roussel PhD, VP, global strategic marketing executive expert at Mersen. "Thus, we can demonstrate our ability to optimize any inverter topologies from our customers, relying on our line of highly reliable bus bars, capacitors, fuses and cooling systems. The versatile Microchip silicon carbide line-up also gives us the capacity to extend these primary specifications to higher voltage, current and switching frequency to meet every customer's operating point needs."

Microchip unifies in-house silicon carbide die production with its low-inductance power packaging and digital gate drivers, enabling designers to make efficient, compact and reliable end-products. These devices pair with a comprehensive portfolio of micro-controllers (MCUs), analog and MCU peripherals, plus communication, wireless and security technology, providing system designers across many applications with proven total system solutions, says the firm.

Microchip's AgileSwitch 2ASC-12A1HP 1200V dual-channel digital gate driver with Augmented Switching technology is production qualified and fully configurable. The AgileSwitch 2ASC-12A1HP gate driver and the next-generation 2ASC-12A2HP are supported by Microchip's Intelligent Configuration Tool (ICT), an interface allowing users to configure gate driver parameters including the gate switching profiles, system-critical monitors and controller interface settings. The ICT, a free-of-charge download, saves development time.

www.mersen.com
www.microchip.com

ST launches third generation of STPOWER SiC MOSFETs

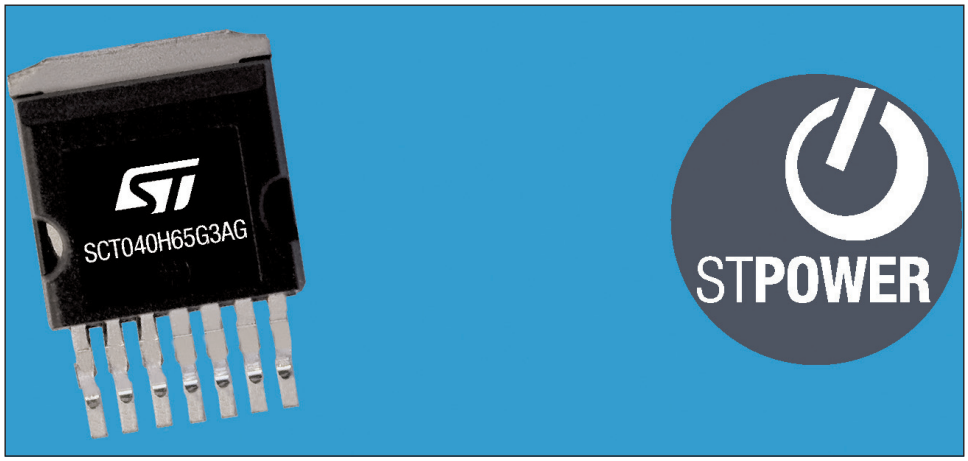
New silicon carbide power devices for EVs and industrial applications

STMicroelectronics of Geneva, Switzerland is introducing its third generation of STPOWER silicon carbide (SiC) metal-oxide-semiconductor field-effect transistors (MOSFETs), intended for electric vehicle (EV) powertrains and other applications where power density, energy efficiency and reliability are important target criteria.

Due to the acceleration of the EV market, many car makers and automotive suppliers are now embracing 800V drive systems to achieve much faster charging and help reduce EV weight. These new systems allow the car makers to produce vehicles with longer driving ranges. ST's new SiC devices are specifically optimized for these high-end automotive applications including EV traction inverters, on-board chargers, and DC/DC converters, as well as e-climate compressors. The new generation also suits industrial applications by boosting the efficiency of motor drives, renewable energy converters and storage systems, as well as telecom and data-center power supplies.

"We continue to drive this exciting technology forward with innovations at both the device and package levels. As a fully integrated SiC products manufacturer, we are able to deliver continued improved performance to our customers," says Edoardo Merli, Power Transistor Macro-Division general manager & group VP of STMicroelectronics' Automotive and Discrete Group. "We are investing relentlessly to support our automotive and industrial programs expected to generate $1bn in SiC revenue in 2024."

ST has completed qualification of the third-generation SiC technology platform and expects to move most of the derivative products to commercial maturity by the end of 2021. Devices with nominal voltage ratings from 650V and 750V up to 1200V will be available, giving more choices for designers to address applications operating from ordinary AC-line voltages up to those of high-voltage EV batteries and chargers. The first products available are the 650V SCT040H65G3AG, priced at $5, and a 750V device in die form (datasheet and quotation upon request).



Leveraging the new third-generation SiC platform, ST's latest planar MOSFETs set what are claimed to be industry-leading benchmarks for the accepted figures-of-merit (FoMs) [on-resistance (R_{on}) x die size, and R_{on} x gate charge (Q_g)] that express transistor efficiency, power density and switching performance. Bettering FoMs using ordinary silicon technology has become increasingly difficult and, as a result, SiC technology holds the key to further improvement.

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Compared with silicon alternatives, SiC MOSFETs also have a higher voltage rating in relation to their die size, making the technology an excellent choice for EV applications and fast-charging EV infrastructures, says ST. In addition, they benefit from a very fast intrinsic diode that delivers the bi-directional properties needed for automotive on-board chargers (OBCs) used in Vehicle-to-X (V2X) power flow allowing the transmission of electricity from an OBC battery to the infrastructure. Moreover, their very high-frequency capability allows smaller passive components within power systems, permitting more compact and lightweight electrical equipment in the vehicle. The same attributes also lower ownership costs in industrial applications.

ST will offer the third-generation devices in various forms, including bare dice, discrete power packages such as STPAK, H2PAK-7L, HiP247-4L and HU3PAK and power modules of the ACEPACK family. The packages offer design features such as specially placed cooling tabs that simplify connection to base-plates and heat spreaders in EV applications. The options give designers choices that are optimized for applications such as EV main traction inverters, on-board chargers, DC/DC converters, e-climate compressors, and industrial applications such as solar inverters, energy storage systems, motor drives and power supplies.

www.st.com

ST launches first PowerGaN products for more energy-efficient, slimmer power supplies

Extra devices in various packages and specifications coming soon

STMicroelectronics of Geneva, Switzerland has unveiled a new family of gallium nitride (GaN) power semiconductors in its STPOWER portfolio that can significantly reduce energy use and enable slimmer designs in a variety of electronic products. Target applications include consumer equipment such as chargers, external power adapters for PCs, LED-lighting drivers, and power supplies inside televisions and home appliances. In higher-power applications, ST's PowerGaN devices also benefit telecom power supplies, industrial motor drives, solar inverters, and electric vehicles and chargers.

"Commercializing GaN-based products is the next frontier for power semiconductors, and we are ready to realize the potential of this exciting technology. Today ST is announcing the first product in a new family, belonging to the STPOWER portfolio, that can deliver breakthrough performance for a large variety of power supplies across consumer, industrial, and automotive applications," says Edoardo Merli, Power Transistor Macro-Division general manager & group VP of STMicroelectronics' Automotive and Discrete Group. "We are committed to progressively building up our PowerGaN portfolio to enable customers to design more efficient, smaller power supplies everywhere."

The first device in ST's new G-HEMT transistor family is the 650V SGT120R65AL with 120mΩ maximum on-resistance ($R_{DS(on)}$), 15A maximum current capability, and a Kelvin source connection for optimum gate driving. It is available now in an industry-standard PowerFLAT 5x6 HV compact surface-mount package, at $3 (in 1000-unit quantities). Typical applications are PC adaptors, USB wall chargers, and wireless charging.

In addition, 650V GaN transistors in development are available now as engineering samples. These include the SGT120R65A2S with 120mΩ $R_{DS(on)}$ in an advanced laminated package, the 2SPAK, which eliminates wire bonding to boost efficiency and reliability in high-power and high-frequency applications, as well as the SGT65R65AL and SGT65R65A2S both with 65mΩ $R_{DS(on)}$ in PowerFLAT 5x6 HV and 2SPAK, respectively. Volume production for these products is expected in second-half 2022.

In addition, a new cascode GaN transistor, SGT250R65ALCS with 250mΩ $R_{DS(on)}$ in a PQFN 5x6, belonging to the G-FET family, will be available for sampling in third-quarter 2022.

The G-FET transistor family is a very fast, ultra-low Q_{rr}, robust GaN cascode or d-mode FET with standard silicon gate-drive for a wide range of power applications.

The G-HEMT transistor family is an ultra-fast, zero Q_{rr} e-mode HEMT, easily parallelable, and well suited for very high-frequency and power applications.

G-FET and G-HEMT both belong to the PowerGaN family of the STPOWER product portfolio.

www.st.com

onsemi Roznov wins Zlín Region manufacturing innovation award

Czech site achieves production of 200mm polishedSiC in three years

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA has been named 'Innovative Company of the Zlín Region' for its site in Roznov, Czech Republic, which won the award presented by the Technological Innovation Center for the project 'Innovation of the manufacturing process of semiconductor wafers with implementation of world-new processes for polished silicon carbide (SiC) wafer manufacturing'.

The SiC-based project's goal was to achieve world-class quality in SiC wafer manufacturing within three years. After extensive evaluation and testing, SiC wafers from the Roznov facility were qualified for device manufacturing at the end of 2020. Production ramp-up began in early 2021, and in September the onsemi Roznov facility joined the club of 200mm SiC wafer producers.

The award reflects "several years of hard work by our team at the Roznov facility," says Ale_ Cáb, VP, onsemi Roznov Operations.

onsemi was one out of 26 firms in the Czech Zlín region submitting its projects for the biennial award. The projects were assessed by a team of independent experts from business, research and academics, who provide participants with feedback on their technical progress.

onsemi in Roznov has a long local tradition of manufacturing semiconductors, starting in 1949. The first silicon single crystal was made in Roznov in 1958, about eight years after the world's first growth of single-crystal silicon. Today, onsemi's high-volume wafer fab and raw silicon wafer and epitaxy production factory as well as its design center in Roznov contribute to an effective semiconductor supply chain.

www.onsemi.com

Nexperia using Aixtron equipment as it enters silicon carbide power electronics market

Fully automated AIX G5 WW C system being used for volume production of SiC epiwafers

Nexperia of Nijmegen, Netherlands — which manufactures diodes, bipolar transistors, ESD protection devices, MOSFETs, gallium nitride (GaN) field-effect transistors (FETs) and analog & logic ICs — is using production technology from deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany to enter the high-performance silicon carbide (SiC) device market. For volume production of silicon carbide epitaxial wafers for SiC power devices, Nexperia requires consistently high epiwafer quality, even at high volumes. At the same time, costs in the production of SiC devices can be reduced due to the high throughput.

"Wide-bandgap semiconductors such as gallium nitride and silicon carbide have unique physical properties. They enable high power density and efficiency at lower system and operating costs," says Mark Roeloffzen, general manager of the Bipolar Discretes Group at Nexperia. "SiC technology is also now advanced enough to meet the stringent requirements for mass production of devices for modern consumer and industrial products. Therefore, it is now time for Nexperia to take our next strategic step, the expansion of our portfolio to include power semiconductor devices based on silicon carbide," he adds.

"In the future, we will also cover the value-added stage of epiwafer production in the field of high-performance components. For this important milestone, we know that Aixtron is the right partner for Nexperia," he adds.

For decades, Aixtron has been working with leading institutes and industry partners worldwide to exploit the benefits of new compound semiconductor material classes such as SiC and GaN for power electronics and is also opening up the use of 200mm wafers with the latest production technologies.

Designed specifically to meet the demands of SiC power electronics, Aixtron's latest-generation fully automated AIX G5 WW C Planetary Reactor is said to ensure the necessary quality of epitaxial layers and has therefore been qualified by market leaders in silicon carbide for the production of SiC devices.

"Nexperia is positioning itself at the right time in one of the most exciting growth markets in the semiconductor industry. We are pleased that Nexperia has chosen us as a partner in this important strategic step into a new market of the future," says Aixtron's CEO & president Dr Felix Grawert. "The performance characteristics of the silicon carbide and gallium nitride material classes, with their high efficiency, offer highly attractive potential for energy savings, heat reduction, weight and system size reduction, and thus lower overall system costs," he adds.

"SiC and GaN semiconductors offer higher energy efficiency in applications compared to conventional power electronics based on silicon and thus contribute significantly to lower CO_2 emissions," continues Grawert. "The properties of the materials predestine them in particular for applications in electric vehicles and their charging stations, data centers or in the field of renewable energies such as solar and wind power plants."

At the beginning of the year, Nexperia had already begun a significant investment program both in the expansion of its production capacities and in R&D worldwide. As part of its global growth strategy, planned investments in Europe this year include production efficiency improvements and the implementation of new 200mm technologies at its European wafer fabs in Hamburg, Manchester and Newport. In particular, in Hamburg the firm is investing in new technologies for the expansion of its portfolio of wide-bandgap SiC power devices.

www.aixtron.com
www.nexperia.com

SemiQ launches second-gen silicon carbide power switch

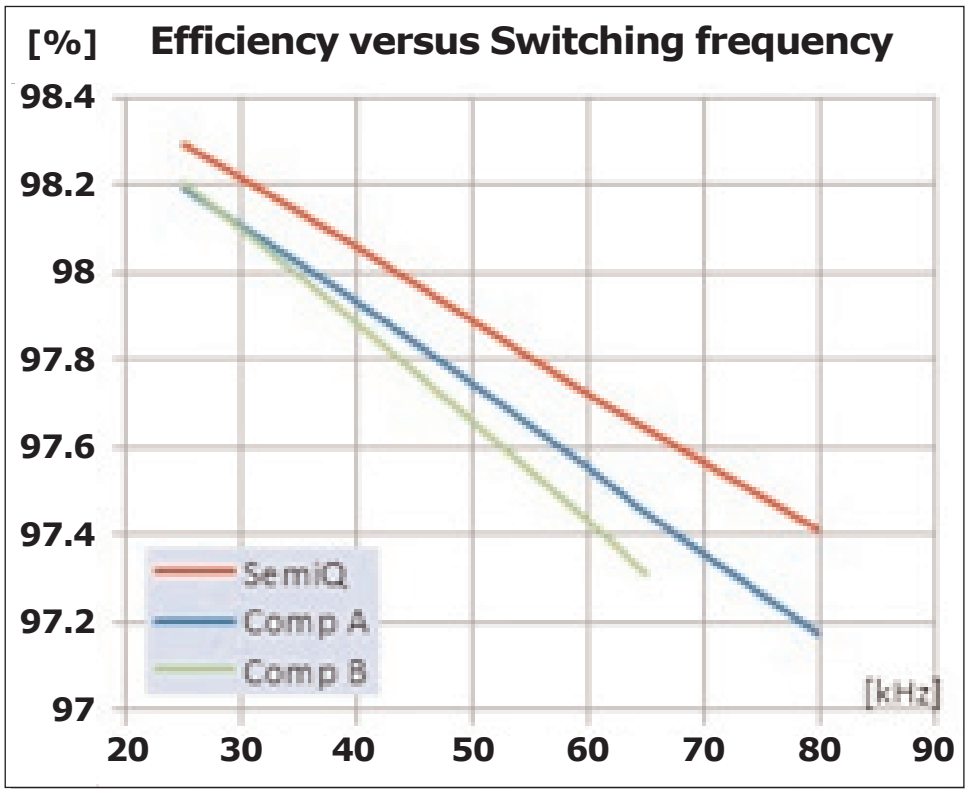
1200V 80mΩ MOSFET complements rectifiers at 650V, 1200V, 1700V

SemiQ of Lake Forest, CA, USA — which designs, develops and manufactures SiC components and 150mm SiC epiwafers for high-frequency, high-temperature and high-efficiency power semiconductor devices — has launched its second-generation silicon carbide (SiC) power switch, a 1200V 80mΩ SiC MOSFET, expanding its portfolio of SiC power devices. The MOSFET complements the firm's existing SiC rectifiers at 650V, 1200V and 1700V.

SemiQ says that it has engineered the MOSFET to provide the best trade-off of conduction and switching losses to benefit the widest possible range of applications.

As shown in the accompanying graph, the new device maintains its efficiency advantage over a full range of frequencies versus popular competing products, giving designers more flexibility over a wider range of applications than other devices on the market, claims SemiQ.

SiC MOSFETs bring high efficiency to high-performance applications including electric vehicles (EVs), power supplies and data centers and are specifically designed and tested to operate reliably in extreme environments. Compared to legacy silicon insulated-gate bipolar transistors (IGBTs), SemiQ's MOSFETs switch faster with lower losses, enabling system-level benefits through reduced size, weight and cooling requirements.



SemiQ's new 1200V 80mΩ SiC MOSFET is available in a TO-247-3L package and will soon be available in a TO-247-4L package and a series of modules. Samples are in stock at SemiQ and are available through distributors DigiKey, Mouser and Richardson Electronics.

www.SemiQ.com

Wolfspeed hires Texas Instruments veteran as VP of backend operations

Global operations team expanded to support long-term growth strategy

Wolfspeed Inc (formerly Cree Inc) of Durham, NC, USA says that Joe Roybal has joined it as VP of backend operations. He joins Wolfspeed from Texas Instruments and has over 20 years of operations and leadership experience.

Roybal previously held the titles of director of quality for the analog signal chain, director of test operations (where he led a 650-employee organization through an operations-wide transformation to increase efficiency) and quality manager for Texas Instruments' first 300mm factories. He has worked with automotive, industrial, communications and personal electronics customers, improving satisfaction through product quality and account management.

Joe Roybal, new VP of backend operations.

"Joe comes to Wolfspeed with a wealth of knowledge in fab, probe and assembly/test operations, and we look forward to his contributions as we continuously improve," says Rex Felton, senior VP of global operations. "His arrival complements our growing operations leadership team and will be a vital asset as we lead the industry-wide transformation from silicon to silicon carbide."

Wolfspeed reckons that the addition to its team of semiconductor manufacturing professionals, paired with its expansion of production capability for silicon carbide materials and devices in New York and North Carolina, will support rapid growth.

www.wolfspeed.com

Navitas opens first GaN IC design center for EVs

Shanghai design center to develop schematics, layouts and firmware for full-function, productizable EV power systems

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has announced the opening of a new electric vehicle (EV) design center in Shanghai, China, further expanding into higher-power GaN markets.

Compared with legacy silicon solutions, GaN-based on-board chargers (OBCs) are estimated to charge 3x faster with up to 70% energy savings. GaN OBCs, DC–DC converters and traction inverters are estimated to extend EV range or reduce battery costs by 5%, and to accelerate adoption of EVs worldwide by three years. An EV upgrade to GaN is estimated to reduce road-sector CO_2 emissions by 20%/year by 2050 (the target of the Paris Accord).

The new design center in Shanghai hosts an experienced team of power system designers with capabilities across electrical, thermal and mechanical design, software development, and complete simulation and prototyping capabilities. EV customers will be supported worldwide by the new team, from concept to prototype, through to full qualification and mass production.

"The design center will develop schematics, layouts and firmware for full-function, productizable EV power systems," says Hao Sun, the new senior director of the Shanghai Design Center. "Navitas will work in partnership with OBC, DC–DC and traction system companies to create innovative, world-class solutions with the highest power density and highest efficiency to propel GaN into mainstream eMobility," he adds.

High-power 650V GaN ICs tailored to EV applications were sampled to EV customers in December.

A 6.6kW OBC concept was displayed at the Xiaomi Portfolio Demo Day on 24 October, and was shown at the Consumer Electronics Show (CES 2022) in Las Vegas, NV (5–7 January).

"EMobility is an exciting expansion market for GaN, with an estimated $250 potential content per EV," says Charles Zha, VP & general manager of Navitas China. "Market-by-market, Navitas is making swift progress into higher-power applications, like EV, data center and solar."

www.ces.tech

GaN power ICs sampled to data-center, solar, EV customers

Feature, function and power upgrades optimize for high-power markets

Navitas says that high-power GaN power IC samples are now available for the first time to data-center, solar and electric vehicle (EV) customers worldwide.

Navitas first introduced its GaNFast ICs to mobile customers three years ago, enabling high-efficiency and ultra-fast charging of mobile devices with ultra-lightweight and miniaturized form factors.

Now, for the first time, the GaN power IC technology — claimed to be the only GaN platform to monolithically integrate drive, control, protection and power — is available to applications operating in the 2–20kW power range, which includes data centers, solar inverters and electric vehicle power electronics.

New products are optimized for each of the high-power markets, with feature, function and power upgrades to become true GaNFast application-specific integrated circuits.

"Navitas engineering teams have delivered on-time again, with high-performance GaN power ICs that drive our market expansions," says co-founder & CEO Gene Sheridan. "This is another successful step along the path we outlined in our financial roadmap to investors, expanding from our number-1 position in the 20–300W mobile fast-charger market into high-power 2–20kW-plus applications."

The new products are power-upgraded, thermally enhanced versions of the proven 650/800V GaNFast platform, with over 30 million units shipped and zero reported field failures. Navitas' GaNFast integration technology has built-in, fast and accurate protection against over-temp, over-current and ESD protection.

www.navitassemi.com

Navitas opens design center in China focused on enabling GaN-based data-centers

First proof point: 1.2kW 'Titanium plus' design, then 2.2kW and 3kW

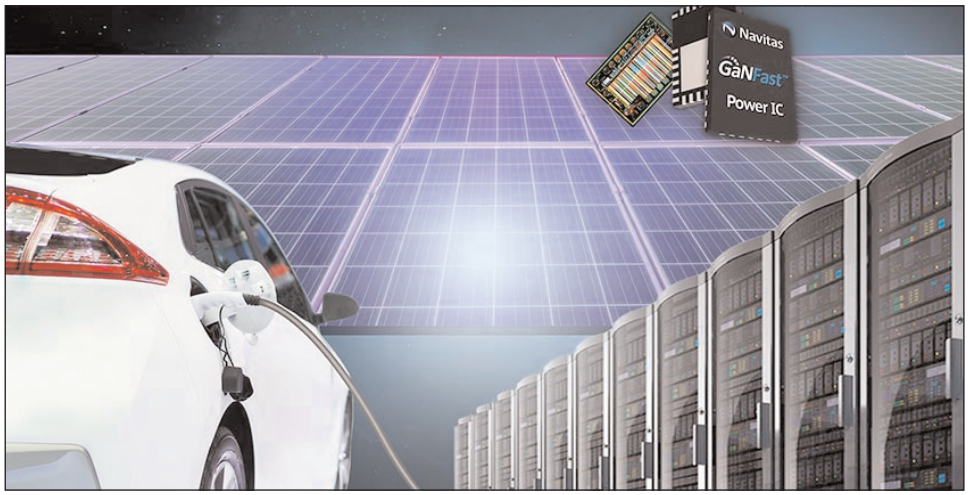
Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has announced its expansion into higher-power markets with the opening of a new Design Center dedicated to bringing next-generation GaN power ICs and associated high-efficiency, high-power-density systems to enable data centers around the world to upgrade from silicon to GaN, thereby significantly improving energy savings, reducing electricity costs and cutting CO_2 emissions.

Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power integrated circuits. Its proprietary GaNFast power ICs monolithically integrate GaN power FETs and GaN drive plus control and protection circuits in a single SMT package. Since GaN is reckoned to run up to 20x faster than silicon, GaNFast power ICs are said to deliver up to 3x faster charging or 3x more power in half the size and weight.

The new Design Center in Hangzhou, China hosts a team of power system designers with capabilities across electrical, thermal and mechanical design, software development, and complete simulation and prototyping capabilities. Data-center power customers will be supported worldwide by the new team, from concept to prototype, through to full qualification and mass production.

The Design Center will develop schematics, layouts and firmware for full-function, productizable data-center power supplies. Solutions for the highest power density and highest efficiency will bring GaN into mainstream data centers, Navitas reckons. Additionally, multiple partnerships will be created for magnetics, thermal substrates, and other materials to assist customers in optimizing their power supply designs.

Navitas estimates that an upgrade from legacy silicon to new GaN could deliver energy savings up to 40%, and save $1.9bn/year in data-center electricity costs worldwide. Data-center supplies are rated to meet tough efficiency criteria, with the extreme 'Titanium' grade demanding 96% efficiency at 50% load. These new benchmarks are not only enabled by GaN but also demanded by legislation such as the European Union's 'Directive 2009/125/EC, 2019 Annex', which states that new data-center power supplies must meet 'Titanium' level efficiency from 1 January 2023.



"The Navitas Data Center team has the new technical skills of GaN power ICs plus the experience of real power supply design and qualification," says Charles Zha, VP & general manager of Navitas China. "The first proof point is a 1.2kW 'Titanium plus' design that not only exceeds the highest efficiency standards for data-center power supplies but is also value-engineered to be lower cost than legacy silicon designs. After this, it's on to 2.2kW and 3kW platforms."

The 1.2kW design was developed in collaboration with Boco and FRD of Hangzhou, and the power supply is now under evaluation for mass production in 2022. "GaNFast power ICs are easy-to-use, digital-in, power-out building blocks that have accelerated time-to-prototype and first-time-right designs," comments Boco's CEO Golden Yin. "GaNFast power ICs are essential to achieving Titanium Plus efficiency, a critical milestone for next-generation data-center power supplies," says Ray Gu, general manager of FRD's Power Supply business unit. "This will help FRD strengthen its product portfolio and provide comprehensive solutions to enterprise customers," he adds.

"As data and communications continue their exponential growth, it is critical for data centers to upgrade to GaNFast power ICs to reduce costs, maximize energy savings and reduce CO_2 emissions," says Navitas' co-founder & CEO Gene Sheridan. "As a critical expansion market, we recruited ahead of our recent IPO funding, and that faith in our data-center design team is already paying dividends. By working in collaboration with data-center engineers around the world, we can accelerate adoption of GaN-based data centers and make a significant impact on energy savings, electricity costs and CO_2 emissions."

Making a GaN power IC has up to a 10x lower CO_2 footprint than for a silicon chip, it is reckoned. Considering use-case efficiency, material size and weight benefits, then each GaN power IC shipped can save 4kg of CO_2, the firm adds. GaN is expected to address a 2.6Gton/year reduction in CO_2 emissions by 2050.

www.navitassemi.com

Navitas GaN ICs upgraded from 650V to 700V for continuous operation

800V rating for transient conditions accommodates inconsistent power grids with voltage spikes

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland says that its GaNFast power ICs with GaNSense technology have been upgraded to increase efficiency, power density and access additional fast-charger markets.

GaN runs up to 20x faster than silicon and enables up to 3x more power, 40% energy savings and 3x faster charging in half the size and weight, says Navitas. GaNFast power ICs integrate GaN power and drive plus protection and control to deliver simple, small, fast and efficient performance. More than 30 million GaNFast power ICs have been shipped with zero reported field failures.

The 'voltage rating' of NV613x and NV615x GaNFast power ICs with GaNSense has been upgraded f rom 650V to 700V for continuous operation, and is rated at 800V for transient conditions. Increased voltage rating enables more efficient power transformer circuit designs, and higher capabilities for areas of the world with unreliable, widely varying power grids with extreme voltage spikes, says the firm. Autonomous system-level monitoring and reaction ensures 'detect and protect' within 30ns — 10x faster than for discrete implementations.

"GaNFast power ICs already deliver the highest reliability and highest performance in the mobile fast-charger market," claims co-founder & chief operating officer/chief technology officer Dan Kinzer. "Navitas' engineering, quality and applications teams continue to deliver leading-edge, next-generation technology with a proven, data-driven approach that enables customers to innovate aggressively in power conversion and fast-charger design — and to access expanded markets in more areas of our world," he adds.

Updated datasheets and reliability reports are available immediately to customers and design partners under non-disclosure agreement (NDA).

www.navitassemi.com

Powerland partners with Navitas on thinnest, lightest 50W GaNFast charger

GaN ICs powering OPPO's Reno7 Pro 'League of Legends' limited-edition 50W 'cookie' fast charger

Navitas says that its GaNFast gallium nitride ICs are powering OPPO's new 50W ultra-thin and ultra-fast 'League of Legions' limited-edition fast charger. This 'collectable' version of OPPO's 'cookie' charger has a thin and light body and a 'lanyard' charging cable.

The OPPO cookie charger uses two 2MHz-rated NV6115 GaNFast ICs in an active-clamp flyback (ACF) architecture with zero-voltage and zero-current switching for the highest efficiency. The low-profile form-factor is achieved using a high-frequency planar transformer. At only 82mm x 39mm x 10.5mm (33cc) in size and weighing just 55g, the OPPO cookie is claimed to be the thinnest, lightest 50W fast-charger.

"GaN is now once again integrated into this charger that has attracted much attention from mobile game fans. This charger brings consumers a light and fast charging experience," says OPPO's chief charging technology scientist Jeff Zhang.

The 'cookie' charger was designed by Powerland Technology.

"Powerland has always insisted on integrating excellent innovative technology like GaNFast power ICs with rich product-development experience, design and production," says the firm's co-founder Dr Qiu Yang. "The 50W 'cookie' charger is the crystallization of our continuous innovation. We look forward to continuing our cooperation with OPPO and Navitas Semiconductor," he adds.

"Our joint goal is to continue to explore gallium nitride's charging potential, to create smaller, lighter, greener and more convenient charging," states Charles (Yingjie) Zha, VP & general manager of Navitas China.

www.navitassemi.com

Xiaomi's new ultrafast-charging Note 11 Pro+ smartphone powered by Navitas

Generation 3 GaN power ICs selected to support new ultrafast mobile charging category

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland says that its GaNFast power ICs with GaNSense technology are being used to ultrafast-charge Xiaomi's new Note 11 Pro+ flagship smartphone. The worldwide launch of Navitas' GaNSense technology was held on 14 November, at the China Power Supply Society's (CPSS) Conference in Shanghai.

Xiaomi's power management and graphene Li-ion battery technology allows ultrafast-charging, with a powerful 120W capability to charge the 4500mAhr battery from 0–100% in only 17 minutes. GaNSense technology delivers what is claimed to be the smallest, most efficient, most portable 120W charger to enable this performance.

Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power integrated circuits. Its proprietary GaNFast power ICs monolithically integrate GaN power field-effect transistors (FETs) and GaN drive plus control and protection circuits in a single SMT package. Since GaN is reckoned to run up to 20x faster than silicon, GaNFast power ICs are said to deliver up to 3x faster charging or 3x more power in half the size and weight, and with up to 40% energy savings compared with silicon chips.

New GaNSense technology delivers another 10% energy saving plus autonomous system-parameter sensing and high-speed protection features for maximum reliability. This enables the GaN power IC to detect and protect in less than 30ns.

The Xiaomi 120W measures only 55mm x 55mm x 28.4mm (86cc), weighs just 138g and achieves what is claimed to be an industry-leading power density of 1.4W/cc. Two NV6134 GaNFast power ICs with GaNSense technology are used in the 120W charger: one in the front-end boost power-factor correction (PFC) section, and the other in the downstream high-frequency quasi-resonant (HFQR) DC–DC stage, utilizing a high-speed, low-profile planar transformer.

"These ultra-fast chargers require double the GaN content per charger, which of course doubles the revenue opportunity for Navitas," notes Charles Zha, VP & general manager of Navitas China. "By our estimates, we project this ultra-fast charger category will represent up to half of the GaN potential in mobile chargers over the next few years."

www.cpss.org.cn
www.navitassemi.com

Navitas' co-founder presenting at Jefferies' 'Net Zero' ESG Expert Call series

CTO highlights GaN ICs for powering EVs, solar, data centers and saving up to 2.6Gtons/year of CO_2 emissions

On 20 January gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland is participating in a Jefferies Financial Group's 'Net Zero' ESG Expert Call.

Navitas co-founder & chief operating officer/chief technology officer Dan Kinzer will highlight how GaN technologies will drive advances in electric vehicles (EVs), industrial applications and renewable energy that are essential to achieving carbon neutrality goals. Kinzer's presentation is open to Jefferies' clients and will take place at 3pm eastern time.

"At a macro level, GaN is expected to address CO_2 emissions of 2.6Gtons/year by 2050 as we work to 'Electrify Our World' and meet the challenge of the Paris Accord," says Kinzer. "Even at a micro level, due to small size and integrated functions, a GaN power IC has up to a 10x smaller carbon footprint in manufacturing than a legacy power silicon chip Add that to GaN's 'in-use' contribution to smaller, lighter, more efficient end-applications then, for every IC shipped, GaN saves 4kg CO_2 compared to silicon."

Kinzer's pioneering 40-year career led to him being inducted into the International Symposium on Power Semiconductor Devices and ICs (ISPSD) inaugural Hall of Fame in 2018. His experience includes developing advanced power device and IC platforms, wide-bandgap GaN and SiC device design, IC and power device fabrication processes, advanced IC design, semiconductor package development and assembly processes, plus the design of electronic systems. Kinzer holds over 130 US patents, and a BSE degree in Engineering Physics from Princeton University.

www.jefferies.com/ESG/ESG/esg/2796

Imec demos monolithic integration of Schottky diodes and depletion-mode HEMTs with 200V GaN IC

GaN-IC platform available for MPW prototyping as imec seeks foundries, design houses and end-users

At the 2021 IEEE International Electron Devices Meeting (IEDM 2021) in San Francisco, CA, USA (11–15 December), nanoelectronics research center imec of Leuven, Belgium is presenting the co-integration of high-performance Schottky barrier diodes and depletion-mode high-electron-mobility transistors (HEMTs) on a p-GaN HEMT-based 200V GaN-on-SOI (silicon-on-insulator) smart power integrated circuit (IC) platform developed on 200mm substrates. The addition of these components enables the design of chips with extended functionality and increased performance that takes monolithically integrated GaN power ICs one step further, says imec. The achievement paves the way towards smaller and more efficient DC/DC convertors and point-of-load convertors.

GaN power electronics are still dominated by discrete components driven by an external driver IC that generates the switching signals. However, to take full advantage of the fast switching speed that GaN offers, monolithic integration of power devices and driver functions is recommended. Imec has already demonstrated the monolithic co-integration of a half-bridge and drivers together with control and protection circuits that are key to an integrated all-GaN power IC in one chip.

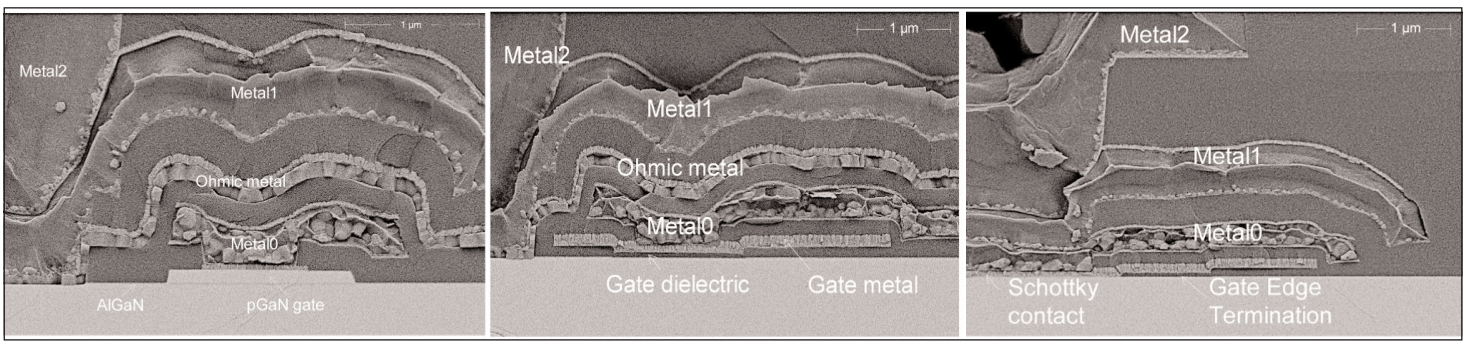
One of the main hurdles to boost the full performance of GaN power ICs remains finding a suitable solution for the lack of p-channel devices in GaN with acceptable performance. CMOS technology uses complementary and more symmetrical pairs of p- and n-type field-effect transistors (FETs), based on the mobilities of holes and electrons for both types of FETs. However, in GaN, the mobility of holes is about 60 times worse than that of electrons. That means that a p-channel device, where holes are the principal carriers, would be 60 times larger than the n-channel counterpart and highly inefficient. A widespread alternative is replacing the P-MOS by a resistor. Resistor-transistor logic (RTL) has been employed for GaN ICs but shows trade-offs between switching time and power consumption.

"We have improved the performance of GaN ICs by using a combination of enhancement-mode and depletion-mode switches (e-mode and d-mode HEMTs)," says Stefaan Decoutere, program director GaN power systems at imec. "By extending our functional e-mode HEMT platform on SOI with co-integrated d-mode HEMTs, we can now take the step from RTL to direct-coupled FET logic which is expected to improve the speed and reduce the power dissipation of the circuits," he adds.

Another important component for co-integration on GaN power ICs is a Schottky barrier diode. Compared with their silicon counterparts, GaN Schottky diodes combine higher blocking voltages with reduced switching losses.

"We have successfully extended our 200V GaN-on-SOI e-mode HEMT GaN ICs platform with monolithically integrated high-performance Schottky barrier diodes and d-mode HEMTs, which brings us a step closer to smart power ICs based on GaN," says Decoutere. "This GaN-IC platform is available for prototyping through our multi-project wafer (MPW) service," he adds. "Our platform is ready for transfer to partners. We're looking for foundries, but also design houses and end-users. The next step will be to develop and release a 650V version of the platform. Target applications for GaN-on-SOI technology include high-voltage power switching and power conversion, fast chargers for mobile phones, tablets and laptops, and on-board chargers for electric cars, and invertors for solar panel connections to the grid".

www.imec.be



Process cross sections of the high-voltage components fabricated on 200mm GaN-on SOI substrates: (a) e-mode pGaN-HEMT, (b) d-mode MIS-HEMT, (c) Schottky barrier diode. All devices include metal field plates based on front-end and interconnect metal layers and separated by dielectric layers.

VisIC and hofer powertrain develop 3-Level 800V GaN inverter in EVs

Gallium nitride extended from 400V to 800V batteries

VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride (GaN) transistors — has partnered with automotive powertrain technology company hofer powertrain of Nürtingen, Germany to work jointly on a GaN-based inverter for 800V automotive applications.

"Our partnership with hofer powertrain for the development of GaN-based power inverters in electric vehicles is the breakthrough of gallium nitride technology for 800V battery systems in the automotive industry," says VisIC's CEO Tamara Baksht. "VisIC's D3GaN technology was developed for the high-reliability standards of the automotive industry and offers the lowest losses per $R_{DS(on)}$," she claims. "It also simplifies the system solution and enables highly efficient and affordable powertrain platforms solutions. The ability to support cars with a 800V battery, along with the 400V battery, is a significant step forward in GaN's worldwide adoption by automotive electrical drivelines."

hofer powertrain has been working for more than five years on the development of 3-Level inverters for automotive powertrain applications, revealing vast benefits that

the 3-Level topology brings compared to existing state-of-the-art 2-Level inverters using silicon insulated-gate bipolar transistors (IGBTs) or silicon carbide (SiC) chips. The special properties of the 3-L topology of an inverter lead to improved overall system energy consumption at the relevant reference driving cycles, such as WLTP, due to reduced harmonic losses in the motor. Moreover, the noise vibration harshness (NVH) behavior of the complete electric drive unit can be improved due to the better total harmonic distortion of the output current affecting noise reduction.

Finally, costs are reduced regarding electromagnetic compatibility measures to meet the increasingly strict requirements (such as Comité International Spécial des Perturbations Radioélectriques 25 class 5), due to the better common-mode behavior of the hofer powertrain 3-Level inverter.

GaN is the key to efficiency improvements and increasing the driving range of electric vehicles, notes VisIC. The technology offers significantly better switching speed and smaller and lighter package size, reducing total system cost.

Today's GaN chips are used for 400V DC-link voltage and hofer powertrain 3-Level topology and, coupled with VisIC's GaN benefits, will yield the next level of improvement in 800V powertrains. The synergy of both parties can be used for 3-Level topologies.

"Both technologies in combination allow us to apply the benefits of GaN and the benefits of the 3-L topology, and thereby multiply the benefits for our customers," says Philipp Matt, Electronics expert at hofer powertrain.

www.visic-tech.com

GaN Systems releases GeN2 Class-D audio amplifier and companion SMPS reference design

Second-generation reference design optimized for sound quality, thermal performance, size and cost

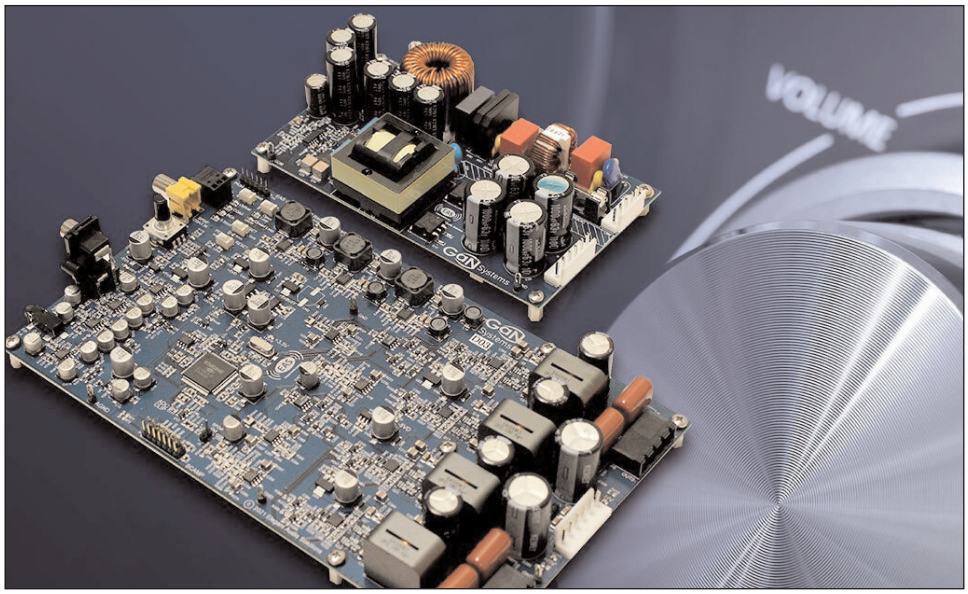
As gallium nitride (GaN) is being embraced in audio (enabling companies to launch better sounding, higher-performance, smaller and more eye-catching audio systems), GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of GaN-based power switching semiconductors for power conversion and control applications) says that it is making it easier to reap the benefits of GaN with the introduction of the GeN2 amplifier and companion switched-mode power supply (SMPS) reference design.

The solution is optimized for sound quality, thermal performance, size and cost. The evaluation kit includes a 2-channel, 200W per channel (8Ω) Class-D audio amplifier with 96% efficiency and companion 400W continuous, 550W peak power audio-grade SMPS. It enables audio design engineers to create premium audio products more quickly, reducing time to market and at affordable prices, says the firm.

The GeN2 reference design features a 20% overall size reduction in the power supply. It has a higher level of protection into lower impedance loads to the amplifier and provides better thermal management, resulting in 10°C temperature reduction. In addition to these improvements, GeN2 also lowers bill-of-materials (BoM) cost.

As entertainment, music, and information have become a more significant part of all aspects of our lives, and with audio consumption at an all-time high, high-quality audio is now a 'must-have' across all audio segments, says GaN Systems. Class-D audio systems with GaN technology provide better sound quality and are smaller and lighter, the firm adds.

The GeN2 reference design allows design engineers to develop a heatsink-less, self-powered (from AC line input) design with no external DC supplies required and smaller-size boards due to a high level of controller and DSP integration.



The reference design offers high efficiency across a wide load range using GaN transistors and advanced control techniques. Designers can quickly scale to a higher power with magnetics and GaN transistor selection.

Additionally, the solution highlights an easy plug-and-play design with features such as multi-audio signal inputs, bridge-tied load (BTL) output, and open-loop/closed-loop toggling.

Audio innovation with GaN Systems

Since announcing its best-performance Class-D amplifier and companion SMPS kit in May 2020, GaN Systems' transistors have been implemented in several high-performance audio solutions, including the Syng Alpha Cell speaker (which was named one of TIME's '100 Best Inventions of 2021') and in Orchard Audio's Starkrimson Stereo Ultra amplifier and all-in-one Starkrimson Streamer Ultra.

- In the Syng Cell Alpha, GaN Systems' transistors are designed into the power supply, which can deliver peak transients of nearly 750W. The Cell Alpha power supply fits in any space, creates minimal heat, and supplies the system's continuous and transient power requirements.
- The Streamer Ultra system delivers commanding sound quality and performance in a discreet package, performing the same functions that once required a rack full of components. GaN Systems is helping the company to achieve: 5–10x better THD+N; 20dB better noise floor (system level) 4–5x better frequency response; and a 4x reduction in power loss.

GaN Systems says that its power transistors are key components of next-generation audio products. While 2021 marked a year where GaN was embraced in the industry, 2022 is anticipated to be even better. The firm predicts exponential growth of GaN in the Class-D audio market, and 2022 will mark a year when the biggest audio names will launch GaN audio products, it adds.

www.gansystems.com/evaluation-boards/gs-evb-aud-bundle2-gs

Winners announced for GaN Systems Cup 2021 China Power Supply Society design competition

China's power electronics engineering students recognized

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) has announced the winners of the 'GaN Systems Cup' China Power Supply Society (CPSS) design competition.

Now in its seventh year, this annual competition challenges engineering students from China's leading universities to design power electronics systems that are more efficient, use less energy, and fewer or smaller materials using GaN power transistors. Unveiled during the on-site finals and CPSS awards ceremony hosted at Chongqing University on 12 November, 11 engineering teams were honored for their GaN-based designs.

The competition "highlights the ingenuity and resourcefulness of engineering students in tackling ambitious power system designs using GaN," says Paul Wiener, GaN Systems' VP of strategic marketing. "It highlights the future game-changers that will be solving critical power systems challenges as industries shift towards greener policies."

The 'GaN Systems Cup' CPSS design competition is the highest-level college student competition in China's power electronics field. The design challenge for 2021 was to develop a high-efficiency, high-power-density wide-output power supply design using GaN Systems' GS-065-011-1-L transistors. Solutions had to meet several rigorous technical requirements.

Forty-one teams from 36 universities across the country enrolled in this year's competition. Out of 30 teams that entered the preliminary round, 11 engineering teams received recognition. A Nanjing University of Science and Technology team was awarded the grand prize. Two teams from Xihua University and Chongqing University won First Prize, three teams from PLA Naval University of Engineering, Nanjing University of Aeronautics & Astronautics team, Shanghai University won Second Prize. Five teams from Beijing Jiaotong University, Xi'an Jiaotong University, Yanshan University, Heilongjiang University of Science and Technology, and Southeast University won the Third Prize awards.

The final teams' presentations showed a high level of design and innovation to create their solutions, says GaN Systems. Each winner met the rigorous design requirements for performance indicators, output voltage stability, harmonics, input current ripple, and more.

The 2021 'GaN Systems Cup' was organized by Chongqing University and sponsored by GaN Systems, CPSS, the organization's Science Popularization Working Committee, and Ningbo Xici Electronic Technology Co Ltd. Itech Electronics Co Ltd is the supplier of the test equipment.

www.cpss.org.cn
www.gansystems.com

GaN Systems and partners tackle Net Zero Challenge

Cleantech investors join EV leaders in $150m growth funding

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) says that its growing ecosystem of partners is collaborating to address the Net Zero Challenge to neutralize emissions of carbon dioxide (CO_2) and other greenhouse gases by accelerating the global sustainability and cleantech revolution.

Efficient power generation, distribution and conversion are key factors in driving sustainability and reducing emissions. Since GaN is inherently more efficient than silicon and silicon carbide (SiC), any power conversion equipment maker designing with GaN contributes to a greener planet, says GaN Systems. The highest paybacks come from implementing GaN at the biggest sources and uses of power. Factory and industrial motors are one of the biggest users of electricity. With GaN in their motor drives, Siemens is, "now able to increase the efficiency of the drives," says Christian Neugebauer, Siemens' product manager for Micro-Drives. "With GaN, Siemens can switch to a higher frequency, thereby enabling a faster motor response time compared with high-voltage drive systems."

And, as we all use more data in our video-watching, picture-sharing, online gaming and music-streaming, GaN is implemented in more and more power supplies in the data centers, reducing power losses by 50% and increasing power densities, GaN Systems adds.

In power generation, Enphase Energy recognizes the importance of GaN for inverter design with higher efficiency and a 50% increase in power density. In addition to ensuring that the source power is clean, Enphase is also reducing consumption of scarce natural resources. Because of GaN's ability to operate power systems at higher powers and in smaller sizes, the use of copper, plastic and other materials is greatly reduced.

In consumer devices, GaN Systems' partners are also making step-function improvements in efficiency and using fewer materials in their products. Dell and Harman are taking the lead. Not only did Harman reduce the size of its chargers and use less material in its manufacturing, Harman took the extra step of using 90% recycled plastic in its products.

Investors see GaN technology as an essential weapon in the fight against climate change, says GaN Systems. Long-time investors in the firm who participated in November's $150m growth round and who are also said to be leaders in cleantech include Business Development Bank of Canada (BDC), Cycle Capital, Export Development Canada (EDC), and BMW iVentures. New investors in the round include Fidelity Management & Research Company LLC (which led the round) as well as USI, Vitesco Technologies, Dockyard Capital Management, and GoldenSand Capital.

"As a long-time investor in GaN Systems, we have always seen the potential for GaN to empower customers to deliver on the net-zero promise," says Cycle Capital's founder & managing partner Andrée-Lise Méthot. "We have been particularly impressed with the company's leadership in reliability and efficiency, which is evidenced in industry leaders choosing GaN Systems for their next-generation power needs. We will continue to support the company as it delivers on its mission and look forward to seeing a next-generation continued positive impact on sustainability from GaN's continued success," she adds.

We saw a range of investors, from strategic partners looking to deepen long-standing relationships to new investors recognizing our technology leadership and seeing the inherent sustainability benefits of GaN

"Interest in the round was strong from the beginning," notes GaN Systems' chief financial officer Chris Zegarelli. "We saw a range of investors, from strategic partners looking to deepen long-standing relationships to new investors recognizing our technology leadership and seeing the inherent sustainability benefits of GaN," he adds.

"GaN Systems' gallium nitride semiconductors represent a key enabling technology for the clean energy transition. GaN brings about important efficiency and performance gains in electric vehicles and renewable energy systems. This technology will also help to significantly reduce energy consumption in data centers and in millions of consumer electronic devices," says Zoltan Tompa, managing director of BDC Capital's Cleantech Practice. "As a long-time investor in GaN Systems, BDC Capital is pleased to increase its support for this high-impact Canadian clean technology company," he adds.

"We saw strong interest and support from strategic partners in this round," notes GaN Systems' CEO Jim Witham. "Our collaboration with Vitesco and USI will enhance our leadership in GaN for electric vehicles. Our partnership with GoldenSand Capital will enable us to drive growth in China across multiple target markets. These partnerships build on a long-standing collaboration with BMW, Toyota, Siemens and others to continue to drive momentum in GaN across our target markets," he adds. "We at GaN Systems are all looking forward to working with these great companies to proliferate GaN across automotive, consumer, enterprise and industrial markets."

www.gansystems.com

GaN Systems showcases smallest GaN fast charger at CES

Firm demonstrating products in power supply, wireless power, audio and automotive solutions

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) says that, at the Consumer Electronics Show (CES 2022) in Las Vegas (5–8 January), the following customer products were on show:

- What is reckoned to be the world's smallest fast-charging GaN charger and chargers from Dell, Philips, Harman, and others.
- One of TIME magazine's 100 Best Inventions of 2021, the Syng Alpha Cell speaker, and several high-performance audio solutions.
- Signify Philips' built-in GaN drivers for LED bulbs.
- Automotive EV on-board charger, traction inverter, DC/DC converter, power modules, and more.

GaN Systems says that it has seen acceptance beyond consumer electronics into automotive, industrial, data center and renewable energy industries. In addition to unlocking the value of smaller, lighter, more efficient and lower-cost power electronics, GaN has become a vital component for reducing companies' environmental impact, enabling them to create more energy-efficient power electronics that require fewer scarce resources and materials.

Faster charging in miniature sizes — Consumers are demanding more from their electronics, including smaller, sleeker, higher-efficiency and faster-charging devices for their laptops, smartphones and other devices. GaN delivers the fast-charging speeds in small, lightweight form factors that consumers want. GaN Systems is showing an array of 30–240W chargers from leading brands and others. On display is Greenworks' vacuum cleaner that features multiple USB charging ports. Visitors to the booth can also get a preview of the world's smallest 65W GaN fast charger.

Revolutionizing the audio experience — GaN is transforming audio, helping companies to launch better sounding, higher-performance, smaller and more eye-catching audio systems. In Class-D audio, GaN is on track to become the de-facto standard, says GaN Systems. In addition to the Syng Cell Alpha wireless speaker, acknowledged for its immersive sound and innovative design, GaN Systems is showcasing Orchard Audio's Starkrimson Stereo Ultra amplifier and all-in-one Starkrimson Streamer Ultra. The Streamer Ultra delivers sound quality and performance in a discreet package, performing the same functions that once required a rack full of components.

Powering next-generation EVs — Technical advances in electric vehicles (EVs) reduce costs and provide the increased driving range that consumers demand. GaN Systems continues to support automotive companies in their e-mobility journey by delivering lighter, smaller and significantly more efficient DC/DC converters, on-board chargers (OBC) and traction inverters. The overall increase in EV efficiency and decline in weight deliver an incremental 6% increase in driving range. GaN endorsement is accelerating across the EV platform, as shown by the recent announcements from GaN Systems with BMW, Vitesco Technologies and USI.

Imagining a world without wires — Wireless Power Transfer (WPT) technology is evolving, with innovations breaking through the barriers in spatial freedom, high power, high efficiency and high frequency, enabling a new generation of genuinely wireless 'drop and connect' applications. GaN Systems is highlighting how GaN is being embraced for wirelessly charging phones, drones, robots and various micro-mobility applications.

"The breadth of GaN-enabled products we're showing at CES clearly demonstrates how much the consumer electronics and automotive industries have embraced our GaN transistors," comments CEO Jim Witham.

www.ces.tech
www.gansystems.com

Transphorm raises $12.9m from MCM Investment

Over $45m equity investment raised in the past two months

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 applications —has secured non-brokered equity financing of $12.9m through a private placement of 1,673,152 shares of its common stock at a price of $7.71 per share to MCM Investment Partners, the investment arm affiliated with MCM Partners and US institutional investor Boardman Bay Capital Management. In connection with the financing, Transphorm issued warrants to purchase an aggregate of 348,649 shares of common stock at an exercise price of $9.25 per share. As result of this financing, Transphorm has now secured $45.9m of equity financings in the past two months. The firm says that it continues to pursue its previously announced plans to uplist shares of its common stock on Nasdaq.

"The GaN power market is growing at a rapid pace, and Transphorm is strongly positioned to address this multi-billion-dollar market with its proprietary core GaN design and manufacturing technology backed by over 1000 worldwide patents," comments MCM Partners' CEO Adrian Valenzula.

"We are happy to increase the size of our investment and ownership in Transphorm," states Will Graves, chief investment officer at Boardman Bay Capital. "The company continues to do an outstanding job developing its patented high-voltage GaN technology as well as accelerating its revenue ramp. We remain very optimistic about GaN power conversion market growth, increased institutional investor awareness of GaN and Transphorm, and the prospects for the company."

Transphorm says that its patented GaN platform differs from competing solutions in ways that are crucial to power conversion application performance requirements — from 45W fast chargers/power adapters, 1.5-4kW gaming, data-center server, crypto-mining and industrial power supplies to renewable energy to higher-power automotive converter and inverter applications. The firm adds that it is one of the few high-voltage GaN manufacturers that is vertically integrated, controlling its GaN FET design(s) through innovation, epitaxial wafers (starting material), and manufacturing process.

Transphorm co-founder & CTO Umesh Mishra awarded IEEE Jun-ichi Nishizawa Medal

Transphorm says that its co-founder & chief technology officer Umesh Mishra Ph.D. was awarded the IEEE Jun-ichi Nishizawa Medal. The honor is given to individuals who have demonstrated outstanding contributions to material and device science and technology, including practical application. Mishra was recognized for his contributions to the development of GaN-based electronics. This is the second IEEE award received by him, the first being the IEEE David Sarnoff Award for the development of GaN electronics.

In 1996, Mishra co-founded Nitres Inc, the first start-up company to develop GaN LEDs and RF transistors. Nitres was acquired by Cree (now Wolfspeed) in 2000. He continued researching and developing GaN-based solutions, expanding focus to high-voltage power conversion applications and, in 2007, co-founded Transphorm. Throughout his business career, Mishra has also served in the academic field as a Distinguished Professor in the Department of Electrical and Computer Engineering (ECE) at the University of California, Santa Barbara (UCSB), where he has been a director of several GaN research centers.

Umesh Mishra.

With Mishra as CTO, engineering achievements at Transphorm include being the first to offer JEDEC and AEC-Q101 (automotive)-qualified devices; owning the largest IP portfolio with more than 1000 patents and applications covering core areas of the GaN process end-to-end; and offering the broadest device portfolio across the power spectrum (45W to 10+kW), it is claimed.

Transphorm's innovations also extend to GaN in the RF space. Based on Mishra's work with his UCSB R&D team, the firm is currently developing nitrogen polar (N-polar) GaN epitaxial wafers. N-polar GaN holds significant promise for the continued advancement of GaN-based electronics, particularly RF/mm-wave applications, says Transphorm.

All this led to Transphorm going public in 2020 (the first pure-play GaN manufacturer to do so). The firm has grown product revenue sequentially for seven consecutive quarters, and targets 200% annual product revenue growth through 2023.

www.transphormusa.com

Transphorm ships over 1 million GaN devices for fast chargers and power adapters in December

Over 3x increase in units shipped in second-half 2021 over first-half

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 applications — says that it shipped more than 1 million SuperGaN Gen IV FETs in December.

The firm says that the milestone confirms its previously stated ability to meet high-volume capacity of qualified packaged devices and its growing market share. It also marks a more than 3x increase in units shipped in second-half 2021 over first-half 2021. Highlighting the continued expansion of Transphorm's ecosystem, the shipped FETs are for use in 45–300W power adapter and fast-charger applications manufactured by new and existing customers in the Asia-Pacific (APAC).

Transphorm's SuperGaN product family for compact power conversion applications currently includes three 650V devices: 480mΩ FETs, 300mΩ FETs and 150mΩ FETs. These are offered in standard PQFN 5x6 and 8x8 packages and meet JEDEC qualification standards at 150°C.

Compared with alternative GaN semiconductors (i.e. e-mode and IC GaN), advantages of the SuperGaN devices are said to include:

- *Superior performance in a smaller die size*:

Data shows that the SuperGaN platform delivers higher efficiency versus lower on-resistance devices.

- *Ease of designability and drivability*:

The SuperGaN platform's patented architecture includes an integrated silicon FET with a universal interface and does not require excessive amounts of peripheral circuitry. This interface allows for the use of popular, off-the-shelf controllers with integrated drivers; a requirement for high-efficiency power adapter topologies such as the QRF (quasi-resonant flyback) and ACF (active clamp flyback).

- *Best-in-class quality & reliability*:

Based on over 30 billion hours of operation, Transphorm devices in the field yield a FIT (failure-in-time) rate of <0.3; meaning less than 0.3 failures statistically over 1 billion operating field hours.

"We're thrilled to have partnered with our suppliers and customers to hit our targeted volume manufacturing goal of 1 million units per month. It demonstrates our rising market share in the rapidly growing fast-charger and power adapter segment as well as our ability to reproduce high-performance, high-reliability GaN devices at scale," says president & co-founder Primit Parikh. "Transphorm's traction in both lower-power and multi-kilowatt high-power applications underscores the leadership of our technology," he reckons. "This, combined with recent capital raises of more than $45m last quarter, supports strong, positive momentum for our continued expansion and growth in 2022."

Transphorm says that the technical advantages of its product portfolio — which currently includes 650V and 900V devices in various packages — are largely driven by the firm's vertical integration. Uncommon in the GaN industry, this operation model allows Transphorm to control its devices' design, epitaxial wafer, and manufacturing process. As a result, the firm now claims that it supports the largest range of power conversion requirements (45W to 10+kW) across the widest range of power applications (power adapters, data-center and gaming PSUs, crypto-mining rigs, automotive converters, inverters for renewables and others).

www.transphormusa.com

UTEP receives $917,000 US Air Force grant to develop gallium oxide materials

University of Texas at El Paso collaborating with Carnegie Mellon

The Center for Advanced Materials Research at The University of Texas at El Paso (UTEP) has received a $917,000 grant from the US Air Force Office of Scientific Research (AFOSR) to continue developing and improving advanced materials for national defense, power electronics and security interests.

"This grant will allow UTEP students to perform cutting-edge research in an area that is critical to the Department of Defense and, most importantly, with the Air Force," says principal investigator for the grant Ramana Chintalapalle Ph.D., director of the Center for Advanced Materials Research and a professor of mechanical engineering at UTEP. "This project will also provide ample opportunities for our students to find pathways to careers that have a direct impact on our national security."

The work will focus on the design and development of advanced materials based on gallium oxide and its alloys. Ultra-wide-bandgap semiconductor materials such as gallium oxide can operate at higher voltages, frequencies and temperatures than traditional semiconductors such as silicon. Because of these properties, gallium oxide has attracted the attention of the scientific and engineering research community for its potential to allow the design and development of devices that can operate in extreme conditions.

The increased interest in gallium oxide and other ultra-wide-bandgap oxides is also attributed to the tunable properties exhibited by this class of materials, which are vital for a range of applications for US defense and national security interests. These applications include energy storage and conversion, and the production of high-efficiency power electronic devices such as those in aircraft electronics, radar systems and electric vehicles.

"We are developing materials that will be lighter and stronger," says Chintalapalle. "Not just stronger from a mechanical standpoint, but they will be strong enough for unseen radiation, unseen weather conditions and unseen extreme high temperatures and pressures," he adds.

The Center for Advanced Materials Research team is collaborating with researchers from Carnegie Mellon University (CMU) on this project.

In addition to the AFOSR grant, the project will leverage contributions from within UTEP and the national laboratories for student opportunities in R&D activities. Students in this project should develop technical and professional skills relevant to the semiconductor industry. Some of them will also spend a summer and/or a full semester at CMU to perform research using advanced facilities in the Bertucci Nanotechnology Laboratory. This will also provide opportunities for cross-fertilization of ideas, student mentoring and interdisciplinary training.

www.utep.edu/orsp/major-research-centers

EPC Space provides demo boards for evaluating rad-hard GaN power devices

Demonstration boards reduce time-to-market in high-reliability and aerospace applications

EPC Space LLC of Haverhill, MA, USA has announced the availability of a family of demonstration boards to help designers quickly and easily implement radiation-hardened (RH) gallium nitride (GaN) power devices into their high-reliability and aerospace applications.

The new family of demonstration boards offers fast prototyping and evaluation of the features and capabilities of EPC Space's rad-hard eGaN power devices. The offering includes the following:

(1) a trio of low-side driver demo boards (EPC7C001, EPC7C002, EPC7C003), which utilize EPC Space's eGaN gate driver modules to drive a corresponding 40V, 100V or 200V discrete eGaN FET;

(2) the EPC7C005 demo board, which allows evaluation of the switching operation and conversion efficiency performance of the FBS-GAM02-P-C50 rad-hard power module connected as a half-bridge point-of-load (POL) output stage; and

(3) the EPC7C006 demo board, which is a three-phase motor demonstration board that utilizes the FBS-GAM02-P-R50 module.

"Radiation-hardened eGaN FETs and ICs offer designers improved performance, lower cost and shorter delivery times compared to RH silicon-based devices," says CEO Bel Lazar. "We are happy to provide an easy-to-use evaluation platform to assist designers looking to convert their RH silicon designs to take advantage of the higher power densities, higher efficiencies, and better cost and delivery that GaN offers."

Five-unit pricing starts at $850/each with lead times of six-weeks.

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Innoscience inaugurates ASML lithography scanner

Process window, line yield, productivity and cost efficiency enhanced in 8" GaN-on-silicon mass production

As an integrated device manufacturer (IDM) manufacturing 8-inch gallium nitride on silicon (GaN-on-Si) wafers for power switching applications, Innoscience Technology (Zhuhai) Co Ltd recently held a ceremony to celebrate the inauguration of a lithography scanner made by ASML of Veldhoven, The Netherlands. Due to the imaging performance and unique dual-stage TWINSCAN architecture of ASML's scanner, the productivity and line yield of Innoscience's GaN-on-Si power devices has been improved, reckons the firm. During the ceremony, ASML VP & China Country general manager Shen Bo (on behalf of ASML) was presented with the 'Best Strategic Partner' award by Innoscience.

In recent years, the global semiconductor industry has put a spotlight on 'third-generation semiconductors' such as gallium nitride (GaN) and silicon carbide (SiC), characterized by their smaller size, higher switching frequencies capabilities and higher-efficiency energy management with higher power densities than what is possible with traditional silicon material. Such new materials can fulfill global strategic needs such as energy saving, emission reduction, smart manufacturing etc, says Innoscience. GaN has broad market prospects and can penetrate a wide range of applications spanning consumers, industrials and automotive.

"We introduced ASML's lithography scanner in the second quarter of this year, which has enhanced our lithography process window, line yield, productivity and cost efficiency," says Innoscience's CEO Jay Son. "After the scanner move-in, ASML's customer service team and our engineers efficiently overcame the technical challenges through on-site verification and iteration to successfully achieve trial production within only three months, and eventually entered the formal mass-production stage in October," he adds. "By working with ASML, the world's leading supplier in the semiconductor industry, Innoscience's production process has been streamlined and accelerated to support the booming GaN semiconductor industry."

This is also the first time that ASML's lithography system has made a breakthrough into the global mass production of 8-inch GaN-on-Si power semiconductor wafers. To better support Innoscience, ASML has been upgrading the lithography scanner according to Innoscience's manufacturing requirements. The introduction of ASML lithography scanner will continue to facilitate the mass production of Innoscience's GaN-on-Si power semiconductor devices and to contribute to its long-term development.

"The booming growth of Innoscience reflects the development and long-term potential of the third-generation semiconductor industry," comments Shen Bo.

"TWINSCAN lithography is verified for the first time in the field of 8-inch GaN-on-Si power semiconductor wafers," notes Ron Kool, executive VP of ASML's DUV business line. "We are fully confident to support Innoscience's continued growth in the future."

www.asml.com
www.innoscience.com

AXT applies for IPO of subsidiary Tongmei on Shanghai's STAR Market

AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — says that its formal application to list shares of its Beijing-based Tongmei Xtal Technology Co Ltd wafer manufacturing subsidiary in an initial public offering (IPO) on the Sci-Tech innovAtion boaRd (STAR Market) has been accepted for review by the Shanghai Stock Exchange. AXT's strategic plan to access China's capital markets and progress to an IPO by Tongmei on the STAR Market was originally announced on 16 November 2020.

"This is a significant achievement and an important milestone for AXT," believes CEO Morris Young. "We founded Tongmei back in 1998. Since then, it has grown into a company that is engaged in the research, development, production and sale of InP substrates, GaAs substrates, germanium substrates, pBN [pyrolytic boron nitride] and other high-purity materials, which we believe makes it an attractive offering on the STAR Market. With success in our addressed markets, strong customer traction, and a number of new applications coming to market this year and beyond, we have significant momentum building in our business," he adds.

"If completed, the IPO will provide proceeds that will be invested in Tongmei to enable us to expand capacity to capture high-volume opportunities across our portfolio and develop new products to drive incremental growth and value from market expansion in 5G, data-center expansion, telecommunications modernization, healthcare monitoring, micro-LEDs, and more."

The process of going public on the STAR Market includes several periods of review and, therefore, is a lengthy process. Tongmei does not expect to complete the IPO until second-half 2022. The listing of Tongmei on the STAR Market will not change the status of AXT as a US public company.

www.axt.com

AXT raises Q4/2021 revenue guidance to $36–37m

AXT is increasing its fourth-quarter 2021 revenue guidance from $34–$36m (provided on 27 October) to $36–$37m, reflecting continued momentum in demand for AXT's products as well as growth in the applications that utilize its substrates. AXT will announce its results for fourth-quarter 2021 and full-year 2021 on 16 February.

"Our expected growth in what is typically a seasonally down quarter for AXT signifies the expanding opportunities we continue to see across our portfolio," notes Young. "Over the past several years, we have laid considerable groundwork to optimize our business to capture these opportunities, and we are pleased to see our efforts bearing fruit."

Gelest names CTO Jonathan Goff as president

Founder Barry Arkles steps down as CEO

Gelest Inc of Morrisville, PA, USA (a subsidiary of Mitsubishi Chemical Corp that manufactures silicones, organosilanes, metal-organics and specialty monomers) has named Dr Jonathan Goff as president of Gelest.

A 13-year veteran of Gelest, Goff most recently served as chief technology officer. Having focused on technology, new product development, market introductions and growing customer relationships throughout his career, Goff now leads Gelest in its core mission of providing cutting-edge chemical technology, products and services.

"Gelest has a strong technology roadmap for the years to come thanks to the entrepreneurial vision of our previous CEO," says Goff. "We are well positioned for strong growth and, with the support of Mitsubishi Chemical Corporation, we will continue to drive through new frontiers of technology and innovation."

Jonathan Goff.

Goff holds a Ph.D. in Macromolecular Science and Engineering from Virginia Tech and has over 60 patents and technical publications.

After many years of leadership, Gelest founder Dr Barry Arkles has officially stepped down as CEO, effective 31 December 2021. Arkles formed Gelest in 1991 to develop and manufacture silicon and metal-organic-based chemicals. He has accepted the position of Distinguished Adjunct Professor at Temple University.

Arkles says of Goff: "His strong grasp of the technology and markets and a leadership style that is at once inclusive and directional gives all stakeholders assurance that the strong growth and innovation that characterizes Gelest will continue."

www.gelest.com

Veeco secures new $150m credit facility

Enhanced liquidity and financial flexibility for corporate objectives

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has entered into a senior secured revolving credit facility that enables it to borrow up to $150m over a five-year term that expires in December 2026.

"We are pleased to secure a $150m facility at attractive interest rates," comments chief financial officer John Kiernan. "The facility provides the company with enhanced liquidity and financial flexibility to carry out our corporate objectives."

The firm has no immediate plans to draw down on the facility. Interest expense under the facility is variable based on the company's secured net leverage ratio and is expected to bear interest based on SOFR plus a range of 150–225 basis points, if drawn. There is a yearly commitment fee of 25–35 basis points, based on the firm's secured net leverage ratio, charged on the unused portion of the facility.

HSBC Bank USA N.A. is acting as administrative agent and collateral agent. HSBC Bank N.A., along with Barclays Bank PLC, Santander Bank N.A. and Citiban N.A., served as joint lead arranger and joint bookrunner on the facility with Silicon Valley Bank as an additional lender. Morrison & Foerster LLP acted as counsel to Veeco.

www.veeco.com

Riber receives European order for MBE 412 cluster system

Pilot production of antimonide-based optoelectronic sensing devices

Riber S.A. of Bezons, France — which makes molecular beam epitaxy (MBE) systems and evaporation sources and effusion cells — says that it has received a multi-million Euro order from a "large European electronics company" for a fully automatic MBE 412 cluster system (to be delivered in 2022) for the development of its antimonide-based materials business, with the objective of producing pilot optoelectronic sensing devices.

Riber's EZ-CURVE instrument will be integrated into the system for better control of the growth process and greater epiwafer production yield.

The MBE 412 system is claimed to be the most suitable 4-inch-wafer MBE research and pilot production tool on the market for III–V and advanced materials.

www.riber.com

Infinitesima launches Metron3D in-line metrology platform

Rapid probe metrology module provides process control for 3D devices

Semiconductor equipment developer Infinitesima Ltd of Abingdon, UK has launched the Metron3D, an in-line metrology platform designed for high-volume semiconductor manufacturing applications.

The Metron3D combines the well-established benefits of atomic force microscopy (AFM) with several fundamentally new inventions that increase throughput at least 100-fold, and probe lifetime 10-fold. The ability of the Metron3D to operate at such high speed while maintaining very high accuracy will permit chipmakers to benefit from process-insensitive profilometry for in-line metrology and inspection applications for the first time, says the firm.

The measurement module of the Metron3D, dubbed the RPM (for rapid probe metrology), is integrated into a platform that has been developed using existing solutions from well-established suppliers in order to ensure a reliable, fab-ready tool.

The Metron3D platform enables critical metrology and inspection capabilities that are required to advance semiconductor process control for maximizing yield and lowering wafer costs, says Infinitesima. As dimensions shrink and device architecture becomes more complex, the Metron3D offers measurement advantages in areas such as chemical-mechanical planarization (CMP) performance (both local and long range), EUV resist characterization and logic FEOL (front end of line) analysis.

With an on-board probe library containing dozens of probes and a dedicated probe loading robot and with software for probe lifetime prediction, continuous operation is guaranteed, even in large-area measurement tasks such as CMP, says the firm. An image recognition-based global alignment system, combined with a highly accurate wafer stage, ensures reliable and reproducible capture and measurement of structures of interest, it adds.

"Moore's Law is undergoing an inflection as it transitions to 3D process integration," says CEO Pete Jenkins. "Infinitesima seeks to revolutionize probe metrology with this highly innovative product to enable in-line 3D process control with Angstrom-level resolution and accuracy," he adds. "Metron3D is the first in a new line of measurement tools that will help solve the process control challenges in coming inflections such as high-NA [numerical aperture] EUV, new materials, and 3D device architecture."

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Aixtron partners in EU project YESvGaN

Vertical GaN power transistors to be deposited on 300mm silicon

Digitalization has triggered a massive increase in applications and electronic devices and thus also in the consumption of electrical energy. Intelligent and efficient power electronics are necessary to secure the power supply and environmentally friendly high energy use efficiency. The YESvGaN (Vertical GaN on Silicon: Wide Band Gap Power at Silicon Cost) research project therefore aims to develop highly efficient power transistors based on a novel process technology for large-scale industrial production.

For the development of vertical gallium nitride (GaN) power transistors with silicon as a substrate, the consortium relies on the epitaxy expertise of deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany. This is because, for this newly developed power device, the compound semiconductor material gallium nitride must grow over a large area in the form of crystalline layers on a suitable substrate such as a silicon wafer.

Combining wide-bandgap high performance and cost advantages of silicon technology

"GaN power transistors on silicon wafers provide us with the intriguing opportunity to combine about 15% higher power density in gallium nitride compared to silicon (Si) with the cost advantages of the established silicon technology. The performance is thus expected to exceed that of modern silicon carbide (SiC) MOSFETs at chip costs rivaling those of Si IGBTs," says professor Michael Heuken, VP Advanced Technologies at Aixtron.

This is made possible by the performance advantages of vertical wide-bandgap (WBG) transistors, which allow transistors made of wide-bandgap semiconductors such as gallium nitride (GaN) to be more powerful than conventional silicon semiconductors. The lower energy losses of up to 50% when switching high electrical power and the lower production costs due to the use of silicon wafers predestine GaN power transistors for use in many price-sensitive applications.

High energy efficiency and low CO_2 emissions

"Added to this is the advantage that they can significantly reduce energy consumption and CO_2 emissions," says Heuken. The YESvGaN consortium estimates the potential electricity savings by the consistent use of such YESvGaN vertical membrane GaN transistors in the EU in 2030 to be equivalent to the power output of seven nuclear power plants or ten coal-fired power plants.

Energy efficiency makes the use of these transistors attractive, particularly in the field of data centers with their high power consumption. These devices are also very beneficial as traction inverters for electric vehicles (EVs). The use of low-loss power electronics makes a valuable contribution to electro-mobility, not only by saving energy but also by extending the ranges of electric vehicles.

To further drive the market penetration of GaN-based devices, Aixtron is also testing epitaxial growth on 300mm-diameter epi-wafers as part of the YESvGaN research project; currently, MOCVD technology is primarily used for crystalline growth on 150–200mm wafers. For the deposition of GaN layers on 300mm silicon substrates, Aixtron is developing the required equipment.

YESvGaN clusters the relevant competences along the value chain in a consortium of large companies, small- and medium-sized companies and institutes from seven European countries. As well as Aixtron, partners include Bosch GmbH, Ferdinand-Braun-Institut GmbH, Leibnitz Institute for Highest Frequency Technology, Fraunhofer Institute for Integrated Systems and Device Technology IISB, Finepower GmbH, X-FAB Dresden GmbH & Co KG, X-FAB Global Services GmbH, NanoWired GmbH and Siltronic AG, Centre national de la recherche scientifique CNRS, Ion Beam Services S.A., STMicroelectronics (Tours) SAS (France), EpiGan N.V., Universiteit Gent (Belgium), EV Group, E. Thallner GmbH, Materials Center Leoben Forschung GmbH (Austria), Hexagam AB, Linkopings Universitet (Sweden), Smart Induction Converter Technologies S.L., Universitat de València (Spain), AUREL S.P.A., Consorzio nazionale interuniversitario per la nanoelettronica, Raw Power Srl (Italy).

YESvGaN is funded by the European Union (EU) and Member States (grant number 16MEE0178).

www.yesvgan.eu/en
www.aixtron.com

Aixtron partnering in EU project TRANSFORM

Aixtron is partnering in the project 'TRANSFORM – Trusted European SiC Value Chain for a greener Economy'.

Funded by the European Union (EU) and national funding authorities, the R&D project aims to create a competitive European supply chain for power electronics based on silicon carbide (SiC) technology within the next three years. To this end, the 34 most important European experts in SiC technology from seven EU countries are collaborating.

The supply chain is expected to reliably provide Europe with silicon carbide components and systems. The European value chain ranges from substrates to energy converters such as transistors or modules and, last but not least, the necessary industrial semiconductor production technology such as production-proven chemical vapor deposition (CVD) systems with high yields.

As a supplier of CVD production technology for the deposition of SiC layers for power electronics, Aixtron is taking on tasks such as the further improvement of CVD deposition technology for silicon carbide. This comprises the development of technology for the simultaneous CVD coating of multiple 200mm SiC substrates in a batch reactor as well as CVD technology for SiC substrates made using the Smart Cut process (which enables the transfer of very fine and thin layers of crystalline silicon carbide material onto a carrier substrate).

Aixtron says that high-performance industrial CVD deposition technology for silicon carbide is at the pivotal point for next-generation silicon carbide technology being jointly developed by the project partners.

The number of potential applications and the demand for SiC technology are very large and range from industrial drives and energy conversion to renewable energies and electro-mobility, the firm adds.

"With such a powerful and at the same time energy-saving SiC supply chain, we can finally holistically optimize power electronics systems and thus achieve the energy efficiency we urgently need," says professor Michael Heuken, VP Advanced Technologies at Aixtron. "TRANSFORM can make this important contribution not only to European competitiveness but also to a more sustainable and greener economy in Europe by significantly increasing energy efficiency with SiC technology."

www.cordis.europa.eu/project/id/101007237

Aixtron partners in EU doctoral program QUANTIMONY

Project consortium supports young academics in researching antimony-based materials and devices for quantum components

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that it is a partner in the new program QUANTIMONY ('Innovative Training Network in Quantum Semiconductor Technologies Exploiting Antimony').

Funded by the European Union's Horizon 2020 research and innovation program under the Marie Skodowska-Curie (grant agreement 956548-QUANTIMONY-H2020-MSCA-ITN-2020), the project is an international network for doctoral education supporting the training of young academics as well as research into quantum technologies utilizing antimony (Sb).

QUANTIMONY provides 14 junior researchers with PhD positions, spanning all scientific and engineering aspects (from modeling to material growth and characterization to industrial use), as an entry into the field of semiconductor science and technology.

QUANTIMONY is configured as a multi-site international network (spanning eight European countries, plus USA, Taiwan and Brazil). The consortium comprises 11 research teams as beneficiaries and is supported by 12 partner organizations, namely the following: Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC), Universidad Politécnica de Madrid (UPM), Lancaster University, University of Warwick, Eindhoven University of Technology (TUE), Technical University Berlin (TUB), University of Würzburg, University of Rome 'Tor Vergata', Aixtron SE, IQE plc, Nextnano GmbH, Bruker AXS, Nanoplus GmbH, Lancaster Materials Analysis Ltd (LMA), TiberLab Srl, QuantCAD LLC, Fluxim AG, Lund University, European Synchro-tron Radiation Facility (ESRF), the National Synchrotron Radiation Research Center, Cardiff University, Universidad de Cádiz (UCA), and Universidade Federal de São Carlos (UFSCar).

Focus on antimonide-based semiconductor components

The work focuses on research into semiconductor quantum components that contain the element antimony. With QUANTIMONY a contribution should be made to raise the full potential of the III–Sb compound semiconductors gallium antimonide (GaSb), indium antimonide (InSb) and aluminium antimonide (AlSb). Antimonic semiconductor components are to be used primarily in optoelectronic applications such as LEDs, lasers and detectors in the infrared spectral range as well as DRAM memories, single-photon sources and solar cells.

Via QUANTIMONY, it is intended for antimony compounds to find a path to volume production by utilizing metal-organic chemical vapor deposition (MOCVD) technology, enabling usage in computers and memories, telecommunications, automobiles, robotics and many other applications beyond those that are already served in aerospace and security.

"Quantum semiconductor technologies based on antimony are an important field of the future," says professor Michael Heuken, VP Advanced Technologies at Aixtron and head of the QUANTIMONY Exploitation and Industrial Engagement Committee. "The research work of these doctoral students within the framework of QUANTIMONY will make a decisive contribution to accelerating the necessary research and development work for this future technology," he adds. "The results will contribute to technological solutions for energy saving and solving the climate emergency."

www.quantimony.eu
www.aixtron.com

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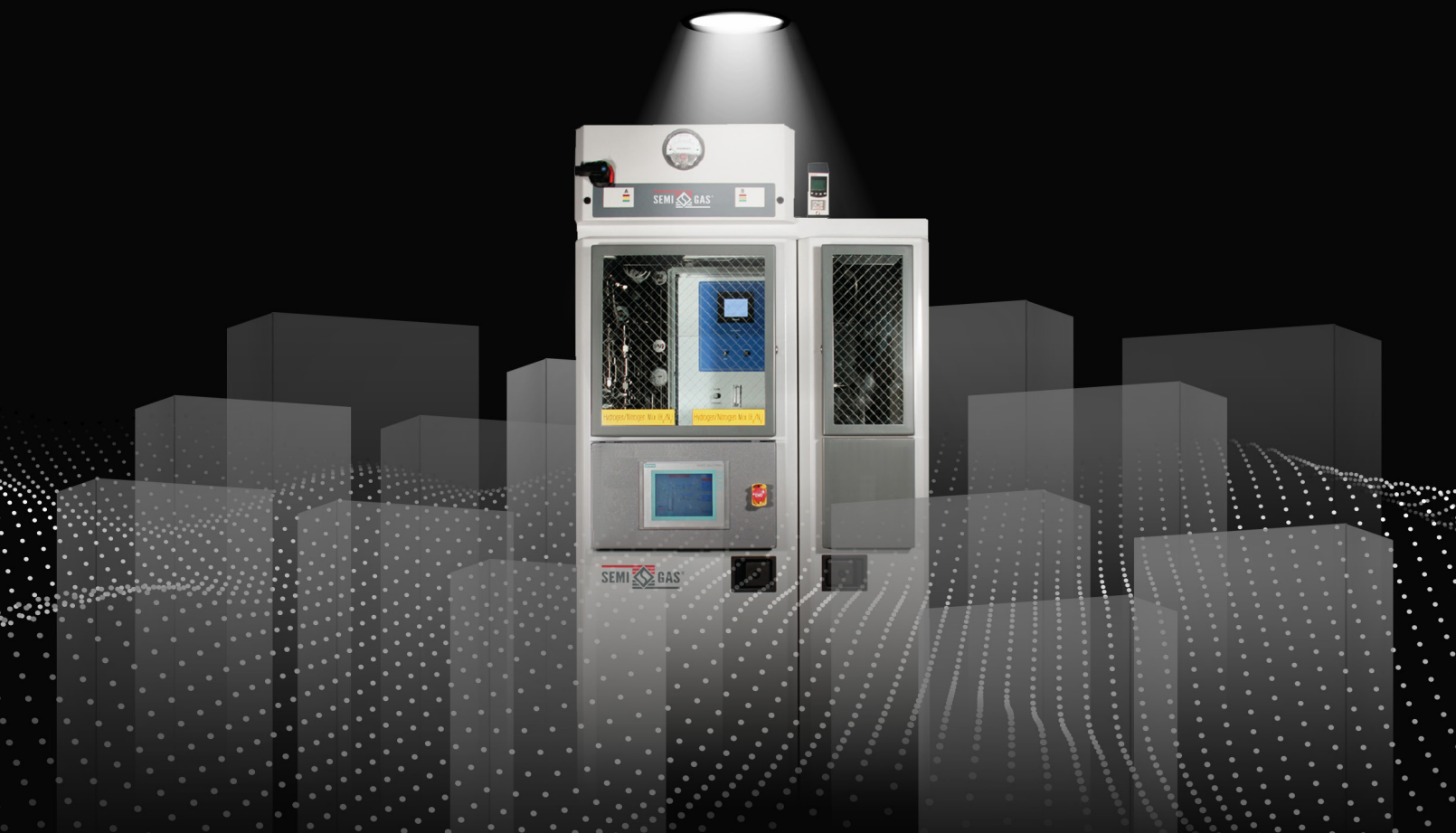

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Oxford Instruments' Atomfab ALD system production-qualified at GaN power electronics device maker

Remote-plasma atomic layer deposition delivers higher-quality Al_2O_3 films than thermal ALD

The UK's Oxford Instruments Plasma Technology, a supplier of plasma etch and deposition high-volume manufacturing (HVM) solutions, has had its remote-plasma atomic layer deposition (ALD) nitride passivation solution qualified for full production by a US-based power electronics manufacturer of gallium nitride (GaN) devices, supporting the first phase of its ramp.

GaN-based devices are now well established in the consumer market, with a wide range of rapid chargers available commercially to support mobile devices. Fast charging and a smaller footprint are among the key benefits of GaN technology and are accelerating the rapid adoption with consumers. The Atomfab ALD system delivers the wafer demand required to meet the cost of ownership of HVM GaN device makers.

"Atomfab is able to significantly reduce the cost per wafer through unique technical innovations including a patent-pending low-damage revolutionary fast remote-plasma source which delivers higher-quality Al_2O_3 films compared to thermal ALD," says Dr Aileen O'Mahony, ALD product manager, Oxford Instruments. "Combining the plasma pre-treatment and film quality benefits of plasma ALD without compromising on throughput or quality is a step change to achieve the wafer ramp and yield our customers demanded," she adds.

The firm says that Atomfab fulfils customer needs on a single-wafer platform with SEMI-standard cluster configurations and improved process controls for the latest compound semiconductor solutions. For this customer, the system was fully and seamlessly integrated into its manufacturing line and fab automation software.

"Factory automation and monitoring is of high importance in fab manufacturing lines," says Oxford Instruments' service director Dean Furlong. "Integration to these systems is equally important as the wafers themselves. These systems are built into all of Oxford Instruments production equipment," he adds. "Following industry standards allowed this customer to quickly interface its factory automation software into our system."

https://plasma.oxinst.com

Beneq unveils ALD systems for 300mm and compound semiconductor device fabrication

Prodigy provides targeted industrial form factor for compound semiconductor production

Beneq of Espoo, Finland — which produces the Transform family of atomic layer deposition (ALD) cluster tools for More-than-Moore device makers — is now broadening its portfolio with two new products: the Transform 300 and the Prodigy, each created in response to specific technology requirements in the semiconductor manufacturing sector.

The Transform 300 is claimed to be the only 300mm ALD cluster tool that combines thermal ALD (batch) and plasma ALD (single wafer) technologies to provide a highly versatile platform for IDMs and foundries. It is designed to meet the growing demand of emerging semiconductor applications at 300mm for devices such as CMOS image sensors (CIS), power devices, micro-OLED/LED, advanced packaging and other More-than-Moore (MtM) applications, which call for a high degree of versatility. The Transform 300 is hence a highly configurable platform that caters to multiple advanced thin-film applications ranging from gate dielectric including in high-aspect-ratio trenches, to anti-reflection coating, final passivation or encapsulation, chip-scale packaging and beyond.

The Prodigy is suitable for manufacturers of compound semiconductor devices including RF ICs (GaAs/GaN/InP), LEDs, vertical-cavity surface-emitting lasers (VCSELs), light detectors as well as for micro-electro-mechanical system (MEMS) manufacturers and foundries looking to enhance device performance and reliability through an affordable stand-alone ALD batch tool. The Prodigy provides what is claimed to be best-of-breed passivation and encapsulation films across multiple wafer types and sizes.

"We created Prodigy to address those market segments that need a simple solution supported by high-end technology," says Patrick Rabinzohn, VP, Semiconductor ALD. "It inherits the ALD design and processing know-how we at Beneq have developed over the last 15 years, packing advanced features in a simpler, targeted industrial form factor."

www.beneq.com

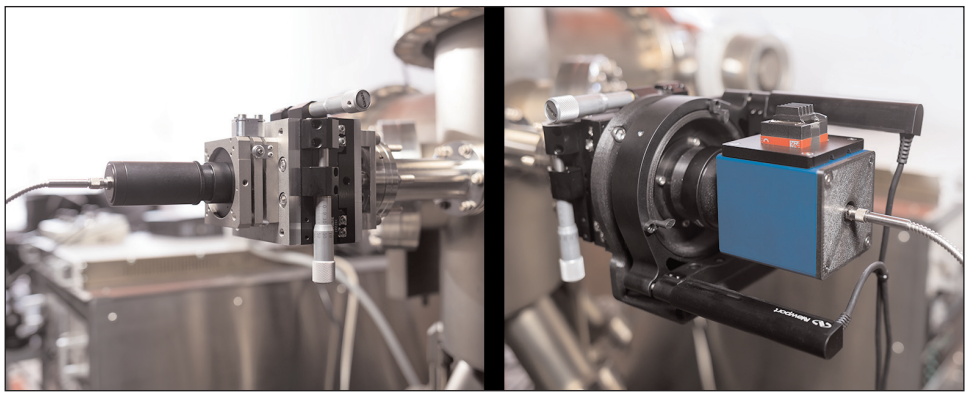
k-Space launches kSA ACE metrology instrument

Flux and growth rate measurement provides atomic control for epitaxy

k-Space Associates Inc has launched its newest thin-film metrology product, kSA ACE (Atomic Control for Epitaxy).

k-Space engineers designed the tool with input from scientists in the research and production communities to provide an accurate and high-resolution in-situ instrument that monitors the flux and growth rate of atomic species, using the principle of atomic absorption spectroscopy. The kSA ACE uses conventional hollow cathode lamps (HCLs) to generate the atomic emission for the elements of interest. The instrument utilizes two high-sensitivity, UV-optimized solid-state spectrometers — one to monitor the absorption and the other to monitor signal drift from the HCLs.

k-Space says that the kSA ACE can measure each material of interest independently and with high accuracy, providing precise control over material-specific flux in multi-source processes. The tool is suitable for applications including the fabrication of III–V and II–V compounds, semiconductor devices, thin-film sensors, solar cells, optical coatings, x-ray optics, and flat-panel displays.



"When we learned that there was a demand for a highly sensitive flux monitoring tool with long-term repeatability under continuous operation, we collaborated with the scientific community to develop the kSA ACE to provide them with the stability and resolution that they need," says CEO Darryl Barlett. "It's been a challenging product to develop, but we're very happy with the end result and are looking forward to seeing it in operation on deposition tools across the globe," he adds.

www.k-space.com

k-Space achieves record annual thin-film metrology sales

Growth of 30% due partly to robust sales of kSA MOS UltraScan

k-Space Associates Inc of Dexter, MI, USA — which produces thin-film metrology instrumentation and software for research and manufacturing of microelectronic, optoelectronic and photovoltaic devices — says that it increased its 2021 thin-film metrology sales by 30% compared with 2020, making it a record sales year. This increase was due partly to robust sales of the kSA MOS UltraScan.

The kSA MOS UltraScan ex-situ metrology tool is a high-resolution scanning system that measures wafer curvature, bow and tilt. Based on proven and patented kSA MOS technology, UltraScan uses a laser array to map the two-dimensional curvature, wafer bow and stress of reflective surfaces such as semiconductor wafers, optical mirrors, glass and lenses. This technology is also available in the kSA ThermalScan model, which includes an integrated heating chamber for thermal stress analysis of wafers.

k-Space kSA MOS UltraScan ex-situ metrology tools

"k-Space has built a reputation for designing and producing superior metrology tools that have varying applications in both research and manufacturing settings," says CEO Darryl Barlett. "And with the ability to customize any k-Space tool to fit each customer's specific requirements, our customers know that their instruments will help them accomplish their research and production goals. That's why so many of our customers come back to us when they have additional specialized metrology needs," he adds.

Nitride Semiconductor verifies inactivating effect of UVC-LEDs on coronavirus

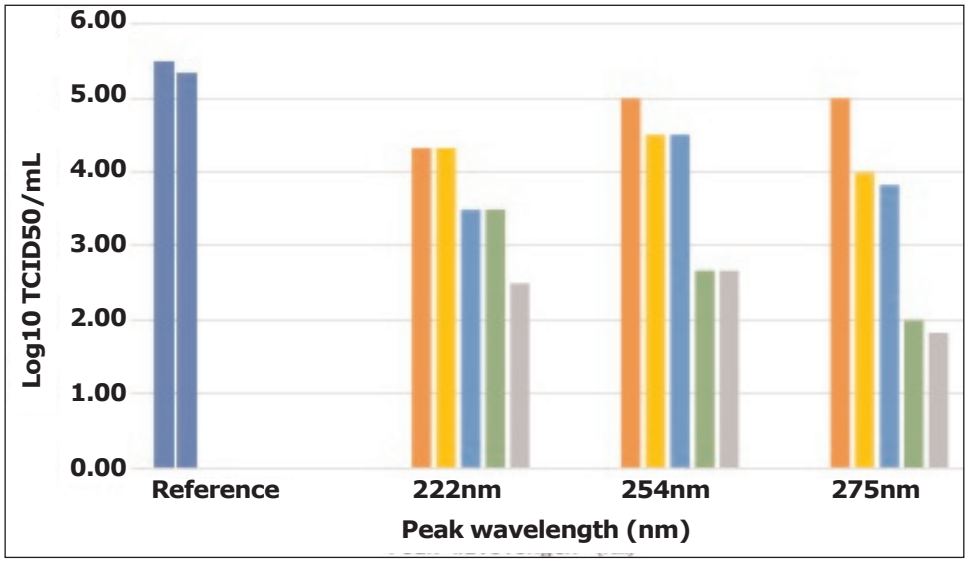
275nm deep ultraviolet LED greater than or equal to 254nm low-pressure mercury lamp

Nitride Semiconductor Co Ltd of Tokushima, Japan (which was spun off from Tokushima University in 2000 and claims to have developed the first highly efficient ultraviolet light-emitting diode) says that, in collaboration with the National Hospital Organization Sendai Medical Center Clinical Research Department Virus Center, it has verified the inactivating effect on OC43 corona-virus (pseudo SARS-CoV-2) using three different wavelengths in the deep ultraviolet region (222nm, 254nm and 275nm).

The team confirmed that the UVC deep ultraviolet wavelength of 275nm has an inactivating effect equal to or greater than that of the sterilization light source 254nm in a comparative test in which each deep ultraviolet wavelength is irradiated with the same amount of light energy under the same environment.

The rapid spread of the SARS-CoV-2 Omicron variant in South Africa has revealed that the vaccine's effectiveness is limited. Mercury-containing UV lamps have been used as germicidal lamps since 1901 when German physicist Hermann Strebel discovered that UV lamps could inactivate bacteria and viruses. Since inactivation by UV lamp does not use chemicals, it has been used in the medical field as a safe and reliable inactivation method without residual substances.

In recent years, through the development of semiconductor technology, similar effects have been confirmed with deep ultraviolet light-emitting diodes (UVC-LEDs) with a wavelength of 300nm or less. The latest research was conducted for the purpose of comparing and verifying two types of ultraviolet light with wavelengths of 222nm and 275nm (which have recently begun to be applied in the deep ultraviolet region) with the conventional sterilization light source of 254nm.



Experiment contents

As a light source for each emission wavelength, the team prepared an excimer lamp with a wavelength of 222nm, a UV (low-pressure mercury) lamp with a wavelength of 254nm, and a deep ultraviolet LED with a wavelength of 275nm.

Since the illuminance of each light source is different, in order to make the conditions the same the team adjusted the length of time to irradiate the object according to the illuminance of each light source so that the amount of irradiation light energy (integrated light amount) was equal.

Results

The figure shows the change over time in the residual infectious titer of OC43 coronavirus (the concentration of viral particles that can transduce cells) adhering to the surface. The two blue bars in the Reference correspond to the standard values of the test conditions, and are the smear sample immediately after creation and the same sample left for 12 minutes in a safety cabinet at 22°C 30–35% RH. The orange, yellow, blue, green and gray bars of each wavelength are used in a bio-cleanroom maintained at 20°C at 8–14% RH, after the smear sample has been completely dried according to the protocol. The figure shows the result of irradiating orange 0J/m^2, yellow 7.5J/m^2, blue 15J/m^2, green 30J/m^2, gray 60J/m^2 light in order from the left at a distance of 50cm from the light source. Regarding the change over time in the residual infection rate, the shorter the bar length compared with the 0.0J/m^2 orange bar graph, the higher the inactivating effect. Notably, the 60J/m^2 gray bar with the largest amount of illuminated light showed the shortest at 275nm, followed by a wavelength of 254nm and finally 222nm.

Significance

Compared with 254nm, which has been conventionally applied as a sterilization line wavelength, the result was that 275nm has the same or better inactivating effect on the pseudo SARS-CoV-2. This is in line with the flow of total abolition of mercury stipulated in the United Nations Environmental Plan (UNEP) 'Minamata Convention on Mercury'. It shows that UVC-LED light can fully fulfill its role of abandoning mercury.

www.nitride.co.jp

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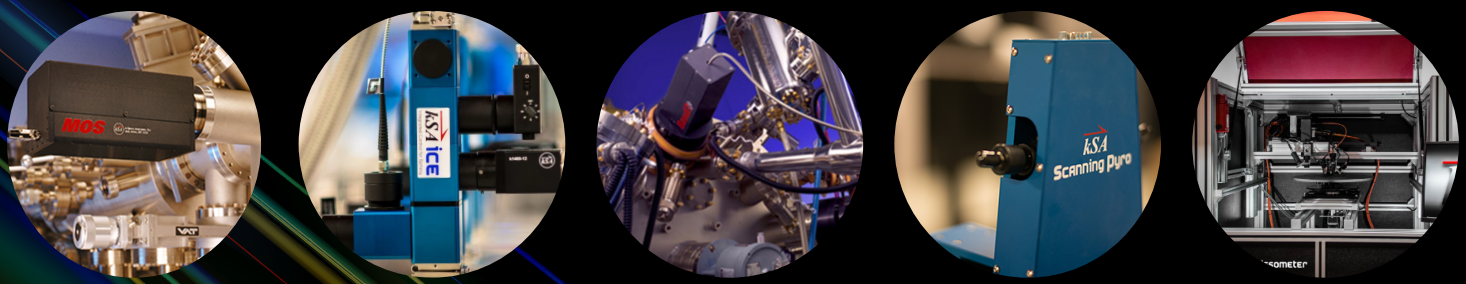

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MICLEDI produces micro-LED arrays for AR glasses on 300mm CMOS wafers

First demonstration units available at CES

MICLEDI Microdisplays B.V. of Leuven, Belgium, a fabless developer of micro-LED displays for high-end augmented reality (AR) glasses, has demonstrated what it claims are the first micro-LED arrays-for-AR built on a 300mm CMOS manufacturing platform. The manufacturing precision, performance and cost-efficiency offered by the 300mm product strategy targets displays for AR glasses manufacturers.

MICLEDI's solution is positioned to address the needs of future AR glasses in terms of display size, resolution, brightness, image quality, power consumption and cost.

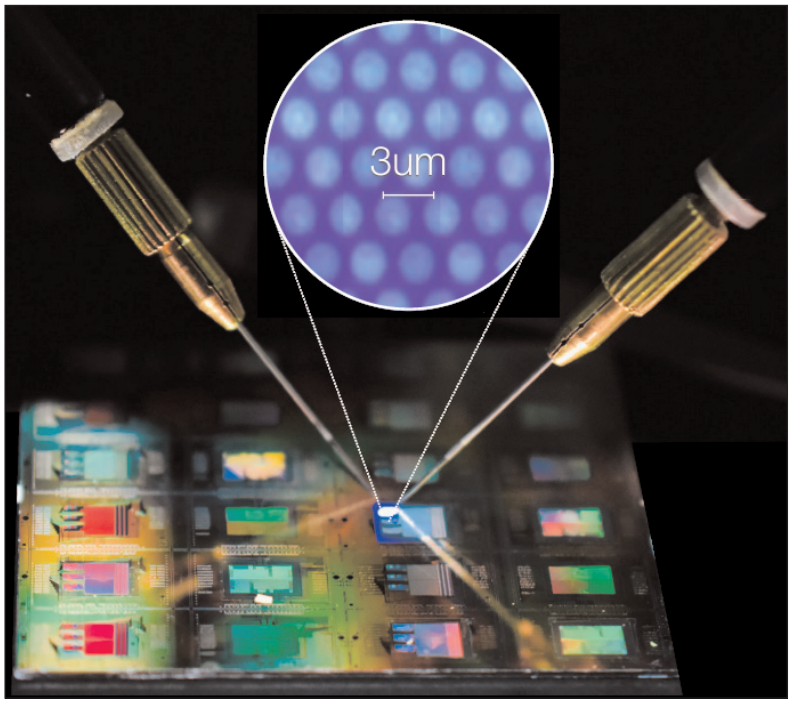
The firm says that the uniqueness of the technology rests on the following attributes:

- CMOS-fab-compatible RGB epitaxial materials reconstituted on 300mm CMOS wafers, co-integrated with advanced-node CMOS backplane ASICs via W2W (wafer-to-wafer) hybrid bonding;
- pixel-level Fresnel lens beam shaping for high-efficiency waveguide integration;
- micro-LED technology tailored for industry-standard tooling and process steps available for volume manufacturing at CMOS foundries.

As a spin-off of nanoelectronics research center Imec, MICLEDI has leveraged IMEC's extensive background in 3D integration technologies and unique access to its 300mm CMOS pilot-line infrastructure for micro-LED development and prototyping.

The next generation of AR glasses

AR headsets are currently heavy and bulky, image realism is poor, resolution is low, and headsets are costly. Nearly every leading technology company is investing in AR to drive the future of their consumer offerings, and micro-LED displays are a mission-critical component. According to industry analyst firm Yole Developpement, demand for micro-displays in AR headsets is projected to grow at a compound annual growth rate (CAGR) of >100%, rising to more than $1.8bn in 2025 and more than $4.9bn in 2027.

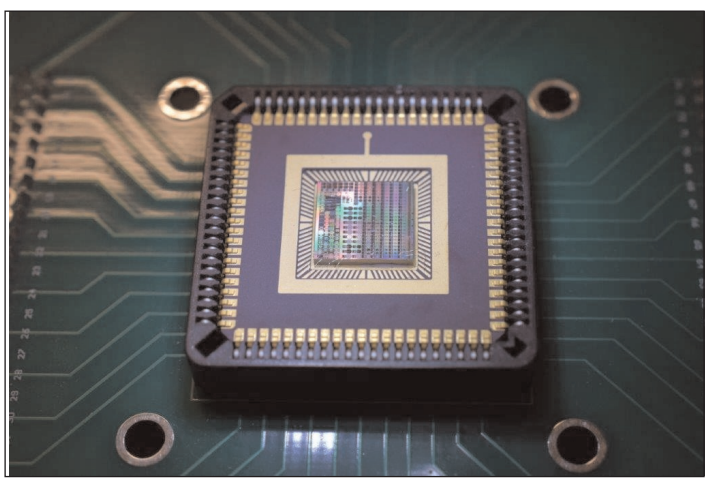


MICLEDI microLED arrays processed on 300mm wafers (via reconstitution and W2W bonding).

"AR headsets today can be found in industrial and medical niche markets. We intend to change that by enabling AR glasses that are stylish, compact, lightweight, with long battery life, and images that look just like reality," says CEO Sean Lord. "Our 300mm manufacturing flow is the technology needed to overcome the challenges with first- and second-generation AR glasses and is necessary to achieve the features consumers will require for the ultimate visually immersive AR experience," he adds,

First demonstration units at CES 2022

The Consumer Electronics Show (CES 2022) in Las Vegas in January marks the first availability of MICLEDI's demonstration units. "CES is where advanced technologies take center stage for all the world to see and AR is one area that is in rapid adoption with leaders from FAANG companies [Facebook, Amazon, Apple, Netflix and Google] and a plethora of smaller innovators," says Lord.



MICLEDI's packaged micro-LED dies with test arrays.

At CES, as well as having a booth, MICLEDI also had a suite at The Venetian hotel for private meetings.

MICLEDI plans to sample its micro-LEDs to customers beginning in first-quarter 2022.

www.micledi.com
www.imec.be

SmartKem collaborating with UCSB's Solid State Lighting & Energy Electronics Center

Flexible organic semiconductor materials to benefit micro-LED displays and sensors

The Solid State Lighting & Energy Electronics Center (SSLEEC) at University of California Santa Barbara (UCSB), a collaborative center that brings researchers and industry partners together to improve and advance solid-state lighting and energy-efficient power switching, has welcomed its newest member: the UK-based electronics company SmartKem.

"We believe that SmartKem's revolutionary high-performance flexible organic semiconductor technology is the perfect material for micro-LED displays, sensors and electronics," says Shuji Nakamura, a UCSB professor of materials and of electrical and computer engineering, and winner of the 2014 Nobel Prize in Physics for the invention of the bright-blue LED. "Matching SmartKem's organic semiconductor materials with gallium nitride micro-LEDs has the potential to afford many benefits in next-generation displays and sensors," adds SSLEEC's executive director Steve DenBaars.

"UCSB has a longstanding tradition of academic excellence and commitment to innovative research and technology development; values that underpin SmartKem's commitment to delivering the next generation of electronics," comments SmartKem's CEO Ian Jenks.

SmartKem says that its semiconductor platform can be used in applications including mini-LED displays, AMOLED displays, fingerprint sensors and integrated logic circuits. Membership of SSLEEC should enable the firm to gain access to the latest in research and intellectual property developed by the center in fields such as micro-LEDs and displays.

www.smartkem.com
http://ssleec.ucsb.edu

Seoul Viosys debuts WICOP mc technology for metaverse VR displays at CES

First no-wire & no-package WICOP technology

At the Consumer Electronics Show (CES) in Las Vegas on 5 January, LED product maker Seoul Viosys — an affiliate of Sensor Electronic Technology Inc (SETi) and a subsidiary of South Korea's Seoul Semiconductor — debuted its WICOP mc (WICOP + Micro Pixel) products, which adopt the world's first no-wire & no-package WICOP technology. The firm announced on 16 December that the WICOP mc, made in the form of a micro-display for metaverse (three-dimensional virtual world) VR, will be specially unveiled in the exhibition hall.

WICOP technology makes it possible to populate new semiconductor chips into a general manufacturing process directly without modification. To manufacture mini- or micro-LEDs of less than 100μm, accessories such as wires should not be present, and WICOP solves this problem, says the firm. Seoul Viosys claims that some large companies sold products that copied WICOP technology, changing only their names to CSP (chip-size package) or COB (chip on board), and even some global companies purchased the infringements. Seoul Viosys filed a patent lawsuit against Philips and 13 automobile parts brand companies that infringed on the technology, and won the case by obtaining a ban on sales.

AR/VR (augmented reality, virtual reality) has received a lot of attention, but has not yet been used in everyday life, because the high-performance displays that meet the characteristics of VR/AR requirements have not yet been fully developed, says the firm. While liquid-crystal displays (LCDs) and organic light-emitting diode (OLED) displays (which have already been mass-produced), do not satisfy the characteristics required by VR/AR such as high brightness, high resolution, power efficiency, and design flexibility, micro LEDs are attracting attention as an alternative. However, it is not easy as it sounds to adopt micro-LEDs for AR/VR because the efficiency of LEDs deteriorates when micro-LEDs are smaller than 50μm, notes Seoul Viosys.

Seoul Viosys adds that WICOP mc not only solves the problem of efficiency degradation but can also realize high-resolution virtual reality of 2000PPI (pixels per inch), meeting all the requirements of micro-display technology.

"We have succeeded in developing LED technology for VR, and this technology will be displayed separately for pre-booked VIP customers," says Seoul Viosys' development manager.

At CES, an FHD 82-inch display with 6.2 million WICOP mc chips and a 40-inch display with 2.8 million chips will make an appearance.

www.seoulviosys.com

Horticulture lighting systems firm Fluence sold to Signify

ams OSRAM to continue as strategic LED component supplier to combined business

ams OSRAM of Premstaetten, Austria has agreed to sell its horticulture lighting systems business and brand Fluence of Austin, TX, USA to Signify of Eindhoven, The Netherlands for $272m (€242m) on a debt-free/cash-free basis, in line with previous comments on an expected larger-size disposal.

The transaction represents a further significant step in the execution of ams OSRAM's strategy to focus and re-align its business portfolio on its core technology areas in illumination, visualization and sensing, which continues to include advanced LED solutions for horticulture lighting. The firm will continue to be a strategic LED supplier to the combined business for horticultural applications.

Fluence is a global provider of energy-efficient LED lighting system solutions for the horticultural industry. A pioneer in creating white light that mimics the spectrum of sunlight, the firm employs about 200 people. In the trailing 12 months (October 2020 to September 2021), Fluence generated $141m (€124m) in revenue. Acquired by OSRAM in 2018, it was recently named in the inaugural list of 'Next Big Things in Tech' by US business magazine Fast Company, where its lighting solutions earned an honorable mention recognizing for the firm's contribution to changing how the world cultivates food.

"Fluence and Signify are a strong match in complementary lighting expertise for the horticulture market," says Wilhelm Nehring, CEO of ams OSRAM's Digital business unit. "Signify is an industry leader with over a century of history bringing innovative lighting technology, products and services to market," he comments.

Signify says that the acquisition of Fluence is in line with its strategy to expand in attractive growth segments and its commitment to improving food availability by providing growers with horticultural lighting that helps them to reduce resource consumption and increase yields. The global agricultural lighting market is expected to grow by more than 20% per year to €1.6bn in 2024.

Specifically, the acquisition should extend Signify's position in the attractive North American horticultural lighting market. Fluence's horticultural lighting technology includes light recipes for the legal growing of cannabis – which, due to the legalization in Canada and many US states in recent years, currently generates the majority of Fluence's sales – and light recipes for the company's fast-growing business to grow other crops. Fluence's technology also includes more than 140 issued and pending patents, focusing on areas such as light quality, thermal management and installation methods. Currently, Fluence generates most of its sales in North America.

"ams OSRAM will continue to build on its position as a leader in red, blue and white LEDs for the horticulture market," says Frans Scheper, executive VP Opto Semiconductor business at ams OSRAM. ams OSRAM offers a horticulture LED portfolio for professional top lighting, inter lighting and vertical farming applications. The High- and Mid-Power LED families include all important wavelengths for plant growth with 660nm (hyper red), 450nm (deep blue) and 730nm (far red) in three different radiation angles 80°, 120° and 150°. "We look forward to continue providing Signify, and Fluence as part of Signify, leading technology for their business," he adds. Fluence will operate as an entity within Signify's agricultural lighting business in Division Digital Solutions.

"Since Fluence's founding, it has been our sole mission to improve the interaction between light and life to yield a healthier and more sustainable world. Adding our lighting solutions to Signify's strong portfolio empowers our combined businesses to deliver the world's most advanced horticulture technology to cultivators on a global scale," reckons Fluence's CEO David Cohen. "The combination of our companies will immediately expand our collective footprints and inject valuable expertise into both companies' product innovations."

The acquisition is expected to close in first-half 2022, subject to standard regulatory approvals and other conditions.

www.ams-osram.com
www.signify.com

ams OSRAM launches smallest multi-zone dToF modules for precise distance measurement

Multiple objects detected per zone, up to a distance of 5m

ams OSRAM of Premstaetten, Austria is expanding its portfolio of direct time-of-flight (dToF) modules with three new devices for multi-zone and multi-object detection with a wider field-of-view (FoV) and extended range.

The modules combine a 940nm vertical-cavity surface-emitting laser (VCSEL), a sensitive single-photon avalanche photodiode (SPAD) detector array with matching multi-lens optics, and an on-chip microcontroller for histogram processing in one device. Due to the compact dimensions of 2.0mm x 4.6mm x 1.4mm, the modules are the smallest multi-zone dToF modules available on the market, it is reckoned.

dToF sensors are a critical technology, used in a wide range of applications, including laser detect autofocus (LDAF) in smartphones, user presence detection in PCs, and light detection & ranging (LiDAR) sensing in industrial and home/business automation systems.

Industrial and in-home robots require sophisticated systems to detect their environment to ensure they are operating in a safe manner. The new multi-zone dToF modules TMF8820, TMF8821 and TMF8828 divide their detection area into multiple zones to collect more and higher-quality information. As a result, automated robots gain more 'sensory awareness', enabling early detection of potential obstacles. System manufacturers also benefit from the compact design and ease of integration of the new modules.

Robots are taking over more and more tasks not only in application areas such as warehouse automation but also in the home. Special ToF systems are used to enable these robots to maneuver around unhindered, enabling them to navigate their environment. For example, vacuum cleaning robots recognize an object in their immediate surroundings and move around the obstacle. ams OSRAM says that its new dToF modules allow precise distance measurement. "TMF8820, TMF8821 and TMF8828 devices report accurate distance measurements for multiple objects across a number of detection zones," says marketing manager David Smith. "This provides system manufacturers with much more information of what is happening in the environment thanks to the sensor that can see and make the appropriate decisions."

The TMF8820 dToF module divides the FoV into 3x3 or 9 individual detection zones, the TMF8821 into 4x4 or 16 individual detection zones, and the TMF8828 into 8x8 or 64 individual detection zones. With multi-zone detection, it is possible to identify where an object is located within the sensor's FoV. The new devices feature a dynamically adjustable FoV up to 63°, enabling customers to select either a narrow or wide FoV to meet their application needs. All three dToF modules have a detection range from 1cm up to 5m.

www.ams-osram.com

Brightest LED for automotive front lighting unveiled

1- and 2-chip variant to be joined in mid-2022 by multi-chip variants

ams OSRAM has unveiled what are claimed to be the brightest LEDs on the market for automotive front lighting. The leadframe-based Oslon Black Flat X family of LEDs is specially developed for low-beam and high-beam solutions in cars.

Automotive lighting has become extremely versatile, with developments in LED technology opening up new possibilities. LEDs offer outstanding brightness but require minimal installation space, giving manufacturers enormous freedom in designing their lighting solutions. "The Oslon Black Flat product family has been an ideal solution for high-quality and at the same time cost-optimized headlamp designs for many years," says Philipp Puchinger, marketing manager Automotive Exterior. "With the two new products in the Oslon Black Flat X line, ams OSRAM is once again underlining its innovation leadership in automotive lighting."

The surface-mountable components can be processed particularly easily in manufacturers' standardized production processes. In addition to brightness of typically 460lm at 1A, the 1-chip variant has compact dimensions of 3.75mm x 3.75mm.

The special QFN platform of the LEDs enables customers to perform particularly simple thermal management, says ams OSRAM. Depending on system, heat sinks can be significantly reduced in size or even eliminated altogether. The Oslon Black Flat X family's leadframe package also achieves a lower thermal resistance (R_{th}) than the leading ceramic packages in this context to date.

With special TiO_2 encapsulation, the black package of the LEDs delivers high contrast of 1:200. Also, the new components are characterized by a very homogenic color over angle radiation.

The Oslon Black Flat X family is launched with a 1- and a 2-chip version. Various multi-chip versions will be added in mid-2022.

www.osram.com

QEPrize awarded to Akasaki, Nakamura, Holonyak, Craford and Dupuis

Recognition for the development of LED lighting

On 8 December, His Royal Highness The Prince of Wales presented the 2021 Queen Elizabeth Prize for Engineering in a ceremony at St James's Palace in London, UK. The 2021 QEPrize laureates Isamu Akasaki, Shuji Nakamura, Nick Holonyak Jr, M. George Craford and Russell Dupuis are recognised for the creation and development of LED lighting, not only for the global impact of LED and solid-state lighting but also for the contribution that the technology has made — and will continue to make — to reducing energy consumption and addressing climate change.

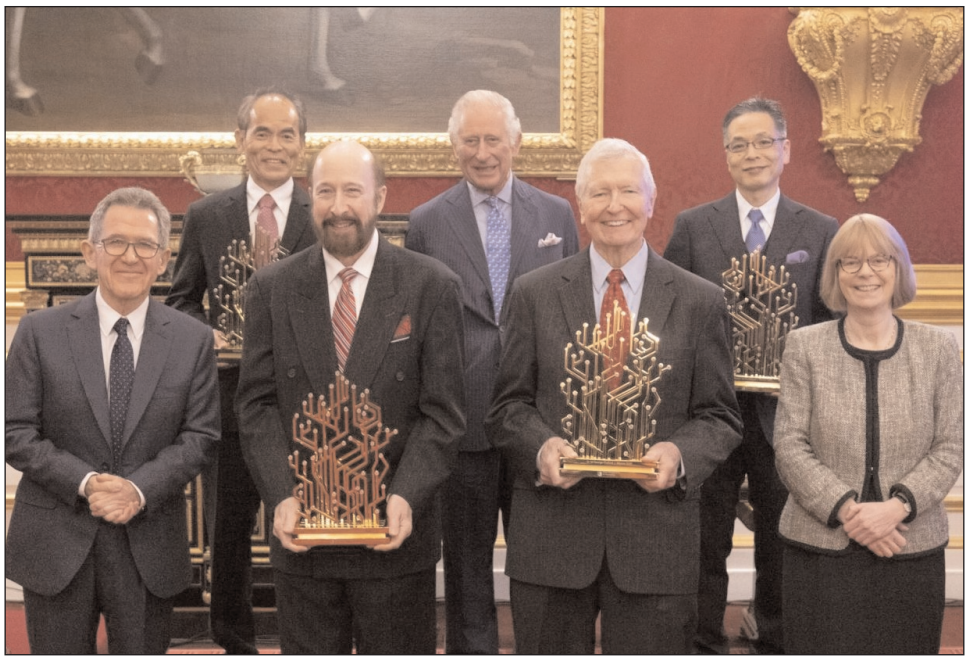
Professor Akasaki passed away in April but was represented at the ceremony by his son-in-law Dr Kazuaki Takahashi.

The Prince of Wales presented each winner with a gold trophy, whose designer and winner of the 2021 Create the Trophy competition, Hannah Goldsmith, also attended.

The QEPrize celebrates engineering's visionaries, encouraging engineers to help extend the boundaries of what is possible across all disciplines and applications. It also aims to inspire young minds to consider engineering as a career choice and to help to solve the challenges of the future.

Visible LEDs are now a global industry predicted to be worth over $108bn by 2025 through low-cost, high-efficiency lighting. LED lighting is 75% more energy efficient than traditional incandescent and compact fluorescent bulbs, and is playing a crucial role in reducing carbon dioxide emissions. LED bulbs last 25 times longer than incandescent bulbs and their large-scale use reduces the energy demand required to cool buildings.

"This is a team prize. I was able to do what I did in the 1980s because of what had come before," comments professor Nakamura. "When I was modifying reactors every morning and every afternoon continuously for a year and a half, I never thought it would be so successful," he adds.



Back row (left to right) professor Shuji Nakamura, HRH The Prince of Wales, Dr Kazuaki Takahishi. Front row (left to right) Lord Browne of Madingley, professor Russell Dupuis, Dr George Craford, professor Dame Lynn Gladden. (Image credit: Jason Alden/QEPrize).

"I am proud to part of something that has made such a big impact on the world," says Dr Craford.

"All five of us each played an important role... In those early days, when it was long days and nights hand-building reactors, Nick Holonyak mentored us. He really drew us in and inspired us," comments professor Dupuis.

"This year's Prize winners have not only helped humanity to achieve a greater degree of mastery over the environment, they have enabled us to do so in a sustainable way. They have created a product which we now take for granted, but which will play a major role in ensuring that humanity can live in harmony with nature for many more centuries to come," stated Lord Browne of Madingley, chairman, Queen Elizabeth Prize for Engineering Foundation.

"The impact of this innovation is not to be understated. It makes lighting a lot cheaper and more accessible for emerging economies," notes professor Sir Christopher Snowden, chair of the 2021 QEPrize Judging Panel. "For example, LEDs are being used on fishing boats where previously the only option would have been paraffin lamps. They are much cheaper and safer. It is not only an extreme engineering achievement, but a societal one that has a significant impact on the environment."

The QEPrize is administered by the Queen Elizabeth Prize for Engineering Foundation and funded by support from the following corporate donors: BAE Systems plc, BP plc, GlaxoSmithKline, Hitachi Ltd., Jaguar Land Rover, National Grid plc, Nissan Motor Corporation, Shell UK Ltd, Siemens UK, Sony, Tata Steel Europe, Tata Consultancy Services, and Toshiba. The 2021 winners are awarded a total cash prize of £1m.

www.qeprize.org

Kyocera SLD Laser achieves record LiFi communications data rate 100 times faster than 5G

Firm demonstrating >90Gbps DataLight LiFi at CES

Kyocera SLD Laser Inc (KSLD) of Goleta, near Santa Barbara, CA, USA, which is commercializing gallium nitride (GaN)-based laser light sources for automotive, mobility, specialty lighting and consumer applications, says that it has achieved what is claimed to be the fastest LiFi system that delivers a data rate of greater than 90Gbps (100 times faster than 5G). The firm demonstrated the DataLight innovation for automotive and consumer applications at the Consumer Electronics Show (CES 2022) in Las Vegas (5–7 January).

"To pioneer the future of lighting and wireless connectivity, our ultra-high-speed LiFi technology is eye-safe, impervious to ambient lighting, secure, efficient and RF-free," says Kyocera SLD Laser's CEO Dr James Raring. "KSLD is commercializing LiFi solutions for customers in mobility applications, automotive and undersea, as well as RF-sensitive environments such as airplane cabins, smart factories, healthcare, secure government facilities and smart cities."

KSLD's DataLight LiFi innovation utilizes its dual-emission visible and infrared LaserLight sources, which enable customers to commercialize potent intelligent illumination systems including functionality of spatially dynamic lighting, night-vision illumination, accurate sensing and 3D LiDAR, as well as optical power transmission. DataLight engines can be configured for customer-specific applications and have the potential to be performance optimized using artificial intelligence (AI) and machine learning.

Kyocera SLD Laser hosted meetings both in person at CES 2022 and virtually (by appointment).

www.kyocera-sldlaser.com
www.ces.tech

Sheffield-led project developing micro laser diode technology for micro-display and VLC devices

Monolithic integration to allow each micro laser diode to be electrically driven by individual HEMTs

In collaboration with Harvard University and Massachusetts Institute of Technology (MIT) in the USA and the universities Strathclyde and Bath in the UK, a newly funded £1.9m project led by professor Tao Wang of the University of Sheffield's Department of Electronic and Electrical Engineering in the UK aims to develop novel epitaxy technology to integrate micro laser diodes (micro-LDs) and transistors on a single chip for use in micro-display and visible light communication (VLC) devices.

Micro-displays are used in smartphones, smartwatches, augmented reality (AR) and virtual reality (VR) devices. VLC technology has the potential to offer much greater bandwidth and efficiency than WiFi or 5G and can be used where radio frequency emissions are controlled or do not work, such as in aircraft, hospitals, underwater and hazardous environments.

A key component of both these technologies are III–nitride visible light-emitting diodes (LEDs), but using laser diodes (LDs) instead has the potential to achieve devices with even higher resolution, speed and efficiency.

Funded by the UK's Engineering and Physical Sciences Research Council (EPSRC), the £1.9m Sheffield-led project is developing a new way of integrating microscale semiconductor light sources and transistors on a single chip.

"The significantly increasing demands on micro-displays are pushing the requirements for ultra-high resolution and ultra-high efficiency," notes Tao Wang, Professor in Advanced Opto-Electronics at the University of Sheffield. "Several fundamental challenges with fabrication and electrical driving methods cannot be met by existing technologies, therefore a disruptive technology needs to be developed," he adds. "Unlike any existing photonics and electronics fabrication approaches, our research will explore a completely different approach to monolithically integrate microscale laser diodes (μLDs) and high-electron-mobility transistors (HEMTs) on a single chip, where each μLD is electrically driven by individual HEMTs."

Fundamental challenges with fabrication and electrical driving methods cannot be met by existing technologies, therefore a disruptive technology needs to be developed

The global micro-display market is predicted to reach $4.2bn by 2025 and the visible light communication market is expected to exceed $8bn by 2030. The Sheffield-led project is already being supported by global tech companies such as Microsoft, Sony and Plessey.

www.sheffield.ac.uk/eee

NTU Singapore launches Quantum Science and Engineering Centre

Semiconductor fabrication technologies to be used to develop quantum chips

Singapore's Nanyang Technological University (NTU) has launched the Quantum Science and Engineering Centre (QSec), which aims to develop devices and technologies powered by quantum science.

The centre, the first of its kind in Singapore, will conduct research on using semiconductor fabrication technologies to develop and produce quantum chips that form the backbone of quantum devices such as quantum chip processors, networks and sensors. These have key applications in areas such as quantum computing, communication, cryptography, cybersecurity and sensor technology.

The center aims to train skilled manpower for quantum engineering, the application of quantum science to real-world scenarios, and to promote and develop Singapore's quantum industry. The new center will collaborate with the Centre for Quantum Technologies (CQT), a Research Centre of Excellence established since 2007, on quantum technology research and engineering application, and look to establish an international platform to collaborate with other overseas partners.

The opening ceremony for QSec was witnessed by Minister for Education Chan Chun Sing and NTU president professor Subra Suresh.

"Quantum science, technologies and engineering have drawn huge investments worldwide. Singapore is a long-standing investor in its potential and remains at the forefront of this field," says Education Minister Chan Chun Sing. "In 2018, the National Research Foundation started a quantum engineering program with the goal of establishing a competitive quantum engineering research community and industry ecosystem to translate the technology into real-world applications. We look forward to the Quantum Science and Engineering Centre's (QSec) contributions to Singapore's efforts in advancing quantum technologies, especially in the development of quantum computing chips and quantum communications," he adds.

(From left to right) QSec's launch ceremony was witnessed by professor Liu Ai Qun; professor Lam Khin Yong (senior VP, Research); NTU president professor Subra Suresh; guest of honor Chan Chun Sing (Minister for Education); professor Ling San (deputy president & provost); and associate professor Kwek Leong Chuan.

"The Quantum Science and Engineering Centre (QSec) aims to conduct ground-breaking research in several areas: quantum key distribution chips, quantum computation, quantum and classical neural network, cluster state computation and quantum sensing," notes NTU president professor Subra Suresh. "NTU's focus in these areas is part of our strategy to be a key enabler in the development of quantum science technologies to support Singapore's efforts in quantum engineering for the benefit of industry and society."

Housed at NTU's College of Engineering, the research center's current projects include research into quantum chip processors, quantum chip networks, and quantum chip sensors.

"QSec aims to not only take up a key role in supporting the local quantum industry, but to also build up strong international collaboration in quantum technologies which will benefit Singapore," says center co-director professor Liu Ai Qun of NTU's School of Electrical and Electronic Engineering.

"The Centre hopes to enhance Singapore's impact on quantum science, engineering and technologies by leveraging on our capability in chip-based devices," says fellow co-director Dr Kwek Leong Chuan, a principal investigator at the Centre for Quantum Technologies (CQT) hosted at the National University of Singapore. "We are also hoping to train and enthuse more engineers and secondary school students in this emerging direction."

Creating light-based quantum chips

One of the QSec's main research projects is the development of a quantum computing chip that can perform quantum calculations using an integrated photonic chip, which can be made with semiconductor materials on a silicon wafer.

Such quantum processor chips hold the promise of solving complex calculations that are impossible for classical computers. Classical computers rely on binary bits as their building blocks, as all computational information can be reduced to either ones or zeros. Instead of using such bits, quantum processors utilize quantum bits (qubits), which can exist in quantum states such that they represent both one and zero at the same time. This allows qubits to encode far more information than binary bits.

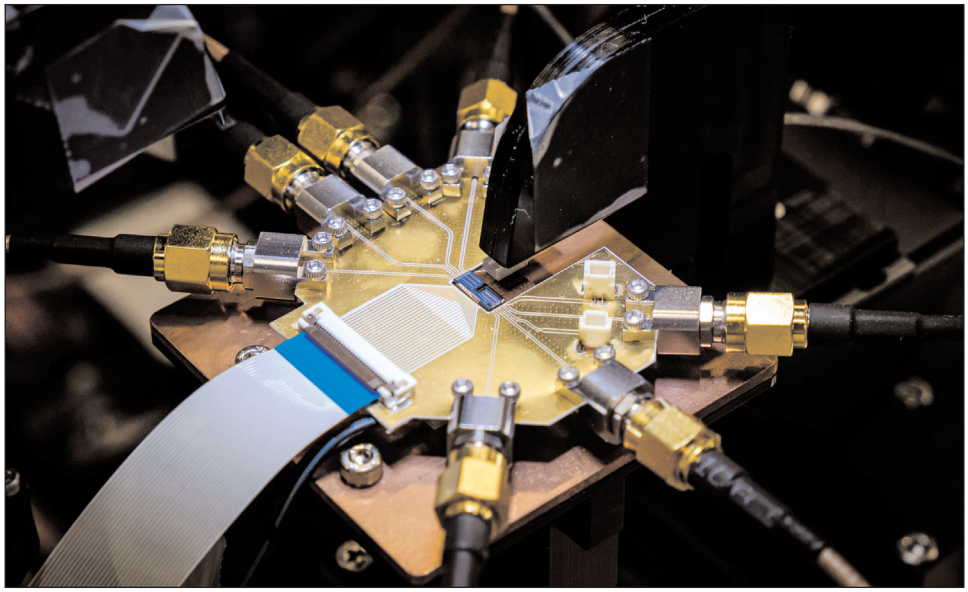
QSec researchers are exploring how photonics engineering can be used in a quantum context. Classical computers use electricity to flip the binary switches between their one and zero states. However, quantum chips can use single particles of light (photons) to represent qubits.

By using lasers and beam splitters within a chip circuit, researchers can manipulate individual photons as qubits. This method (termed boson sampling) uses light to perform quantum calculations that can far exceed the performance of supercomputers. Creating such a quantum photonic chip that can do this will open the possibility of bringing quantum computers into mainstream, real-world use.

These quantum computers should be able to rapidly solve calculations and tackle problems in diverse fields such as financial modelling, transport optimization, and artificial intelligence (AI) and machine learning.

Keeping communications secure with quantum cryptography

As cyberattacks become more sophisticated and hacking tools become more powerful, quantum cryptography offers an alternative to secure sensitive information against future cyber-attacks and unforeseen technological advances.



The most well-known developed application of quantum cryptography is quantum key distribution (QKD), a method that allows two remote users — who are embedded in an untrusted network such as the Internet — to exchange secret keys in the presence of an attacker who may own unlimited computing resources.

By taking advantage of the sensitivity of quantum signals, QKD chips can detect when an attacker attempts to eavesdrop on communication. The secret keys, which are transmitted as a series of quantum signals, become disturbed and will scatter if an attacker intercepts it, rendering them useless.

QSec researchers have managed to develop a quantum communication chip small enough to fit into everyday devices such as laptops or smartphones, which could lead to highly secure, encrypted communication.

QSec is also currently developing a version of QKD chips called measurement-device-independent quantum key distribution (MDI-QKD) that aims to make QKD even more secure. MDI-QKD chips will also allow multi-user quantum communication, going beyond the two-user applications of traditional QKD.

Further educational goals

The Centre currently houses 30 researchers including professors, research fellows, PhD students, and engineers. It is jointly funded by a Ministry of Education (MOE) Academic Research Fund Tier 3 grant (which supports high-impact, multi-disciplinary research programs) and by NTU.

It also offers outreach activities for secondary and upper-secondary school students in quantum technologies, especially in chip-based engineering and technology, and its researchers have given educational talks to various schools.

"We welcome the Centre's outreach activities in secondary and tertiary education institutions, which helps to boost interest in the field among our aspiring scientists, engineers and researchers," says Chan.

QSec is described as an important chapter for NTU's 2025 Strategic Plan, as the university expands and enriches its research and postgraduate educational offerings. QSec's high-level research in quantum engineering is expected to translate into innovative solutions and technologies that will benefit industry and society through partnerships.

This also aligns the Centre with Singapore's Research, Innovation and Enterprise 2025 (RIE2025) Plan under the Academic Research, and Innovation and Enterprise pillars.

www.eee.ntu.edu.sg

Vector Photonics appoints Olek Kowalski as principal development engineer

High-power laser design and manufacturing expertise gained from Sivers Photonics/CST Global and Intense

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK has appointed Dr Olek Kowalski as principal development engineer. Kowalski brings both academic and commercial photonics experience, which he has gained from over two decades of design, R&D, project management, process development and material characterization roles in the industry.

"Olek is a well-known and hugely respected photonics engineer," comments chief technology officer Dr Richard Taylor. "He has unrivalled expertise in high-power laser design and manufacture, which will inform our research and development of PCSELs for additive manufacturing and 3D metal and plastic printing."

Vector Photonics' new principal development engineer Olek Kowalski.

Kowalski joins Vector Photonics from Sivers Photonics (formerly CST Global), where he was a senior development engineer, managing commercial interactions with key foundry customers and overseeing increases in product quality and yield. He was also the technical lead for funded UK and European collaborative R&D programs. He helped to establish the company's metal-organic chemical vapor deposition (MOCVD) epitaxial growth capability and worked on the development of its high-power distributed feedback (DFB) and buried-heterojunction laser products. Before that, Kowalski was a founder member and product manager at Intense Ltd from 2000 (a start-up acquired by CST Global in 2010).

Kowalski has a first-class degree in Physics as well as a PhD in optical spectroscopy from the University of Sheffield, where he also won the Ifor Austin award and Clarke prize for experimental physics. He then went on to be a post-doctoral research fellow at the University of Glasgow, developing next-generation all-optical communication networks.

www.vectorphotonics.co.uk

Vector Photonics appoints principal design engineer

Pavlo Ivanov to develop laser design, automated test and characterization systems

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK has appointed Dr Pavlo Ivanov as principal design engineer, responsible for laser device design and characterization.

"Dr Pavlo Ivanov is an engineer at the forefront of the photonics industry, with extensive academic and industrial experience," comments chief technology officer Dr Richard Taylor. "He will play a critical part in device testing and characterization, helping to fast-track our PCSEL technology into next-generation datacoms, telecoms and 3D printing markets."

Ivanov joins Vector Photonics from Phoelex Ltd of Cambridge, UK, where he helped set up the company's automated optical testing and characterization laboratory. Prior to that, he was a research associate in the knowledge transfer partnership between Sivers Photonics (formerly CST Global) and the University of Glasgow, testing indium phosphide (InP)-based, distributed feedback (DFB) lasers and TOSAs (transmitter optical sub-assemblies), working with professor Anthony Kelly and professor Richard Hogg.

Vector Photonics' new principal design engineer Dr Pavlo Ivanov.

Ivanov has held research associate and research fellow roles at Bristol University, Leeds University and Sheffield University, gaining a wealth of test and characterization experience. His experience ranges from gallium arsenide (GaAs) and gallium nitride (GaN)-based DFB lasers and PCSELs to silicon/silicon-germanium (Si/SiGe) quantum cascade lasers and super-luminescent diodes (SLEDs). He also has expertise in DFB laser modelling tools.

Ivanov has a PhD degree in laser optics and physics from the National University of Radio and Electronics (NURE) and the National University, Kharkiv, Ukraine. He has a further, specialist degree in electronic engineering from NURE.

www.vectorphotonics.co.uk

Sivers Photonics receives SEK5.3m in orders for custom photonics devices

Aim is to accelerate orders as new customer moves to volume production

Sivers Semiconductors AB of Kista, Sweden (which supplies chips and integrated modules) says that its subsidiary Sivers Photonics (formerly CST Global of Glasgow, Scotland, UK) has received two new orders from a US-based customer (bringing the total order to SEK5.3m) for custom photonics devices.

"We're excited to work closely with this new customer, supplying a highly customized version of our photonics devices, designed on our technology platform, on which we are already supporting many applications," says Sivers Semiconductors' group CEO Anders Storm. "We hope to accelerate orders and support this customer as they move to volume production," he adds.

www.sivers-semiconductors.com

II-VI Inc completes $990m offering of notes

Syndication of $4bn senior secured credit facilities also completed

Engineered materials and optoelectronic component maker II–VI Inc of Saxonburg, PA, USA has completed its offering of $990m aggregate principal amount of 5.000% senior notes due 2029 in a private transaction exempt from the registration requirements of the Securities Act of 1933, as amended. The notes are guaranteed by each of the company's domestic subsidiaries that guarantee its existing credit agreement.

The notes are unsubordinated, unsecured obligations of the company and bear interest at a rate of 5.000% per year. The firm will pay interest on the notes on 15 December and 15 June of each year, commencing 15 June 2022. The notes will mature on the 15 December 2029.

The company also says that the lead arrangers for its proposed senior secured credit facilities have allocated and priced its $850m term loan A credit facility, $2800m term loan B credit facility, and $350m revolving credit facility. The term A facility and revolving credit facility borrowings in US dollars will each bear interest at LIBOR (subject to a 0.00% floor) plus a range of 1.75–2.50%, depending on the firm's total net leverage ratio. The term A facility and the revolving credit facility borrowings are initially expected to bear interest at LIBOR plus 2.00%. The term loan B facility will bear interest at LIBOR (subject to a 0.50% floor) plus 2.75%.

II–VI intends to borrow the term facilities in connection with the closing of its pending business combination with Coherent Inc of Santa Clara, CA (which provides lasers and laser-based technology for scientific, commercial and industrial applications), pursuant to an agreement and plan of merger of 25 March, by and among the company, Coherent and Watson Merger Sub Inc (a subsidiary of the firm).

The revolving credit facility is expected to be available concurrently with the closing of the acquisition. II–VI intends to use the proceeds from the offering of the notes and the term facilities, together with other financing sources and cash on hand to fund the cash consideration, the repayment of certain indebtedness and certain fees, and expenses in connection with the acquisition.

www.ii-vi.com

Vector Photonics a finalist at Scottish Business Insider 'Deals & Dealmakers Awards'

Investor Foresight Williams nominates firm for 'Early-Stage Deal of the Year' award

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics Ltd of Glasgow, Scotland, UK is a finalist at the Scottish Business Insider 'Deals & Dealmakers Awards'.

The Deals & Dealmakers Awards 2020/21 acknowledge and reward excellence in corporate finance transactions. They recognize the bankers, venture capitalists, lawyers and accountants who initiate, structure and negotiate investments essential to business growth success. Judging of the awards is conducted by an independent panel of experts.

"We are honoured that Foresight Williams, an investor in Vector Photonics, nominated us for the 'Early-Stage Deal of the Year' award," says CEO Neil Martin. "We are one of only two companies shortlisted for the award, which recognizes the quality of the investment capital; the level and quality of the syndication; the scale of the market opportunity; the potential return for investors; and the role of the management team in successfully realizing the investment," he adds.

www.vectorphotonics.co.uk

Tower & Juniper unveil first open-market silicon photonics platform with monolithically integrated III–V lasers

Foundry-ready process enables next-gen optical communications for telecoms and data centers plus AI and LiDAR for autonomous vehicles

Specialty analog foundry Tower Semiconductor Ltd (which has fabrication plants in Migdal Haemek, Israel, and at its US subsidiaries in Newport Beach, CA and San Antonio, TX, and at TowerJazz Japan Ltd) and optical network provider Juniper Networks Inc of Sunnyvale, CA, USA have announced what is claimed to be the first silicon photonics (SiPho) foundry-ready process with integrated III-V lasers, amplifiers, modulators and detectors.

This integrated laser process addresses optical connectivity in data centers and telecom networks, as well as new emerging applications in artificial intelligence (AI), light detection & ranging (LiDAR) and other sensors for autonomous vehicles (AVs) etc. According to market research firm Yole Développement, the silicon photonics transceiver market for data centers is expected to rise rapidly at a compound annual growth rate (CAGR) of 40% to over $5bn in 2025.

The new platform co-integrates III–V lasers, semiconductor optical amplifiers (SOA), electro-absorption modulators (EAM) and photodetectors with silicon photonics devices, all monolithically on a single chip. This enables smaller, higher-channel count and more power-efficient optical architectures and solutions. Foundry availability will enable a broad array of product developers to create highly integrated photonic integrated circuits (PICs) for diverse markets.

Process design kits (PDK) are expected to be available by year end and the first open multi-project wafer (MPW) run are expected to be offered early next year. First samples of full 400Gb/s and 800Gb/s PIC reference designs with integrated lasers are expected to be available in second-quarter 2022.

"Our mutual development work with Tower has been extraordinarily successful in qualifying this innovative silicon photonics technology in a high-volume manufacturing facility," comments Juniper's CEO Rami Rahim. "By offering this capability to the entire industry, Juniper offers the potential to radically reduce the cost of optics while lowering the barrier to entry for customers," he adds.

"Our partnership with Juniper on silicon photonics is bringing a paradigm shift for product development across our industry," reckons Tower's CEO Russell Ellwanger. "It is now possible to mix the advantages of III-V semiconductors with high-volume silicon photonics manufacturing," he adds. "Being the singular open-market, integrated laser silicon photonics platform, and having a multi-year advantage over any potential foundry competitor, we are jointly creating breakthrough products with truly unique value for our industry."

www.towersemi.com
www.juniper.net

POET appoints VP of intellectual property

Ditizio to lead expansion of IP portfolio related to Optical Interposer

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — has appointed Dr Robert Ditizio to VP of intellectual property.

Previously serving in a consulting capacity for the firm since 2017, he assumed a permanent role in December to lead continued expansion of POET's IP portfolio, primarily related to the POET Optical Interposer platform. Ditizio has over 20 years of IP portfolio management expertise and expansive knowledge of materials and semiconductor processing technology.

As well as holding BS, MS and PhD degrees in Engineering Science from The Pennsylvania State University and an MBA from the Sonoma State University, Ditizio holds 10 patents in the areas of semiconductor materials and processing technology, and has authored and contributed to numerous technical publications in related fields of work.

www.poet-technologies.com

Voyant raises $15.4m in Series A funding to deliver 3D sensing with chip-scale LiDAR

Silicon photonics technology from optical datacoms applied to machine perception

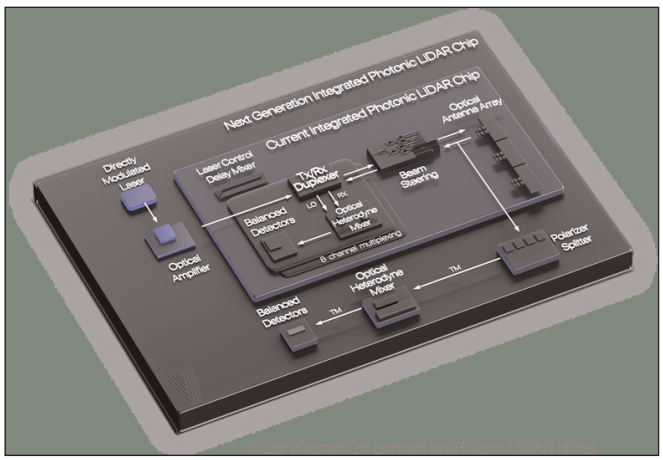
Voyant Photonics of Long Island City, NY, USA has raised $15.4m in a Series A funding round led by UP.Partners and joined by earlier investors LDV Capital and Contour Ventures.

Containing thousands of optical components fabricated on a single chip, Voyant's light detection & ranging (LiDAR) system enables the integration of an effective and exponentially more scalable LiDAR system than possible to date, it is claimed. LiDAR enables 3D vision across many industries including transportation, robotics, industrial automation, and consumer electronics. Voyant developer kits are now available for select customers on its waiting list.

Previously, LiDAR systems were fabricated using discrete mechanical and optical components, resulting in large and expensive solutions. Voyant says that its solution reduces the size and manufacturing complexity of LiDAR, and that its chips can pave the way for large-scale adoption of 3D sensing in the same way that CMOS image sensors enabled the accelerated growth of digital photography.

Voyant leverages commercially available and scalable semiconductor fabrication processes that combine thousands of optical and electrical components onto a single chip. This enables the firm to mass produce a LiDAR system similar to how computer chips are made, presenting the possibility of making it a ubiquitous technology for machine perception.

Co-founders Chris Phare and Steven Miller had been working on LiDAR chips for years at Columbia University's Lipson Nanophotonics Group when they decided to commercialize their technology and launched Voyant Photonics. Their insight was to apply the silicon photonics technology used for optical data communications, the same technology that has made high-performance data-center fiber optics affordable. "When you fabricate a LiDAR system on a chip, the fabrication cost stays the same regardless of how many components you use," says Phare. "We will soon be selling LiDAR systems for a few hundred dollars, and longer-term will sell them for less than a hundred dollars at scale."

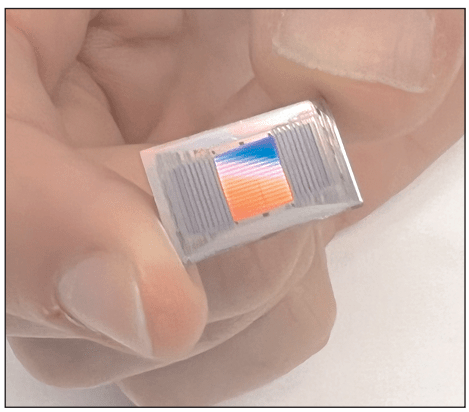


Block diagram of current and future LiDAR chips.

Voyant's devices demonstrate a complete LiDAR system in a field-deployable package, using Voyant's patented techniques for on-chip digital beam steering, optical signal processing, and laser control.

"When we started on our mission to make LiDAR a ubiquitous technology for machine perception, a lot of people said silicon photonics was not ready to leave the lab," says Miller. "Our successful first milestones prove that we can build a complete LiDAR solution that meets industrial needs, using silicon photonics, and deploy it anywhere," he adds.

"Now that we can make LiDAR systems on semiconductor chips, we can make them better and less expensive with every development cycle, similar to Moore's Law for computer chips," reckons Phare. "While the excellent performance of our first LiDAR chips surprised even us, this is just the beginning. Just like with computer chips and camera sensors, every design iteration will get better," he adds.



Voyant's founder holding a LiDAR-on-a-chip.

"Ubiquitous 3D vision is critical to enabling the transformation of the world of transportation and beyond," says Ben Marcus, managing partner of UP.Partners. "Their solution will leapfrog all competitors and deliver a scalable solution to enable 3D vision," he adds.

"We are delivering the first LiDAR systems of their type powered by an integrated photonic chip," claims Peter Stern, a serial entrepreneur with a background in creating military-grade LiDAR who started as an advisor to Voyant and recently became CEO. "Our diverse customers in robotics, AGVs, mobility, industrial automation and security all have one thing in common — they are building solutions that need to understand the world around them… That is what our LiDAR systems provide."

www.voyantphotonics.com

Intel Research Center for Integrated Photonics for Data Center Interconnects opened

Multi-university center gathers photonics and circuit researchers to develop next-generation computer I/Os

Intel Labs recently opened the Intel Research Center for Integrated Photonics for Data Center Interconnects. The center's mission is to accelerate optical input/output (I/O) technology innovation in performance scaling and integration, with a specific focus on photonics technology and devices, CMOS circuits and link architecture, and package integration and fiber coupling.

"At Intel Labs, we're strong believers that no one organization can successfully turn all the requisite innovations into research reality," says James Jaussi, senior principal engineer and director of the PHY Research Lab in Intel Labs. "By collaborating with some of the top scientific minds from across the United States, Intel is opening the doors for the advancement of integrated photonics for the next generation of compute interconnect. We look forward to working closely with these researchers to explore how we can overcome impending performance barriers."

The ever-increasing movement of data from server to server is taxing the capabilities of today's network infrastructure. The industry is quickly approaching the practical limits of electrical I/O performance. As demand continues to increase, electrical I/O power-performance scaling is not keeping pace and will soon limit available power for compute operations, says Intel. This performance barrier can be overcome by integrating compute silicon and optical I/O, a key research center focus, it adds.

Intel has recently demonstrated progress in critical technology building blocks for integrated photonics. Light generation, amplification, detection, modulation, CMOS interface circuits and package integration are essential to achieve

the required performance to replace electrical as the primary high-bandwidth off-package interface.

Additionally, optical I/O has the potential to dramatically outperform electrical in the key performance metrics of reach, bandwidth density, power consumption and latency. Further innovations are necessary on several fronts to extend optical performance while lowering power and cost, says Intel.

The Intel Research Center for Integrated Photonics for Data Center Interconnects brings together universities and researchers to accelerate optical I/O technology innovation in performance scaling and integration. The research vision is to explore a technology scaling path that satisfies energy efficiency and bandwidth performance requirements for the next decade and beyond.

Intel says that academia is at the heart of technological innovation, so it seeks to catalyze innovation in research at leading academic institutions worldwide. The new center reflects Intel's ongoing commitment to collaborate with academia in developing new and advanced technologies that improve computing.

The following researchers are participating in the Research Center:

- John Bowers, University of California, Santa Barbara (UCSB); Project: 'Heterogeneously Integrated Quantum Dot Lasers on Silicon' — The UCSB team will investigate issues with integrating indium arsenide (InAs) quantum dot lasers with conventional silicon photonics. The goal is to characterize expected performance and design parameters of single-frequency and multi-wavelength sources.
- Pavan Kumar Hanumolu, University of Illinois, Urbana-Champaign (UIUC); Project: 'Low-power optical transceivers enabled by duo-binary signaling and baud-rate clock recovery' — This project will develop ultra-low-power, high-sensitivity optical receivers using novel trans-impedance amplifiers (TIAs) and baud-rate clock & data recovery architectures. The prototype optical transceivers will be implemented in a 22nm CMOS process to demonstrate very high jitter tolerance and excellent energy efficiency.
- Arka Majumdar, University of Washington;

Project: 'Nonvolatile reconfigurable optical switching network for high-bandwidth data communication' — The UW team will work on low-loss, non-volatile electrically reconfigurable silicon photonic switches using emerging chalcogenide phase-change materials. Unlike existing tunable mechanisms, the developed switch will hold its state, allowing zero static power consumption.

- Samuel Palermo, Texas A&M University;

Project: 'Sub-150fJ/b optical transceivers for data center interconnects' — This project will develop energy-efficient optical transceiver circuits for a massively parallel, high-density and high-capacity photonic interconnect system. The goal is to improve energy efficiency by employing dynamic voltage frequency scaling in the transceivers, low-swing voltage-mode drivers, ultra-sensitive optical receivers with tight photodetector integration, and low-power optical device tuning loops.

- Alan Wang, Oregon State University;

Project: '0.5V silicon micro-ring modulators driven by high-mobility transparent conductive oxide' — This project seeks to develop a low-driving-voltage, high-bandwidth silicon micro-ring resonator modulator (MRM) through heterogeneous integration between the silicon MOS capacitor with high-mobility Ti:In2O3. The device promises to overcome the energy-efficiency bottleneck of the optical transmitter and can be co-packaged in future optical I/O systems.

- Ming Wu, University of California, Berkeley;

Project: 'Wafer-scale optical packaging of silicon photonics' — The UC Berkeley team will develop integrated waveguide lenses that have the potential to enable non-contact optical packaging of fiber arrays with low loss and high tolerances.

- S.J. Ben Yoo, University of California, Davis;

Project: 'Athermal and power-efficient scalable high-capacity silicon-photonic transceivers' — The UC Davis team will develop extremely power-efficient athermal silicon photonic modulator and resonant photodetector photonic integrated circuits scaling to 40Tb/s capacity at 150fJ/b energy efficiency and 16Tb/s/mm I/O density. To achieve this, the team will also develop a new 3D packaging technology for vertical integration of photonic and electronic integrated circuits with 10,000 pad-per-square-mm interconnect pad density.

www.intel.com

Hesai and Lumentum partner on LiDAR for automotive applications

First 200m, long-range VCSEL-based hybrid solid-state LiDAR for ADAS

Light detection and ranging (LiDAR) sensor manufacturer Hesai Technology of Shanghai, China and Lumentum Holdings Inc of San Jose, CA, USA — which provides vertical-cavity surface-emitting laser (VCSEL) arrays for 3D sensing and other applications — have partnered on hybrid solid-state directional LiDAR solutions for advanced driver-assistance systems (ADAS).

LiDAR sensors are an essential part of autonomous vehicles (AVs), but conventional LiDAR approaches have been challenged by high costs and poor manufacturability. Incorporating VCSEL array light sources can significantly improve LiDAR cost competitiveness and scalability.

"As the automotive industry transitions from the testing phase for AVs to mass-volume-production phase for ADAS applications, cost and manufacturability are the biggest challenges the industry faces," says Hesai's co-founder & CEO Dr David Li. "We are pleased to be collaborating with Lumentum on our hybrid solid-state LiDAR AT128 for ADAS applications, which contains an all-VCSEL-based design to achieve high-affordability, and automotive-grade reliability and consistency requirements," he adds.

Hesai's AT128 is a hybrid solid-state directional LiDAR that features a 200m range at 10% reflectivity, high point density (>1.5m points per second), and small form factor. Each AT128 incorporates 128 of Lumentum's high-power multi-junction VCSEL arrays emitting at 905nm. The multi-junction VCSEL arrays are built on the manufacturing foundation developed over the past several years of high-volume VCSEL array shipments serving the consumer electronics market.

"We are excited to leverage our leading-edge multi-junction VCSEL array capabilities and manufacturing scale in working with Hesai to help enable innovative, cost-effective and high-volume LiDAR solutions," says Lumentum's president & CEO Alan Lowe.

Over the past few years, more than a billion Lumentum VCSEL arrays have been deployed in mobile, consumer electronics, industrial and other applications, creating significant manufacturing economies of scale. At the same time, Lumentum's advances in VCSEL array technology have resulted in what is claimed to be record peak optical power densities and efficiencies, making the firm's VCSEL arrays suitable for high-performance ADAS and AV applications.

High-volume shipments of the AT128 into multiple existing ADAS OEM design-wins are expected to begin in 2022.

www.lumentum.com/en/products/multi-junction-vcsel-arrays

OIF adopts CMIS work initiated by QSFP-DD MSA

CMIS can be used by pluggable or on-board modules, such as QSFP-DD, OSFP, COBO, QSFP

The Optical Internetworking Forum (OIF) says it is expanding its role in driving industry interoperability through the addition of the Common Management Interface Specification (CMIS) work initiated by the Quad Small Form Factor Pluggable Double Density (QSFP-DD) Multi Source Agreement (MSA).

CMIS may be used by pluggable or on-board modules, such as QSFP Double Density (QSFP-DD), OSFP, COBO, QSFP, and future module developments like co-packaged optics with host-to-module management communication based on a two-wire interface. This specification is targeted at systems manufacturers, system integrators and suppliers of CMIS-compliant optical and copper modules.

"The QSFP-DD MSA initiated the CMIS effort to address an industry need for commonality in managing pluggable modules, and it has been broadly and successfully adopted across the industry," says Cisco's Mark Nowell, QSFP-DD MSA Group founding member and MSA co-chair. "OIF is very well suited to maintain and extend the development of this effort and I look forward to seeing their progress," he adds.

"Adopting CMIS from the QSFP-DD MSA, with the goal to build on and extend the specification, is an ideal expansion of OIF's work," says TE Connectivity's Nathan Tracy, OIF's VP of marketing. "OIF is where the cloud gets its work done, and extending CMIS is a giant step forward and an integral linkage to the other work that OIF members are doing to enable an interoperable ecosystem."

In August, OIF announced the new Physical & Link Layer (PLL) Working Group Management track to include the transition of ownership and maintenance of CMIS from the QSFP-DD MSA to OIF and a project to focus on CMIS extensions for co-packaging implementations. OIF will take over the ongoing CMIS revisions and further enhancements and CMIS extensions under this track. This track is co-vice-chaired by Cisco's Gary Nicholl and Ciena's Ian Alderdice.

"OIF's value to the industry is deep, as proven by the industry's support and endorsement of this transfer of the CMIS work to OIF," comments Tracy.

The current CMIS and prior revisions (from QSFP-DD MSA) are now available to members on the OIF website.

www.oiforum.com/documents/archived-non-oif-generated-specifications

II-VI Inc signs renewable energy contract in China

Wuxi to become II-VI's largest all-renewable-powered site over the next four years

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA has signed a major renewable energy contract in China.

The II-VI site in Wuxi represents about 50% of the firm's footprint in China and about 20% of its global footprint by area. Over the next four years, this facility will become the largest II-VI site to be powered with 100% renewable electricity.

"This purchase agreement includes approximately 167 million kWh of renewable electricity over the next four years, thereby avoiding nearly 92,000 metric tons of CO_2 emissions cumulatively over this period," says Gary Lin, senior VP, Operations, Photonic Solutions Segment. "This demonstrates our commitment to increase the sustainability in our energy supply across our global footprint."

II-VI says that it has set as a top priority to reduce its carbon footprint across its global operations. II-VI announced last October that it is powering all of its facilities in Europe with 100% renewable electricity sources. Globally, II-VI has entered into renewable electricity contracts for 25 sites, including 14 of them now covering 100% of their annual electricity usage with renewable sources.

Over 25% of II-VI's global electricity needs are now supplied by renewable sources across the USA, Europe and China. The amount of renewable electricity powering II-VI's operations is expected to grow annually and, in the future, include the company's other major manufacturing sites in Asia.

www.ii-vi.com

First Solar wins 1.2GW order from Swift Current Energy

PV modules to be delivered in 2023 and 2024

First Solar Inc of Tempe, AZ, USA says that Swift Current Energy (which acquires, develops, constructs, owns and operates utility-scale wind, solar energy and battery storage projects across the USA) has placed an order for 1.2GW$_{DC}$ of its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules, to be delivered in 2023 and 2024.

Founded in 2016, backed by Buckeye Partners L.P. and Nala Renewables, and headquartered in Boston, Massachusetts (with offices in Illinois, Maine, Montana and Texas), Swift Current has commercialized 1.1GW of renewable energy projects, and has a growing pipeline of over 6GW of planned renewable assets across North America.

"This is our largest procurement yet and demonstrates our ongoing commitment to investing in renewable energy," says Swift Current Energy's CEO Eric Lammers. "First Solar, with its record of quality and sustainability, is a great match for our team and will support our work to develop, construct and own best-in-class renewable energy projects safely, on time and within budget," he believes.

Designed and developed at its R&D centers in California and Ohio, First Solar's modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance. First Solar also operates a recycling program that recovers more than 90% of CdTe for use in new modules.

"We look forward to enabling their [Swift Current Energy's] efforts to support our country's march towards sourcing 45% of its electricity from solar by 2050 with responsible solar technology that is designed and developed in the United States," says First Solar's chief commercial officer Georges Antoun. "As US project developers look for reliable module supply partners, we're able to support their needs not only with advanced technology that reliably performs in the field, but also with our ability to provide long-term pricing and supply commitments."

First Solar is investing $680m in expanding the USA's domestic PV solar manufacturing capacity by 3.3GW annually by building its third US manufacturing facility (in Lake Township, Ohio). The new facility is expected to be commissioned in first-half 2023 and, when fully operational, will scale the firm's Northwest Ohio footprint to a total annual capacity of 6GW, which is believed to make it the largest fully vertically integrated solar manufacturing complex outside China.

In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia, and is building a new 3.3GW factory in India that is expected to be commissioned in second-half 2023. With First Solar's expansion in the USA and India and optimization of its existing fleet, the firm anticipates that its nameplate manufacturing capacity will double to 16GW by 2024.

www.firstsolar.com
www.swiftcurrentenergy.com

First electrically pumped lithium niobate/III-V laser

O-band tuning of 36nm achieved for hybrid laser comprising InP optical gain chip butt-coupled to an LNOI lithium niobate on insulator photonic integrated circuit.

Sun Yat-sen University in China and University of British Columbia in Canada claim the first electrically pumped hybrid lithium niobate/III–V laser [Ya Han et al, Optics Letters, v46, p5413, 2021]. The device consisted of an indium phosphide (InP) optical gain chip butt-coupled to a lithium niobate ($LiNbO_3$) on insulator (LNOI) photonic integrated circuit (PIC). The hybrid laser achieved a 36nm tuning range in the O-band infrared optical communication range (1260–1360nm).

Lithium niobate (LN) features a wide transparent bandwidth, and high electro-optic and second-order nonlinear optical coefficients. The researchers believe that integrating an LNOI modulator section to the hybrid laser could pave the way to a fully integrated optical transmitter beyond 100gigabit/second data rates for wavelength-division multiplex (WDM) systems. WDM requires electrically pumped tunable single-mode lasers.

The light of the hybrid laser was generated in an InP-based reflective semiconductor optical amplifier (RSOA), coated to provide an anti-reflective front facet (<0.01% reflection), and partially reflective (~10%) rear facet. The front facet was tilted 8° to further reduce back reflection into the RSOA, avoiding lasing just within the InP device.

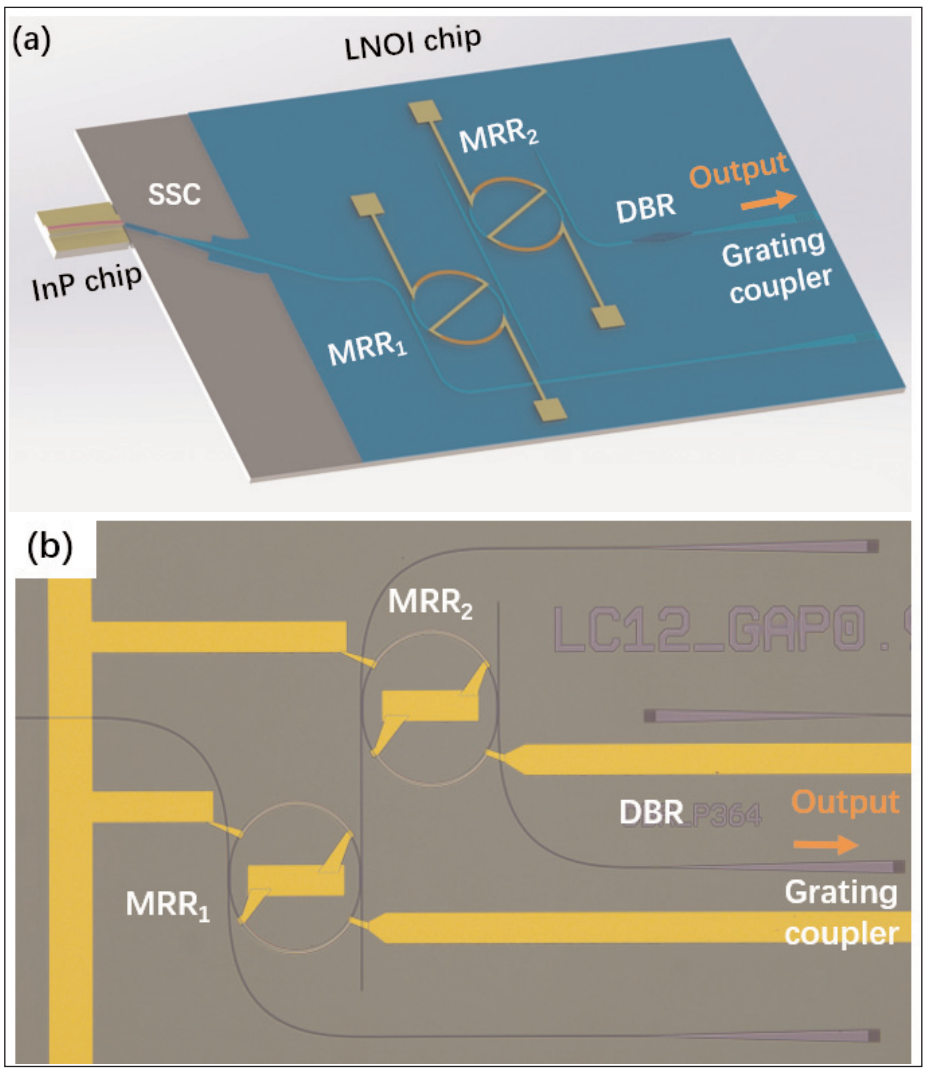


Figure 1. (a) Schematic for tunable hybrid LN/III-V laser using LNOI PIC for laser feedback; (b) microscope image of fabricated LNOI PIC.

The LNOI PIC (Figure 1) included a spot size converter (SSC) to couple the light from the RSOA efficiently. The complete 5.18mm-long Fabry-Pérot laser cavity was between the rear partially reflective facet of the RSOA and a distributed Bragg reflector (DBR) on the LNOI PIC.

The laser wavelength was tuned by two cascaded micro-ring resonators (MRRs) with slightly different free spectral range, using a Vernier filter effect. The laser wavelength was altered by heating the MRRs.

The researchers used LNOI with x-cut LN crystal orientation. The LNOI wafer consisted of 360nm LN layer, 4.7μm thermal silicon dioxide insulator, and 500μm silicon substrate. Patterning of the LN consisted of electron-beam lithography and inductively coupled plasma etch. This patterning was carried out in two steps: the first creating the waveguide, and the second the inverse tapered structure for off-chip coupling.

The LNOI fabrication was completed with plasma-enhanced chemical vapor deposition (PECVD) of 1μm silicon dioxide, lift-off processing of nickel-chromium with gold contact pads for the heaters, and polishing the facet for efficient light coupling to the RSOA.

The beam from the RSOA chip was elliptical with 1.98μmx0.99μm waist. The SSC was a bilayer inverse taper design with the bottom layer being a trident waveguide, and the top was a butt-coupling interface.

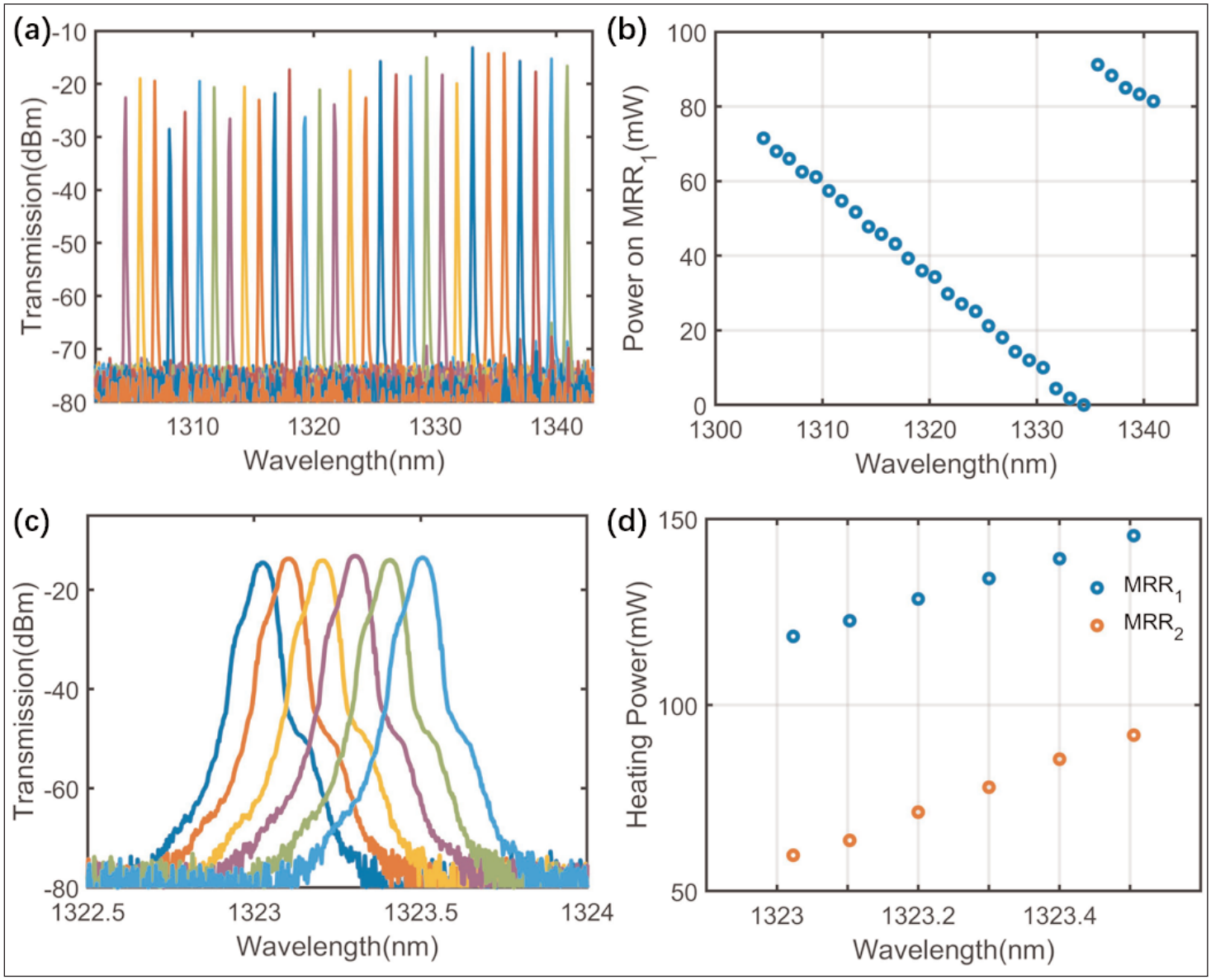


Figure 2. Superimposed spectra of (a) coarse tuning and (b) corresponding lasing wavelength and heating power on MRR1. Superimposed spectra of (c) fine tuning and (d) corresponding lasing wavelength and heating power on MRR1/MRR2.

The light was output through a grating coupler.

The threshold current for lasing at 1331.88nm wavelength was 100mA, corresponding to 2.5kA/cm^2 density. The maximum output power was 2.5mW, at 300mA injection current. The output power was limited by the leakage from the back facet of the RSOA, while the DBR had 90% reflection to ensure lasing. Unfortunately, the researchers' setup did not allow light collection from the RSOA's back facet.

The light output power did not increase monotonically, since there was mode hopping as the current increased. At 200mA, the light output was at 1325.5nm wavelength with single-mode suppression ratio (SMSR) higher than 60dB.

By variously heating the MRRs, a wide range of wavelengths, 1.3045–1.3409μm, was achieved (Figure 2). For all these wavelengths, the SMSR was more than 43dB with 200mA injection.

The team comments that the results achieved were comparable with the performance of state-of-the-art combinations of InP RSOAs with other PIC technologies using silicon (1.647–1.69μm wavelength range) or silicon nitride (1.524–1.568μm) waveguide materials. The InP–LNOI combination also had a wider wavelength range and higher SMSR than a monolithic III–V O-band laser (1.2802–1.312μm, 52dB peak SMSR). The monolithic laser did have much higher output power: 7.8mW, compared with 2.5mW for the LNOI hybrid.

The researchers point out that the low rear facet reflectivity suggests that much better performance can be reached by increasing from a measly 10% to 90%. "Furthermore, reducing the coupling loss between the RSOA and LNOI chip can further improve the on-chip output power," they add. ■

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Author: Mike Cooke

Defect-tolerant type-II QW lasers on silicon

An estimated 312,000-hour mean time to failure is reckoned to be the first report of a MTTF beyond 1000 hours.

Université de Montpellier and Université Paris-Saclay in France have used 'type-II' quantum well (QW) structures to produce extremely dislocation-tolerant III–antimonide interband cascade lasers (ICLs) on silicon substrates [Laurent Cerutti, Optica, v8, p1397, 2021].

One measure of the dislocation tolerance was an estimated 312,000 hour mean time to failure (MTTF) for devices tested under continuous-wave operation at 40°C. The team comments: "To our knowledge, it is the first report of a lifetime longer than 1000 hours for any interband (QW or QD) laser with a density of dislocations above 108/cm^2."

Beyond devices based on gallium antimonide/aluminium antimonide (GaSb–AlSb), the researchers see potential for their type-II QW techniques in other compound semiconductor families, such as indium phosphide, gallium arsenide or zinc selenide.

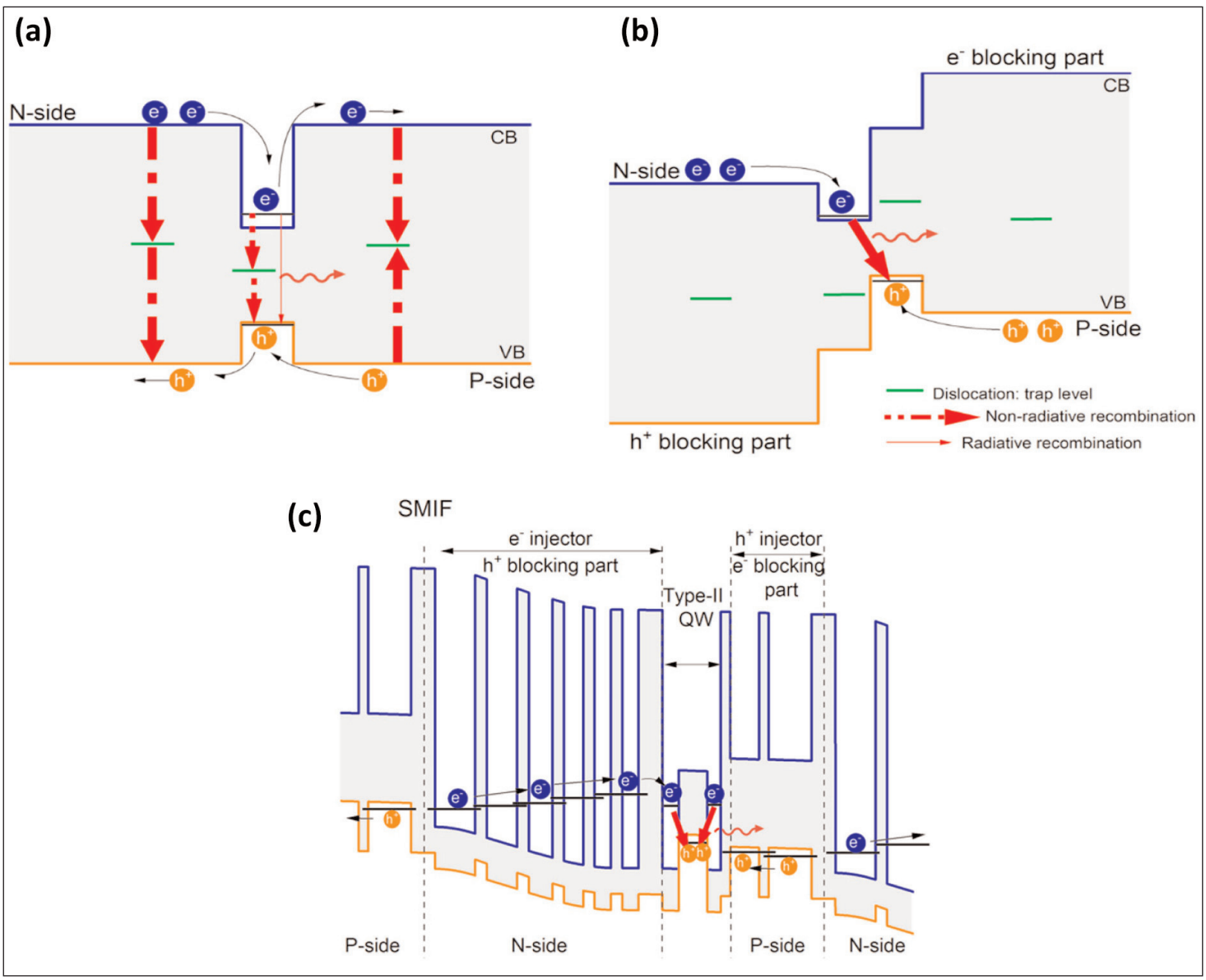

Figure 1. Representations of recombination processes in (a) type-I and (b) type-II QW active regions. (c) Type-II QW ICL with band diagram criteria represented in (b).

III–V light emitters on silicon such as Montpellier/Paris-Saclay's ~3.5μm ICL are highly desired for integration in silicon photonic integrated circuits (PICs) for interconnects and on-chip sensing.

The usual technique to avoid the performance degradation from threading dislocations is to use localized quantum dots (QDs) to isolate electron–hole recombination into photons from the non-radiative recombination that generally occurs near dislocations and other defects. Even so, lifetimes rapidly reduce when dislocation density exceeds 10^7/cm^2. QW lasers with $5x10^7$/cm^2 dislocations have previously achieved a mere 200 hour MTTF.

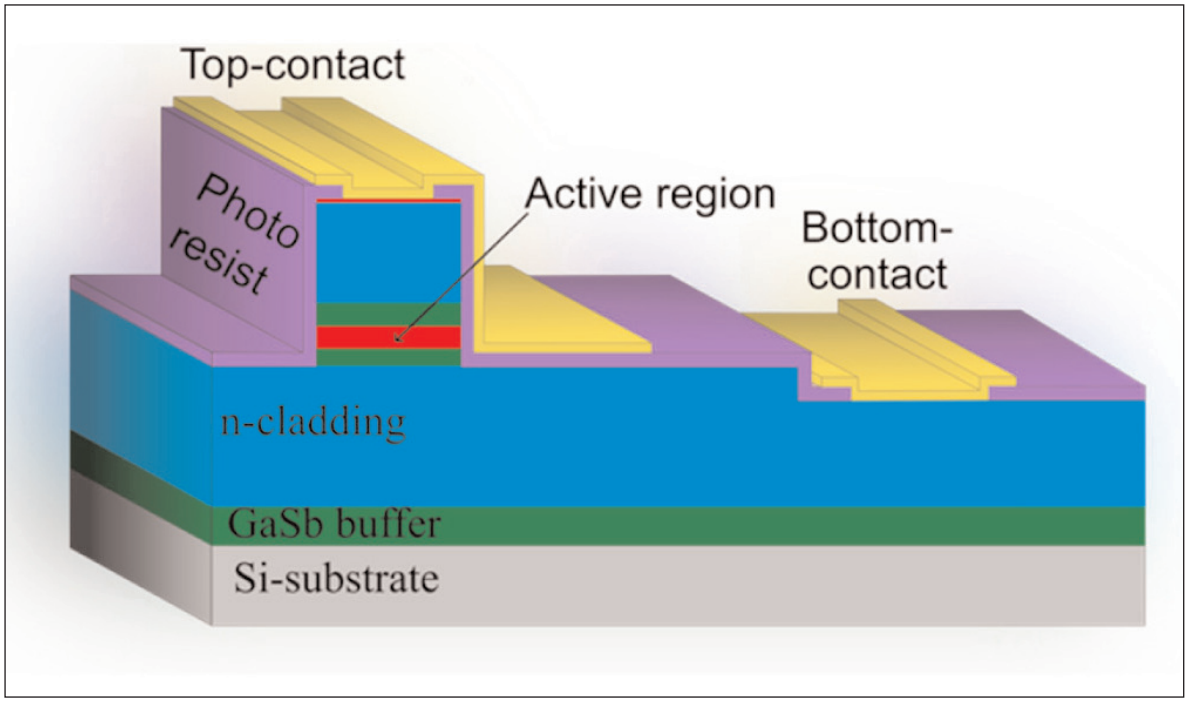

Figure 2. Schematic representation of processed ICL grown on silicon substrate.

The non-radiative recombination at dislocations doesn't just sap device efficiency, it also moves and generates dislocations, a process known as 'recombination-enhanced defect reaction', further impeding device performance, pushing it toward failure.

The more usual type-I QWs use a band alignment where the electrons and holes gather in a single well (Figure 1). Type-II QW structures instead use separate, neighboring electron and hole QWs. This makes radiative recombination more favorable relative to the mid-gap non-radiative recombination associated with dislocations. Another advantage of the type-II layout is the barrier created to the other carrier type, rather than using the usual separate electron-hole blocking structures to reduce non-radiative recombination in the doped cladding/contact layers.

The Montpellier/Paris-Saclay devices used ICL structures grown by solid-source molecular beam epitaxy on on-axis (001) silicon. The high 13% lattice mismatch with GaSb resulted in a high dislocation density of 10^{13}/cm^2. The GaSb buffer was 1.5μm thick. The laser material consisted of 7 IC stages aimed at 3.5μm wavelength emission. The optical confinement was provided by a GaSb separate-confinement heterostructure, along with N-type AlSb/InAs superlattice cladding. The antimonide materials comprised a total thickness of 7.9μm, below the 10μm level where GaSb-based heteroepitaxy on silicon tends to crack.

The researchers comment that most dislocations generated at the GaSb/Si interface were confined within the first 0.5μm growth. By the time the full buffer layer was grown, the dislocation density was in the 8–$9x10^8$/cm^2 range. The AlSb/InAs superlattice cladding reduced this slightly to ~$5x10^8$/cm^2 range, still a relatively high level for laser performance.

The material was processed into 8μm-wide ridge-waveguide laser bars (Figure 2). The cleaved facets were uncoated. The turn-on voltage was around 3V at 20°C, comparable to similar devices produced in the same way on GaSb substrates. The series resistances for 3–1mm cavities were 20–30Ω on silicon, but 1–3Ω on GaSb. The researchers attribute the high resistance on silicon to the "lateral current path and the poor electrical conductivity of the low-doped upper part of the AlSb/InAs bottom cladding layer where this contact is located".

The laser threshold was in the range 30–70mA, depending on cavity length with similar performances on silicon and GaSb substrates. The output power reached 19mW/facet, and the slope efficiency 0.3W/A.

Below threshold, a 2mm-cavity laser emitted at 3.425μm wavelength with 172nm full-width at half maximum (FWHM). Above threshold, the peak narrowed and red-shifted to 3.436μm.

The increase in threshold with temperature was represented by a characteristic temperature (T_0) of 43K between 15°C and 35°C. The shift became more rapid between 40 and 50°C with a reduced T_0 of 26K. The thermal performance on GaSb was similar.
The multi-mode emission peak also red-shifted from around 3.49μm at 15°C to 3.53μm at 45°C.

To assess long-term reliability, the devices were operated at 40°C and 120mA current injection (~1.5x

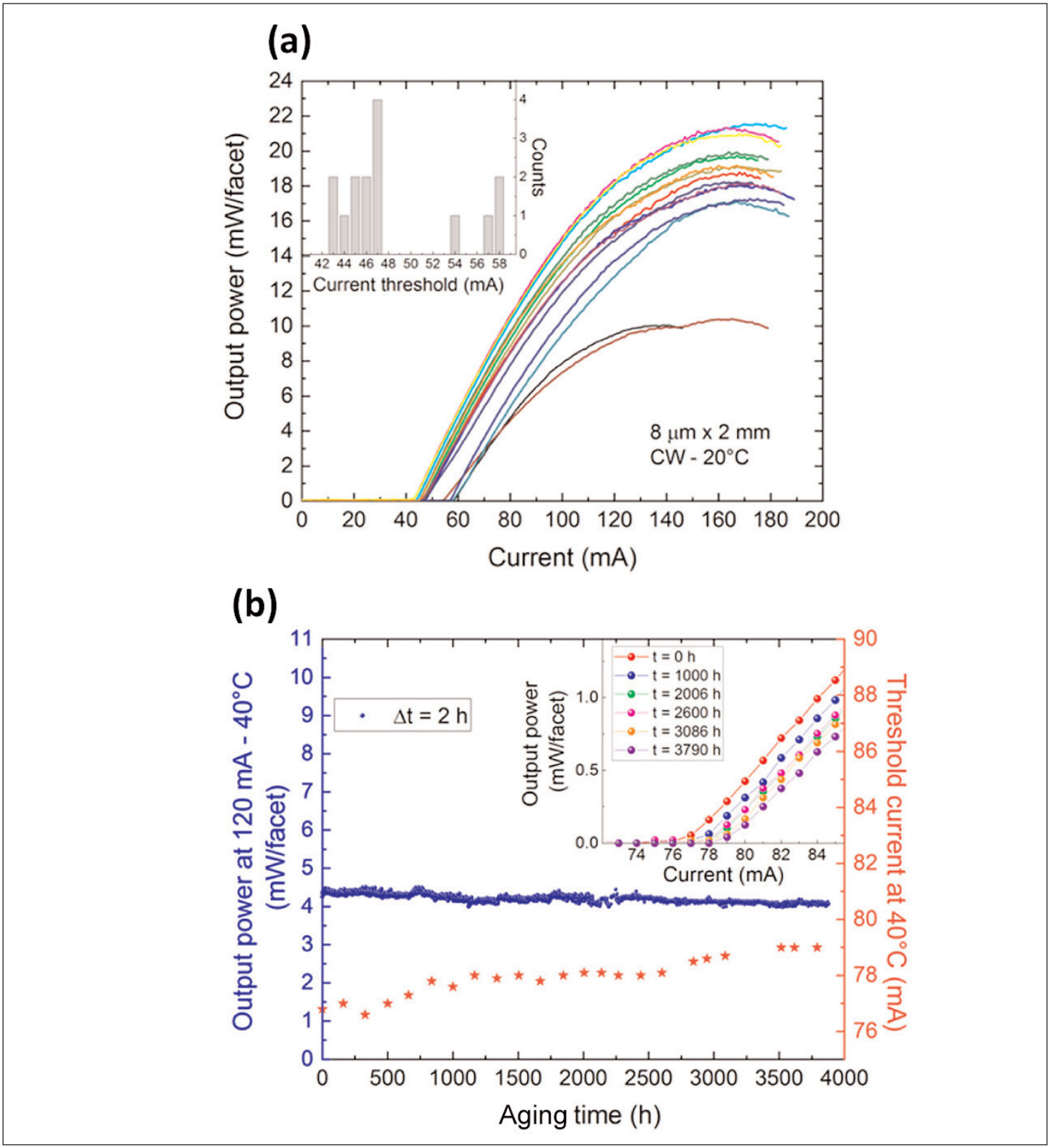

Figure 3. Continuous wave (CW) reliability of ICL grown on silicon. (a) Output power-current (L–I) characteristics of 15 8μmx2mm ICLs tested at 20°C. Inset: histogram of CW threshold current at 20°C. (b) Aging data at 40°C and under 120mA current injection. Inset: L–I characteristics of laser around threshold at different times of aging.

threshold) and the output power tracked. Periodic threshold measurements were also made (Figure 3). The high operating temperature induced accelerated aging.

Over 3800 hours, the threshold increased 2.8%, and the output power fell 6.5%. The researchers extrapolate a mean time to failure (MTTF), using a sub-linear data fit, of 312,000 hours, the time needed to double the threshold current. ■

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Silicon nanocrystal white LED progress

White light-emitting diodes based on silicon nanocrystals achieve peak luminance of 2060cd/m^2 and external quantum efficiency of 0.16%.

Fudan University in China reports progress towards effective white light-emitting diodes (WLEDs) based on silicon nanocrystals (SiNCs) [Yu-Chen Zhang et al, Optics Express, v29, p34126, 2021]. The main attraction of such a development is that silicon is about 20,000 times more abundant than gallium, the base material for commercial, efficient III–nitride WLEDs, which are increasingly being deployed to reduce light energy consumption relative to fluorescent and, even more so, incandescent technologies.

Gallium (and its group–III relative indium) are produced as a byproduct of mining for more common materials, such as from bauxite, the source of aluminium, another group-III relative (indium often comes from zinc ores). The average 15 parts per million concentration means purification from such ores is an expensive, painstaking process.

Further attractions of silicon-based light emission is the potentially much easier monolithic integration with low-cost silicon electronics. However, bulk silicon suffers from low efficiency of light emission due to the indirect nature of the bandgap. SiNC structuring can overcome this problem to some extent, creating the potential for silicon-based LEDs. However, while the Fudan research is promising, it seems at the moment that much further development is needed before the technology will become commercial.

The SiNCs were formed using hydrogen silsesquioxane (HSQ with formula $[HSiO_3/2\text{-}]_n$) solution (Figure 1). The solution was dried at 80°C to give a powder, which was then annealed at 1100°C in a 5%:95% hydrogen/ nitrogen forming gas mix, creating SiNCs in silicon dioxide (SiO_2). This material was ground up in ethanol using a ball mill. The SiNCs were then separated out of the solution using vacuum filtration, etched in a water/ethanol/hydrogen fluoride solution, and stored in pentane. The average SiNC size was ~2.4nm.

The substrate for the WLED (Figure 2) was <100> p-Si, textured using a water/hydrogen peroxide/hydrogen fluoride solution. Most layers of the device were applied using physical vapor deposition (PVD)/sputtering. The first sputtered layers were 5nm molybdenum oxide (MoO_3) hole transfer and 20nm SiO_2 rear charge confinement.

The active layer of SiNCs was applied using spin coating of the crystals in pentane along with HSQ. The structure was annealed at 400°C in nitrogen for an hour. The 'self-organized' SiNC source was naturally red-emitting with a peak around 480nm wavelength. The white emission was arranged from forming a colloid of SiNCs and HSQ, and annealing. The photoluminescence quantum yield (PLQY) of the white sample was 11.4%. Varying the annealing temperature gave somewhat different emission electroluminescence spectra of the WLEDs.

The researchers comment: "The white light emission is attributed to the differential passivation of SiNCs, where SiNCs were terminated by both hydrogen (H) and oxygen (O) atoms, with the numbers of adsorbed H and O atoms being different from one SiNC to another."

The device layers were completed with further sputtering: 15nm SiO_2 front charge confinement, 50nm zinc oxide (ZnO) electron transfer, 150nm indium tin oxide (ITO) transparent conductor/current spreader, and 500nm silver (Ag) grid as front electrode. Thermal evaporation of aluminium (Al) onto the back-side of the p-Si substrate gave the rear electrode. The structure was annealed at 400°C in nitrogen to improve the Ohmic behavior of the metal contacts to the device layers.

The white emission was arranged from forming a colloid of SiNCs and HSQ, and annealing. The photoluminescence quantum yield of the white sample was 11.4%. Varying the annealing temperature gave somewhat different emission EL spectra of the WLEDs. White light emission is attributed to the differential passivation of SiNCs, where SiNCs were terminated by both H and O atoms, with the numbers of adsorbed H and O atoms being different from one SiNC to another

During testing the WLED was placed on a Peltier cooler and copper heatsink. The peak electroluminescence wavelength was 536nm, 592nm and 613nm, for active layers annealed at 400°C, 700°C and

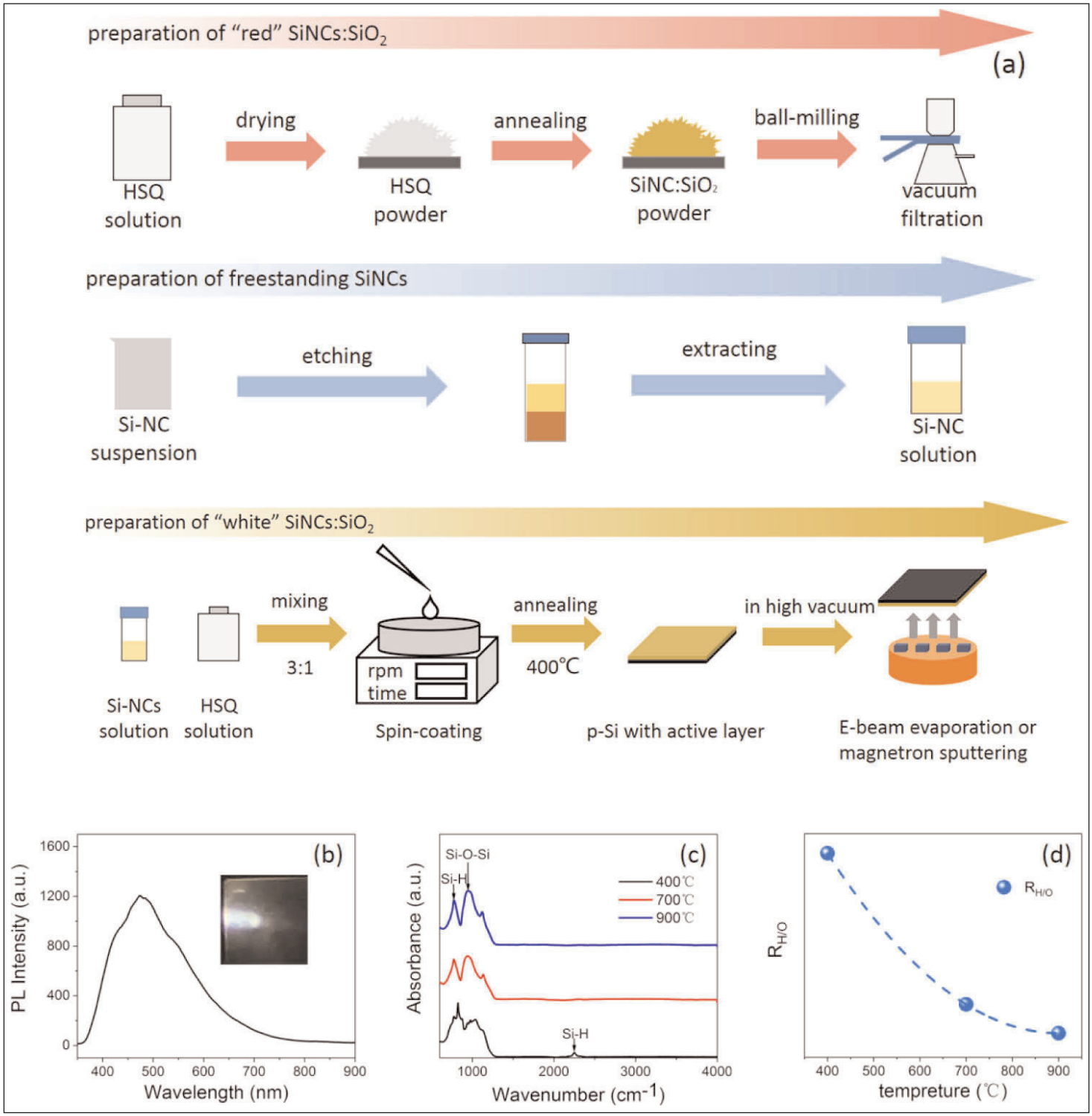

Figure 1. Schematic of freestanding SiNCs and 'white' SiNCs:SiO_2 thin-film sample process flow (a). PL spectrum of 'white' sample, with (inset) photograph of sample under ultraviolet illumination (b). Fourier-transform infrared (FTIR) spectra for 'white' samples with different annealing temperature (T) (c). Ratio of adsorbed H to O as function of T (d).

900°C, respectively. The corresponding color temperatures were 5297K, 4689K and 3686K.

The "best" device was that with the active layer annealed at 400°C. This WLED achieved a peak luminance of 2060cd/m^2 at 13.0V bias, while the external quantum efficiency (EQE) was 0.15%. Turn-on came at 3.7V. The peak EQE was 0.16% at 9.8V. By contrast, blue LEDs based on gallium nitride can reach beyond 80% EQE. Commercial WLEDs usually add a yellow or more complex phosphor to spread the wavelengths from blue, reducing the efficiency somewhat.

The emission intensity for a given injection current decayed over time. At 0.52A/cm^2 injection, the exponential decay time constant was ~94 hours.

The researchers suggest that practical general lighting based on SiNCs "is attainable by further optimizing the

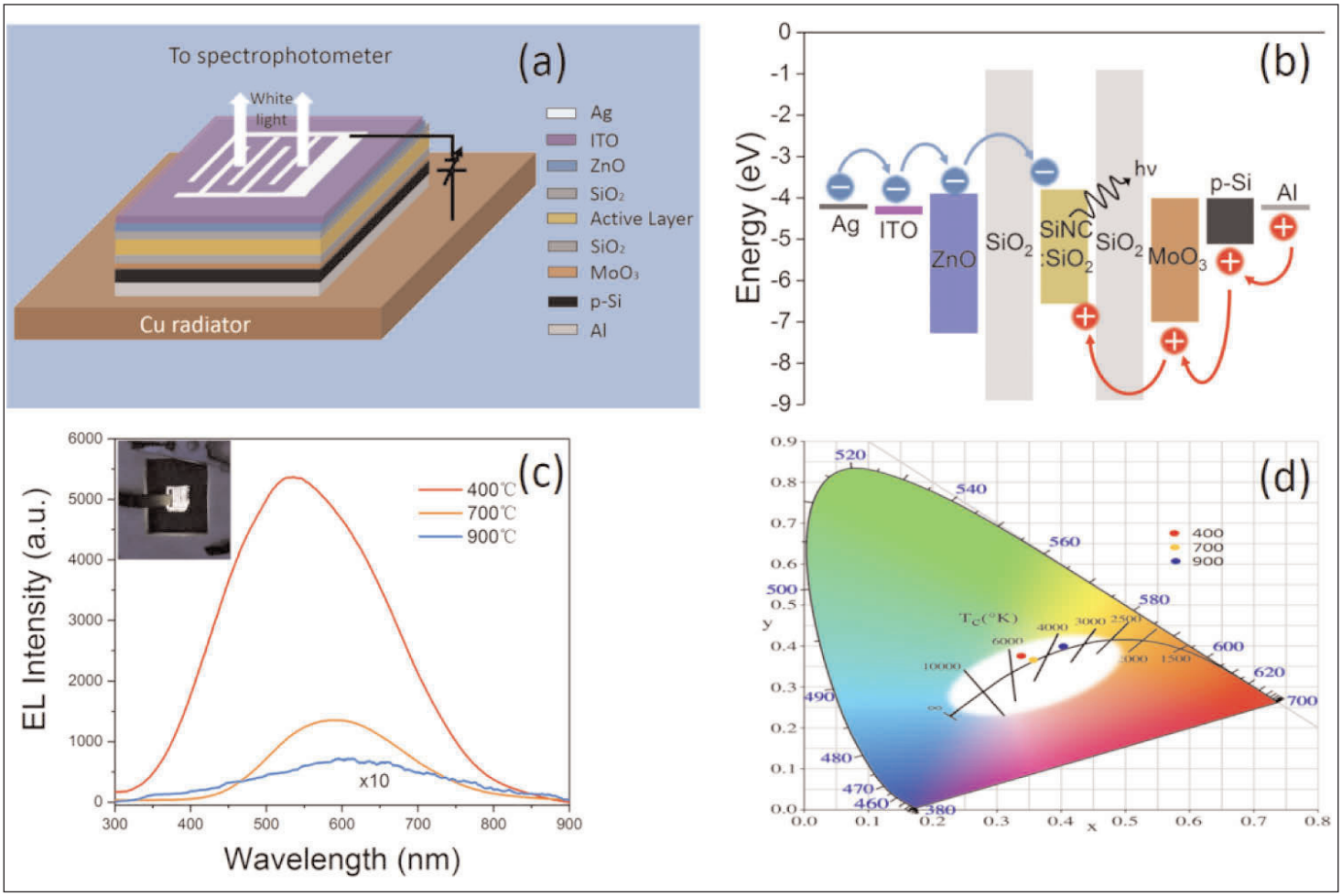

Figure 2. Schematic of SiNC WLED (a). Energy diagrams of components of SiNC WLED (b). EL spectra for different Ts, and inset photograph of silicon LWED for 400°C active layer annealing (c). Chromatic chart for SiNC WLEDs for different temperatures (d).

components following the strategy of optimizing the rate of injection and transport of charges, strengthening the confinement of the injected charges within the active layer, increasing the PLQY of the active layer, and enhancing the efficiency of light extraction and the heat dissipation." ■

https://doi.org/10.1364/OE.437737

Author: Mike Cooke

AlN passivation for InGaN micro-LEDs

Atomic layer deposition on sidewalls leads to boosts in emission and detection efficiency.

Fudan University in China has reported improved efficiency for indium gallium nitride (InGaN) micro-scale (blue) light-emitting diodes (micro-LEDs) from using aluminium nitride (AlN) passivation [Dingbo Chen et al, Optics Express, p36559, v29, 2021]. AlN passivation has previously been deployed in power GaN applications, and for p-GaN LED contacts, but not so far for micro-LED sidewalls, according to the team.

Passivation of mesa sidewalls is critical in micro-LEDs since activity there increases in relative importance as scales reduce. Dangling bonds and surface damage from etch processes lead to non-radiative recombination centers, and also increase surface conductivity, leading to leakage currents.

The researchers see future opportunities arising from combined micro-scale light emission/detection devices for intelligent display and communication systems.

Aluminium nitride applied using atomic layer deposition (ALD) is more compact than the more common plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2). In fact, PECVD SiO_2 does not provide sufficient surface coverage in very small devices.

The micro-LED structure (Figure 1) was grown by metal-organic chemical vapor deposition (MOCVD) on silicon (Si). The p-GaN contact was activated by annealing at 700°C for 10 minutes in nitrogen.

Device fabrication began with forming the p-side Ohmic contact and transparent current spreader by using electron-beam evaporation and annealing of 5/5nm nickel/gold. The 800nm-high device mesa was sculpted using plasma and wet etch with patterning from ultraviolet photolithography.

The sidewalls were passivated with 30nm AlN from plasma-enhanced ALD. The structure was then covered with PECVD SiO_2.

The device (Figure 2) was completed by wet etch through the SiO_2/AlN and application of titanium/gold electrodes. The peak electroluminescence wavelength was found to be 460nm.

The researchers compared the AlN passivation with aluminium oxide (Al_2O_3) passivation produced from ALD with oxygen replacing ammonia (NH_3) as precursor. In both cases, trimethyl-Al was used as the metal-organic precursor. Al_2O_3 passivation has previously been found to improve the performance of InGaN micro-LEDs.

The turn-on performance improved as the devices became smaller with the turn-on voltage reducing. "This effect is explained by improved thermal and current spreading inside smaller devices," the team comments.

The AlN passivation reduced the leakage current below turn-on by up to two orders of magnitude rela-

Contact	p-GaN	250nm
Electron blocker	p-AlGaN	100nm
Quantum wells	9x($In_{0.13}Ga_{0.87}N$/GaN)	
Contact	n-GaN	2.5μm
Buffer	GaN	1.5μm
Nucleation	AlN	200nm
Substrate	Si (111)	4-inch diameter

Figure 1. Epitaxial structure.

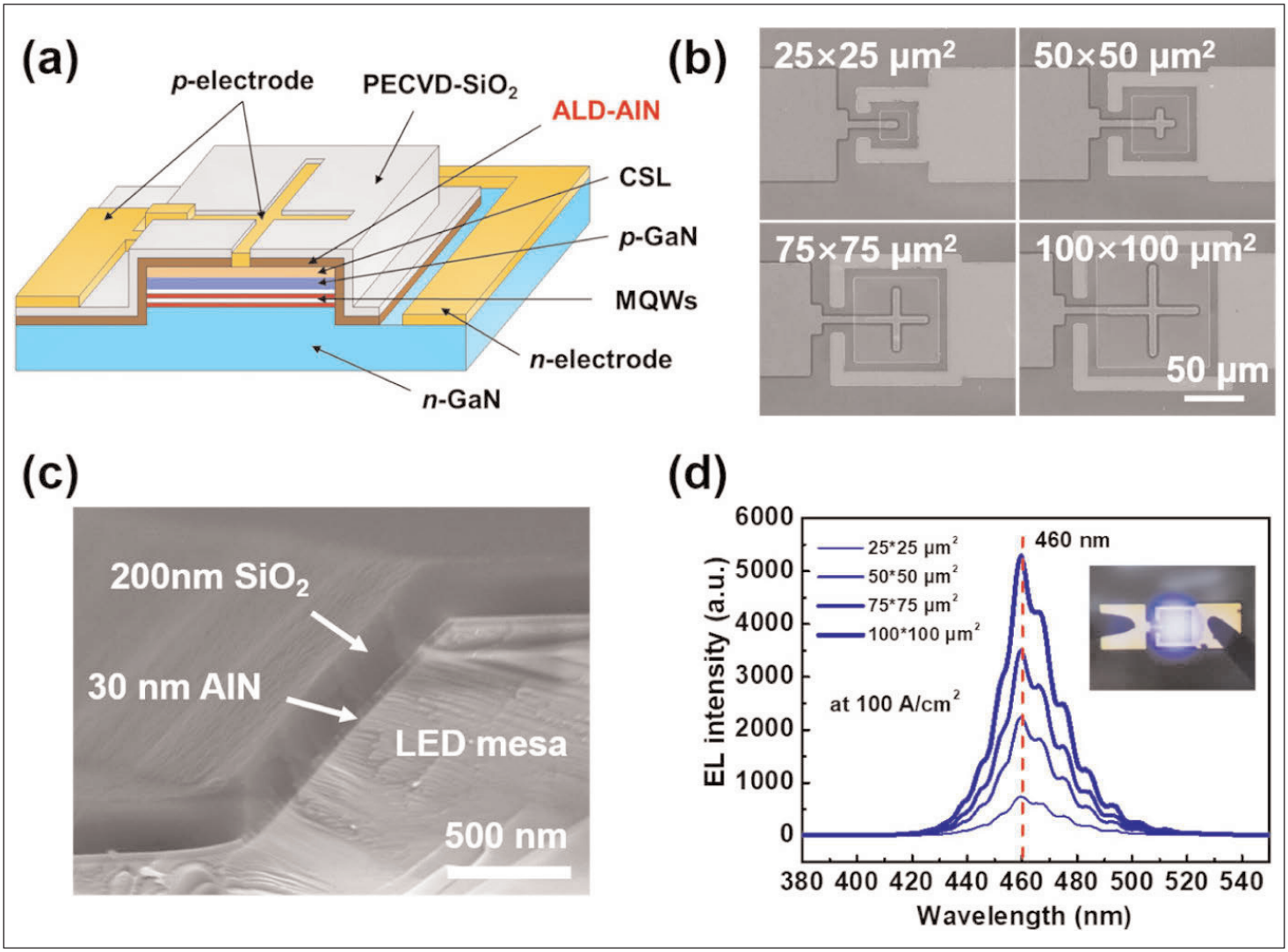

Figure 2. (a) Micro-LED design; (b) scanning electron microscope (SEM) images of fabricated micro-LEDs with different sizes; (c) SEM cross-section of passivated sidewall of micro-LEDs; (d) electroluminescence characteristics of micro-LEDs at 100A/cm^2. Inset: microscope image of 50μmx50μm device.

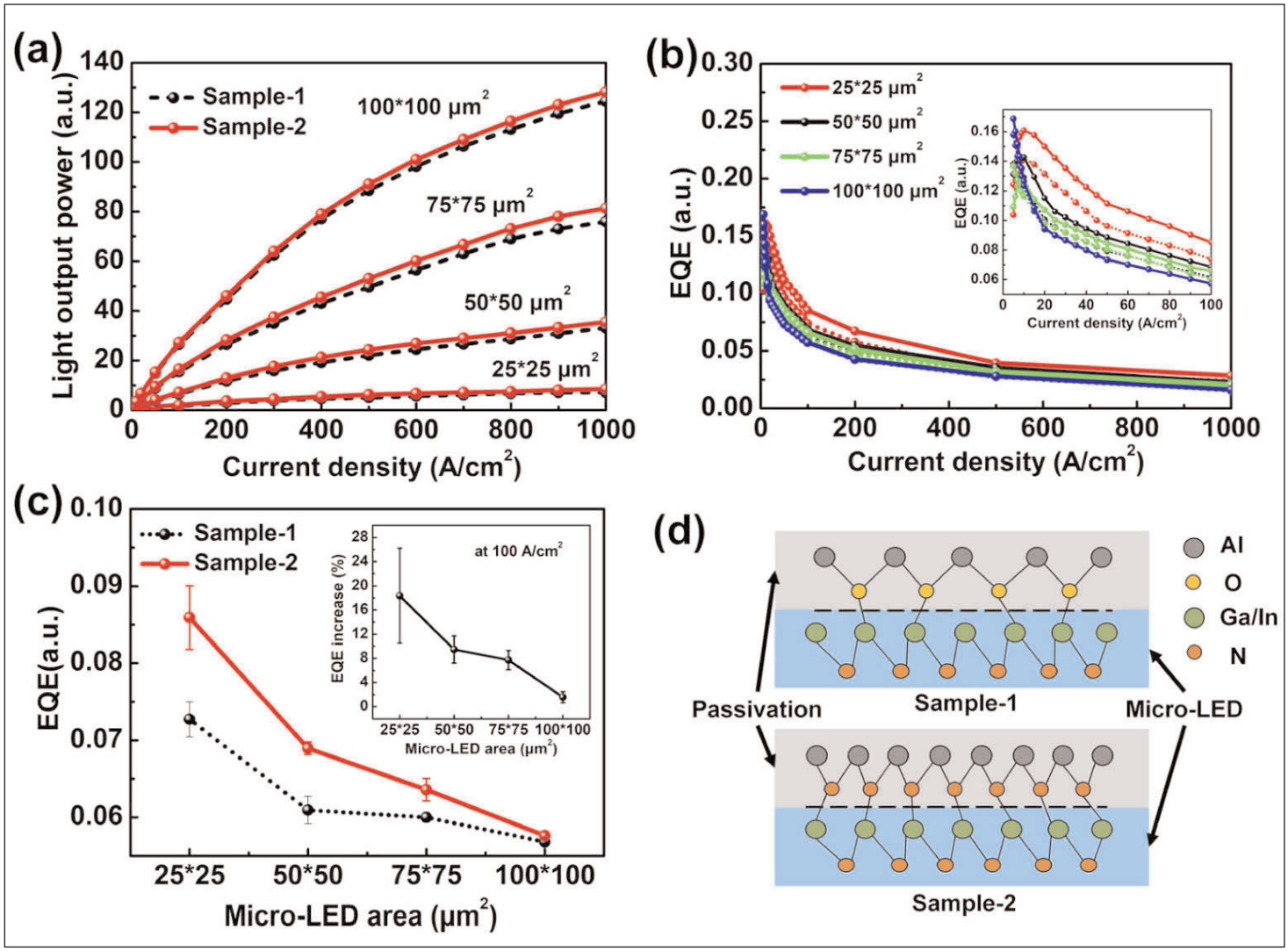

Figure 3. (a) LOP and (b) EQE versus current density characteristics of micro-LED with different passivation and sizes. Inset: EQE in 0–100A/cm² range. Dashed lines represent Sample-1 (Al_2O_3 passivation) and solid lines represent Sample-2 (AlN). (c) Comparison of EQE at 100A/cm². Inset: EQE increase of sample-2 relative to sample-1 versus micro-LED sizes. (d) Ball and stick models for passivation interfaces.

tive to the Al_2O_3 device. The minimum ideality factor (d(ln I)/dV-kT) was measured just above 2V bias. The AlN passivation ideality minimum was 1.6; that of Al_2O_3 was 2.5. Ideality above 2 is indicative of trap-assisted tunneling and carrier leakage, the researchers point out.

The light output power (LOP) had similar performance relative to current density for both device types (Figure 3). However, the reduced voltage that is needed to achieve a given current increased the external quantum efficiency (EQE) of the AlN passivated devices.

Both micro-LEDs suffered severe efficiency droop. Smaller devices had better EQE performance except at very low current, less than 20A/cm². For the smallest 25μmx25μm devices, using AlN passivation improved the peak EQE by 18.3% over Al_2O_3. The improvement in 100μmx100μm LEDs was just 1.6%.

The researchers suggest that the improved AlN passivation results from a better lattice matching with GaN resulting in fewer dangling bonds at the AlN/GaN sidewall interface, relative to Al_2O_3/GaN.

The research team also studied the inverse of light emission — self-powered 0V-bias photodetection. The response spectrum was found to lie mainly in the wavelength range 200–500nm. The peak response was around 360nm, ultraviolet. The EQE of the smallest 25μmx25μm device was about an order of magnitude smaller (~0.05) than the other sizes (0.25–0.4). The AlN passivation, however, gave a 57.7% improved EQE over Al_2O_3 for this smallest micro-LED structure. The improvement for other sizes were: 26.8% for the 50μm square mesas; 11.7%, 75μm; and 3.2%, 100μm.

The researchers suggest that the poor performance of the smallest form factor could be due to "the relatively small proportion of the light absorption area of the device of this size". ■

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Author: Mike Cooke

Metal modulated AlGaN superlattices

A novel epitaxy technique results in highly coherent self-assembled structures.

Georgia Institute of Technology (GaTech) in the USA has been exploring the use of metal modulated epitaxy (MME) to produce aluminium gallium nitride (AlGaN) self-assembled superlattices (SASLs) [Zachary Engel et al, J. Appl. Phys., v130, p165304, 2021].

AlGaN superlattices have a wide potential in III–nitride device structures through providing strain management and dislocation filtering in buffer layers through to electroluminescence in multiple quantum wells (MQWs) and distributed Bragg reflectors (DBRs) for creating laser cavities. In terms of systems and so on, these features could enable production of better power electronics and light-emitting diodes/lasers.

The bandgap range (3.4–6.1eV, GaN–AlN) of AlGaN alloys ranges from the near-ultraviolet to deep-ultraviolet: 365nm to 200nm wavelength. Light around 250nm has a strong virus/bacteria-killing effect through DNA disruption.

GaTech's MME method avoids growth interruptions where the unintentional accumulation of contaminants at interfaces can lead to loss of optical emission and/or structural defects.

The MME technique was applied using molecular beam epitaxy (MBE) on 1cmx1cm AlN-on-sapphire templates, produced by halide vapor phase epitaxy (HVPE). The researchers sputtered 2μm of tantalum on the backside of the templates with a view to improving thermal uniformity during the MME/MBE process.

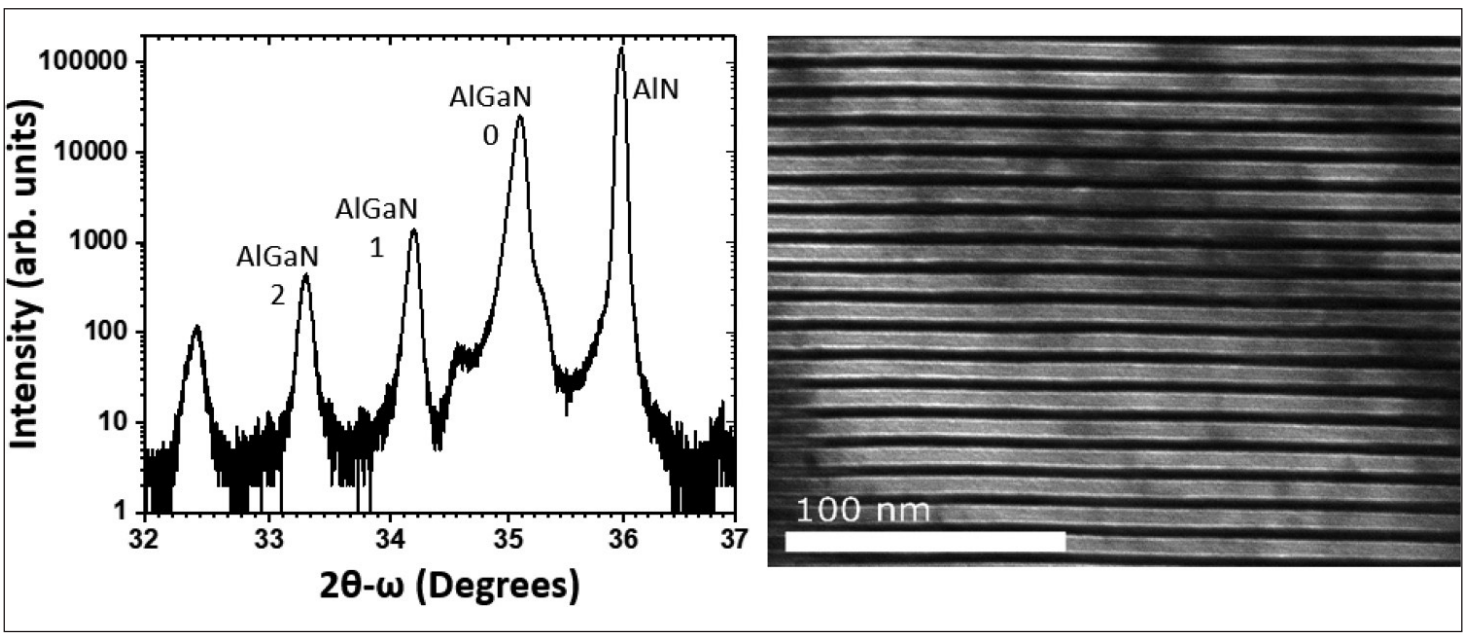

Figure 1. X-ray diffraction 2θ–ω scan (left) of SASL and cross-sectional transmission electron micrograph (right) of sample grown with 1.3 III/V, 14s open-shutter, 2.4μm/h instantaneous growth rate.

Table 1. SASL parametes extracted from x-ray diffraction data, using simulations. Material with 3s open time was single-phase $Al_{0.55}Ga_{0.45}N$.

Sample ID	Shutter open time (s)	Average well Al%	Well thickness (nm)	Average barrier Al%	Barrier thickness (nm)	SL period (nm)	$T_{well}/T_{barrier}$
D1	3	N/A	N/A	N/A	N/A	N/A	N/A
D2	10	31	1	66	3.5	4.5	0.29
D3	14	18	1.5	70	4.9	6.4	0.31
D4	20	8	2.1	67	7	9.1	0.3

After an initial MBE AlN buffer layer, the MME process consisted of supplying the group-III metals with a 1.3 III/V ratio, and shuttering the metal supply with an open/close cycle of up to 21/11s. The substrate temperature was 725°C. The process was monitored using reflection high-energy electron diffraction (RHEED).

The SASL growth effect from MME (Figure 1) arises from the different compositions of the AlGaN when the shutter is open and closed, due to different chemical strengths of the Ga–N and Al–N bonds. During the open part of the cycle Al/Ga metal is supplied to the growth front along with nitrogen plasma. When the metal is cut off, metal on the surface of the sample continues to consume the nitrogen, which continues to be supplied during the closed phase, producing a different composition AlGaN. The periods of the SASLs varied with the shutter-open time: 4.6nm, 6.4nm and 9.1nm for metal doses of 10s, 14s and 20s, respectively (Table 1).

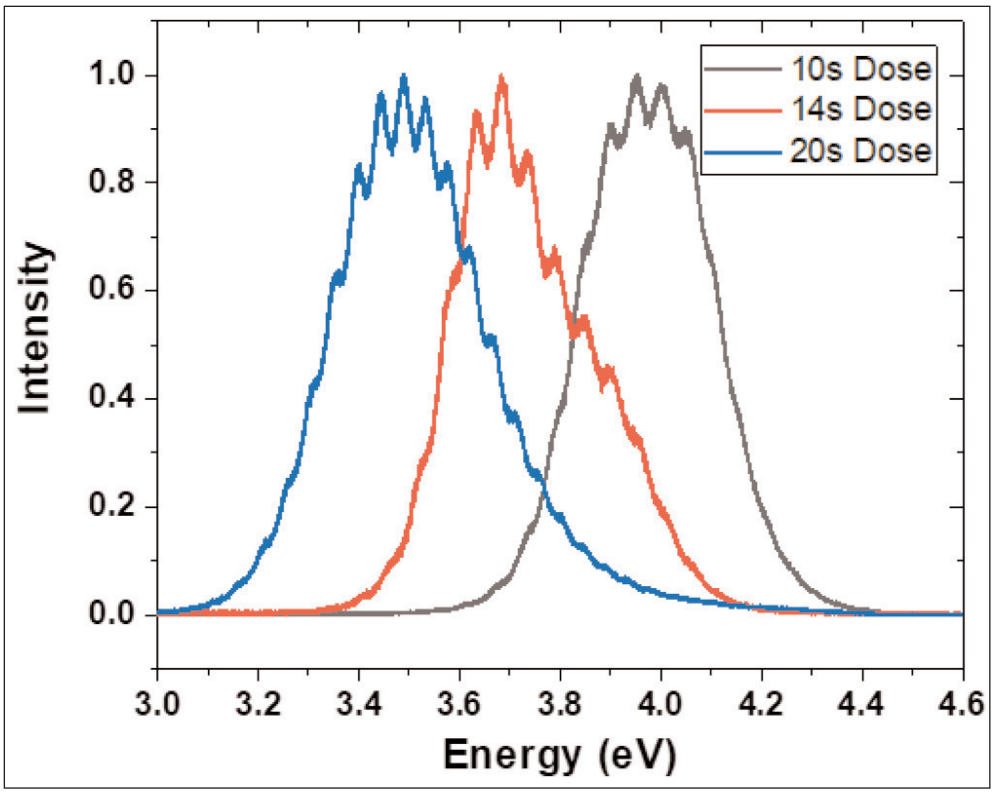

Figure 2. Room-temperature PL spectra of AlGaN SASL structures grown with 10s, 14s and 20s dose showing control of emission energy.

The ratio of lower (well) to higher (barrier) Al composition material thickness was relatively constant at around 30%. The researchers posit that the 30% arises from the III/V ratio being 1.3, 30% being the excess metal during the open phase, which is then consumed during the closed phase. This suggests that the barrier part is the material grown during the open part of the cycle.

The team comments: "We note that the compositions of the well and barrier are different because Al is preferentially grown into the film compared to Ga because the Al–N bond strength in AlGaN is stronger than the Ga–N bond strength in AlGaN. Thus, the metal remaining on the surface after the barrier is grown (at the end of the shutter open time) is Ga-rich, leading to a lower-Al-composition well..."

The researchers also note that the barrier Al content varies by only 4 percentage points, while the well content ranges from 8% to 31%. They suggest that this is a result of the higher-Al-content material being a closer lattice match to the AlN template. This is another factor favoring Al incorporation during the open-shutter time.

Photoluminescence (PL) measurements (Figure 2) confirm the shift in well composition with the peak varying from ~4eV (31% Al well) photon energy down to 3.5eV (8% Al). The mid- 18% Al structure had a peak ~3.7eV. All PL spectra show oscillations from Fabry–Perot interference/reflections from the 4–5μm cavity structure of the samples. The linewidth is fairly broad due to the large numbers of wells: 44, 63 and 88 wells for 20s, 14s and 10s doses, respectively.

Increasing the III/V ratio to 1.8 resulted in a well/barrier ratio of 80%. A structure grown with 14s open-shutter time had 4nm Al0.4Ga0.6N wells and 5nm $Al_{0.7}Ga_{0.3}N$ barriers. The barrier composition matched that with 1.3 III/V. The Al composition in the well was higher than for 1.3 III/V, and the Ga had to be consumed over a thicker well.

The flux of the precursors was also varied. The instantaneous growth rate was increased from 1.3μm/h to 2.8 with 14s shutter-open and 1.3 III/V. The heterostructure consisted of 3.3/11.1nm $Al_{0.14}Ga_{0.86}N/Al_{0.67}Ga_{0.33}N$ wells/barriers. The higher growth rate naturally resulted in thicker structures: 910nm, compared with 400. The higher growth rate was also found to result in a more coherent SASL, according to the x-ray diffraction (XRD) data.

The instantaneous growth rate was defined as "(the deposited material thickness per cycle)/(the cycle time minus the dead time per cycle)". The dead time was the amount of time the RHEED monitoring indicated that no growth was taking place in the shutter-closed part of the cycle.

The researchers comment: "We can specify any arbitrary SASL geometry by controlling III/V ratio, total metal dose, and instantaneous growth rate." ■

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Author: Mike Cooke

HVPE p-GaN vertical pn junction diodes

A single process using halide vapor phase epitaxy, including the p-type layers, enables ideal breakdown behavior.

Japan's Nagoya University has used gallium nitride (GaN) halide vapor phase epitaxy (HVPE) to produce vertical p^+n-junction diodes (PNDs) with "ideal" breakdown voltage [Kazuki Ohnishi et al, Appl. Phys. Lett., v119, p152102, 2021]. Normally, such devices are produced with the slower metal-organic VPE (MOVPE) process. The key to the HVPE p^+n-junction diodes was Nagoya's recent development of an HVPE recipe for p-GaN without detectable silicon contamination.

GaN is being developed to replace silicon in power electronics applications, where high breakdown voltages are needed. The III–nitride material features high critical electric fields, high saturation voltage and high mobility, thanks to its wider bandgap compared with silicon.

MOVPE processes suffer from a tendency for the carbon of the organic precursors to become incorporated in the growing semiconductor material. Carbon is both a deep donor and deep acceptor in GaN. Thus, the presence of carbon reduces the effectiveness of any doping design. To reduce carbon incorporation, MOVPE growth speeds are even further reduced.

In vertical power devices, one usually balances thick, lightly doped n-GaN drift layers against thinner, heavily doped p-GaN layers. Thicker drift layers allow higher voltages to be handled by distributing the electric field strength over a longer distance. Such drift layers need low doping to be effective. Carbon impurities impede the achievement of this low n-type doping.

HVPE avoids carbon incorporation by using carbon-free precursors. Here, one needs to control silicon and oxygen impurity incorporation. Unwanted silicon and oxygen can be avoided by using quartz-free equipment.

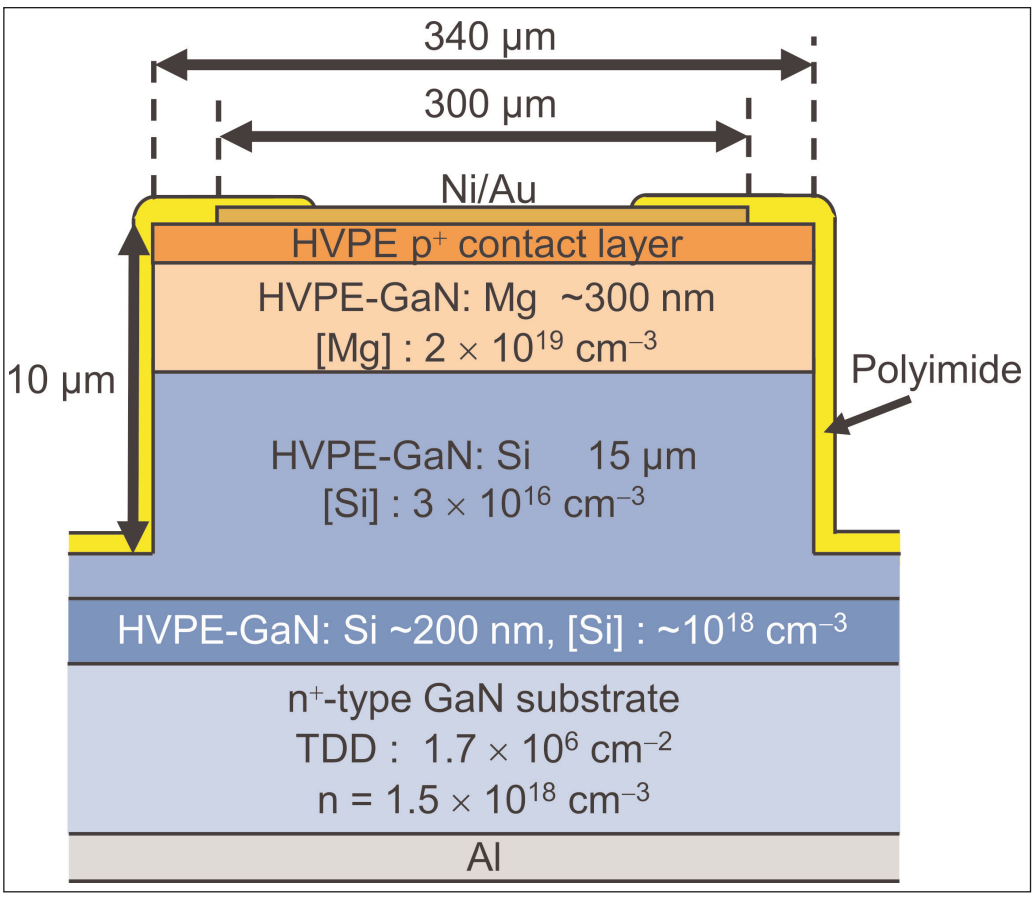

Figure 1. Schematic cross section of vertical GaN p^+-n junction diode grown by HVPE. Substrate parameters from supplier.

Until recently, there has been no suitable HVPE process for p-GaN layers. One way around this has been to use hybrid HVPE-MOVPE for the n-GaN and p-GaN layers, respectively. However, diodes produced from such processes suffer from silicon accumulation effects, which lead to high leakage and premature breakdown.

The Nagoya researchers used a freestanding HVPE n^+-GaN substrate on which further layers of variously doped GaN were grown by 1050°C HVPE at atmospheric pressure to give the semiconductor material for the diode. The 15µm low-doped n-GaN drift layer was grown at 30µm/hour. The p-type layers were grown at a much slower rate of 3µm/hour.

The Ga precursor was gallium chloride (GaCl) gas from reaction between hydrogen chloride and a Ga melt at 900°C. The nitrogen came from ammonia (NH_3).

The silicon for n-type doping came from silicon tetrachloride ($SiCl_4$).

The magnesium doping for the p-type layers was sourced from magnesium oxide (MgO). The researchers believe that the MgO reacted with HCl in the system to form $MgCl_2$ before delivery at the growth front. The final heavily doped p^+-GaN contact layer was 20nm thick.

The diodes were fabricated into 340μm-diameter inductively coupled plasma etched mesas with nickel/gold (Ni/Au) alloy anode on the p^+-GaN contact, and aluminium (Al) cathode on the back-side of the wafer. The Mg doping was activated by 700°C 5-minute annealing after the plasma etch. A 3μm polymide layer was used to passivate the mesa sidewalls.

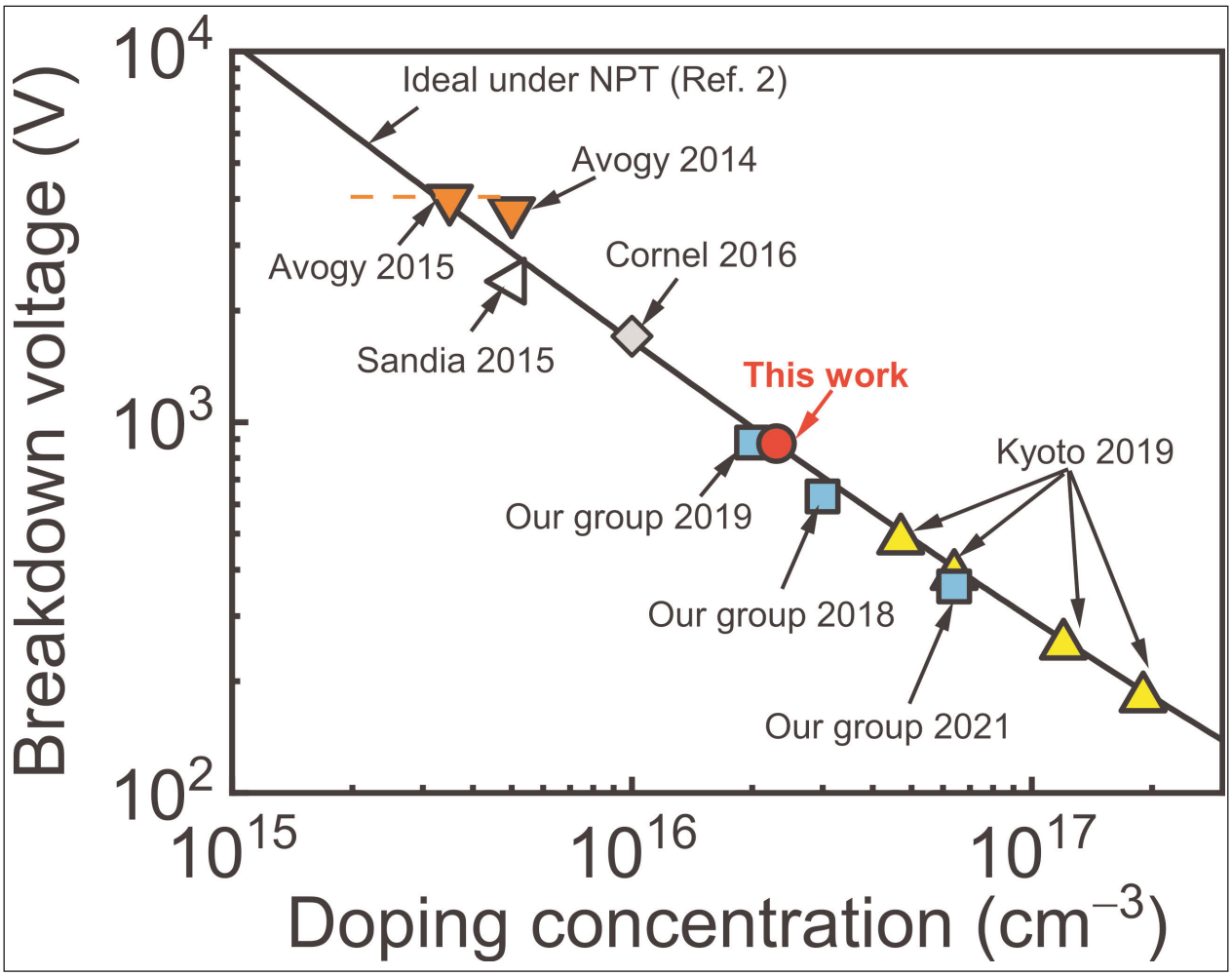

Figure 2. Breakdown voltage as function of drift-layer doping concentration for reported GaN p^+n-junction diodes: solid line - ideal breakdown voltage for GaN p^+n junction under non-punch-through condition; red circle - latest Nagoya experimental work; other plots — previously reported GaN p^+n-junction diodes grown by MOVPE; dashed line - doping concentration range of one group.

Secondary-ion mass spectroscopy (SIMS) showed oxygen, carbon and hydrogen concentrations in the 15μm drift layer below the detection limits of $7x10^{15}$, $3x10^{15}$ and $3x10^{15}/cm^3$, respectively. In the p-type layer as-grown (i.e. before annealing to drive out the H atoms), the hydrogen concentration increased with Mg doping, passivating the acceptors. The Mg concentration in the drift layer was $5x10^{15}/cm^3$, blamed on memory effects (i.e. residual Mg in the reaction chamber from previous p-GaN growth processes).

The minimum ideality factor was 1.6 at 298K, which compares with the range 1.1–2.3 for p^+n-junction diodes grown by MOCVD. The breakdown voltage of the device was 874V at 25°C and 974V at 200°C. The increase in breakdown with increased temperature suggests an ideal avalanche multiplication mechanism for the breakdown. "This is because the phonon scattering rate in a semiconductor increases, and it is too difficult to obtain sufficient energy of carriers to cause impact ionization with the increasing temperature," the team explains.

Further experiments showed a linear increase of the non-destructive avalanche breakdown voltage with temperature. Comparison with theory suggests that the device has "ideal critical electrical field and avalanche capability," according to the researchers. The breakdown voltage was also found to be in line with that achieved by MOVPE (Figure 2). Reducing the drift layer doping should increase the breakdown voltage.

The diode did suffer from a higher leakage under reverse bias than similar devices grown by MOVPE. The team says that it is not clear whether this is a specific problem for HVPE growth or not, since the reverse-bias behavior of some MOVPE diodes reported is similar to that of the Nagoya group's HVPE diodes. ■

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Author: Mike Cooke

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10 Gas and liquid handling equipment

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

CS CLEAN SOLUTIONS AG
Fraunhoferstrasse 4,
Ismaning, 85737,
Germany
Tel: +49 89 96 24000
Fax: +49 89 96 2400122
www.csclean.com

Entegris Inc
129 Concord Road,
Billerica, MA 01821, USA
Tel: +1 978 436 6500
Fax: +1 978 436 6735
www.entegris.com

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

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

VACUUM BARRIER VBC CORPORATION

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

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

11 Process monitoring and control

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

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

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

LayTec AG
Seesener Str. 10–13,
10709 Berlin,
Germany
Tel: +49 30 89 00 55 0
Fax: +49 30 89 00 180
www.laytec.de
LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

Vacuum Barrier Corporation
4 Barton Lane, Woburn, MA 01801,
USA
Tel: +1 781 933 3570
Fax: +1 781 933 9428
www.vacuumbarrier.com
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WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)
Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald, Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

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

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

13 Characterization equipment

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

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

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

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

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

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

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

17 Assembly/packaging foundry

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

18 Chip foundry

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

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

19 Facility equipment

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

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

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20 Facility consumables

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

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

21 Computer hardware & software

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

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

22 Used equipment

Brumley South Inc
422 North Broad Street,
Mooresville,
NC 28115,
USA
Tel: +1 704 664 9251
Email: sales@brumleysouth.com
www.brumleysouth.com

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Decatur, GA 30035,
USA
Tel: +1 770 808 8708
Fax: +1 770 808 8308
www.ClassOneEquipment.com

23 Services

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

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

24 Resources

Al Shultz Advertising Marketing for Advanced Technology Companies
1346 The Alameda,
7140 San Jose,
CA 95126, USA
Tel: +1 408 289 9555
www.alshuktz.com

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

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

event calendar

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

22–27 January 2022
Photonics West 2022
Moscone Center, San Francisco, CA, USA
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-west

13–18 February 2022)
24th European Microwave Week (EuMW 2021)
ExCel, London, UK
E-mail: eumwreg@itnint.com
www.eumweek.com

6–10 March 2022
Optical Fiber Communication Conference and Exhibition (OFC 2022)
San Diego Convention Center, San Diego, CA, USA
E-mail: custserv@optica.org
www.ofcconference.org

20–24 March 2022
37th annual Applied Power Electronics Conference (APEC 2022)
George R. Brown Convention Center, Houston, Texas, USA
E-mail: apec@apec-conf.org
http://apec-conf.org/conference/sessions/technical

25–27 April 2022
18th International Conference on Concentrator Photovoltaic Systems (CPV-18) and 13th World Conference on Thermophotovoltaic Generation of Electricity (TPV-13)
University of Miyazaki, Japan
E-mail: info@cpv-18.org
www.cpv-18.org

26–28 April 2022
25th Annual Components for Military & Space Electronics Conference (CMSE 2022)
Four Points by Sheraton (LAX) Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

3–6 May 2022
45th WOCSDICE — Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe & 16th EXMATEC — Expert Evaluation and Control of Compound Semiconductor Materials and Technologies (WOCSDICE EXMATEC 2022)
Ponta Delgada (São Miguel island - Azores), Portugal
E-mail: WE2022@ua.pt
https://we2022.av.it.pt

9 May 2022
36th annual Reliability of Compound Semiconductors Workshop (ROCS 2022)
Monterey Marriott & Conference Center, Monterey, CA, USA
E-mail: rocs@jedec.org
www.jedec.org/events-meetings/rocs-workshop

9–12 May 2022
2022 CSMANTECH (International Conference on Compound Semiconductor Manufacturing Technology)

advertisers' index

Monterey Marriott & Conference Center, CA, USA
E-mail: chairman@csmantech.org
www.csmantech.org

10–12 May 2022
PCIM (Power Conversion and Intelligent Motion) Europe 2022
Nuremberg, Germany
E-mail: pcim@mesago.com
www.mesago.de/en/PCIM/main.htm

12–13 May 2022
Collaboration and innovation across the CS supply chain (CoInnovateCS)
Monterey Marriott & Conference Center, CA, USA
E-mail: events@csconnected.com
www.coinnovatecs.com

15–20 May 2022
2022 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

30 May – 3 June 2022
IEEE 72nd Electronic Components and Technology Conference (ECTC 2022)
The Sheraton San Diego Hotel and Marina, San Diego, CA, USA
E-mail: reg.ectc@gmail.com
www.ectc.net

13–17 June 2022
2022 IEEE VLSI Symposium on Technology & Circuits - Technology and Circuits for the Critical Infrastructure of the Future
Hilton Hawaiian Village, Honolulu, HI, USA
E-mail: vlsi@vlsisymposium.org
www.vlsisymposium.org

10–15 July 2022
(postponed from 14-19 June 2020, then 4-9 July 2021)
20th International Conference on Metal Organic Vapor Phase Epitaxy (ICMOVPE XX)
Stuttgart, Germany
E-mail: info@icmovpexx.eu
www.icmovpexx.eu

21–25 August 2022
SPIE Optics + Photonics 2022
San Diego Convention Center, San Diego, CA, USA
E-mail: customerservice@spie.org
www.spie.org/opstm

31 August – 2 September 2022
PCIM (Power Conversion, Intelligent Motion) Asia 2022
Shanghai New International Expo Centre, China
E-mail: pcimasia@china.messefrankfurt.com
www.pcimasia-expo.com

11–16 September 2022
19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2022)
Davos, Switzerland
E-mail: info@icscrm2021.org
www.icscrm2021.org

19–21 September 2022
48th European Conference on Optical Communication (ECOC 2022)
Basel, Switzerland
E-mail: info@ecoc2020.org
www.ecoco2020.org

25–30 September 2022
25th European Microwave Week (EuMW 2022)
MiCo, Milan, Italy
E-mail: eumwreg@itnint.com
www.eumweek.com

16–21 October 2022
International Workshop on Bulk Nitride Semiconductors — XI (IWBNS-XI)
Lehigh Valley, PA, USA
E-mail: iwbns-xi@gmail.com
www.iwbns-xi.org

15–18 November 2022
SEMICON Europa 2022 (co-located with electronica)
Messe München, Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

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

17–22 September 2023
26th European Microwave Week (EuMW 2023)
Berlin Messe, Germany
E-mail: eumwreg@itnint.com
www.eumweek.com
www.eumwa.org/en/26th-eumw-2023.html?cmp_id=20&news_id=208&vID=50

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