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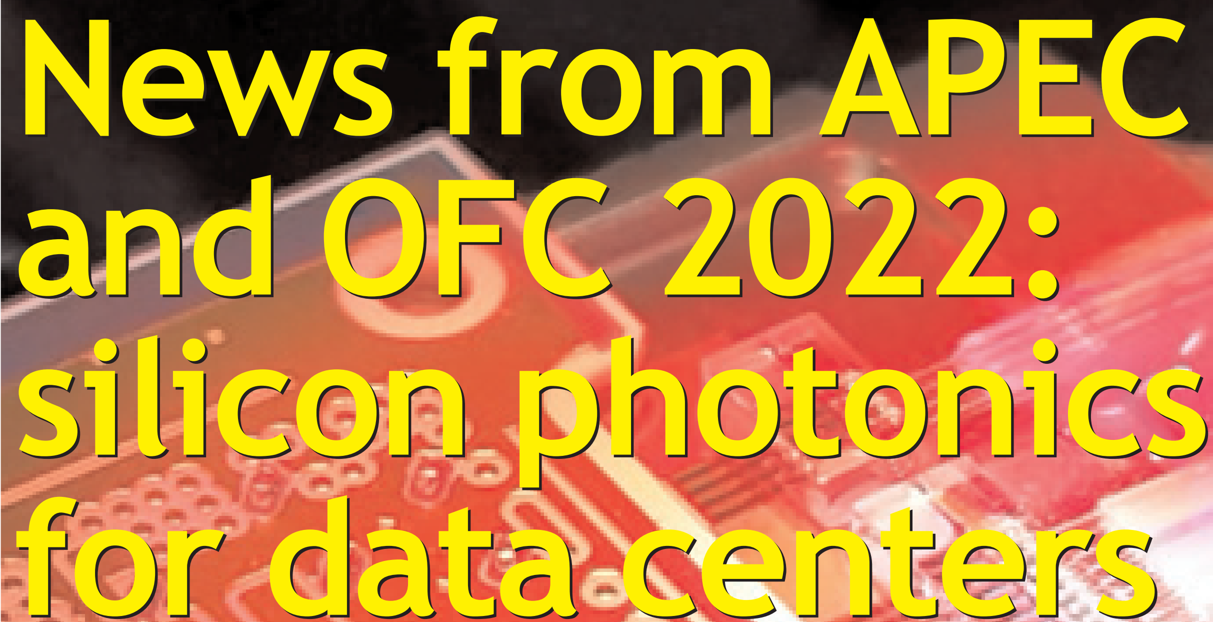

SOITEC expands for SmartSiC • BluGlass buys US laser fab
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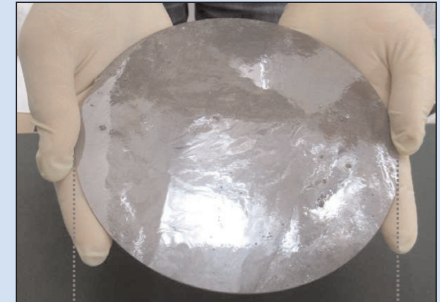
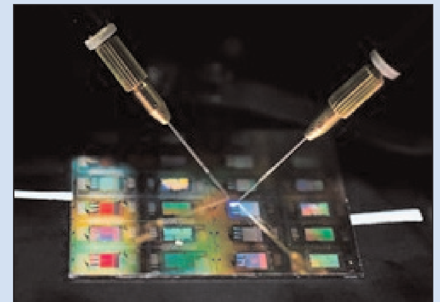
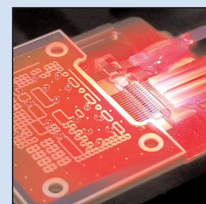


p30 Together with Osaka University, Toyoda Gosei has increased the diameter of GaN substrates for power devices to a record 6-inches.



p42 MICLEDI has demonstrated micro-LEDs on its 300mm wafer flow. Micro-LED displays for AR glasses are to be manufactured by GlobalFoundries.

p74 Sandia has reported a GaN diode with record 6.4kV breakdown. The target is 20kV, to protect the electric grid from electromagnetic pulses.



Cover: An 8-core Ranovus Odin 100Gbps optical I/O with internal and external laser source options for high-capacity data-center interconnect. Ranovus has delivered the first monolithic 100G optical I/O cores for data centers based on GlobalFoundries' GF Fotonix platform. **p54**

The need for secure supply chains

Apart from the death, destruction and upheaval throughout Ukraine and beyond, Russia's "special military operation in the Donbas" since 24 February has threatened to cause unpredictable economic consequences worldwide through financial and trade sanctions and disruption.

Apart from the counter-effect on the sanctioning parties of self-deprivation of either the products bought from Russia or the revenue from sales into Russia, one problem with sanctions is that there is a disparity in the type of products and their essentialness. While 'the West' can withhold many high-value end-products (financial and IT services, consumer electronics, and high-end micro-chips), Russia can withhold commodity raw materials.

Albeit dwarfed by the interruption to vital supplies (oil and gas for energy; grain for food), Ukraine supplies over half of the world's semiconductor-grade neon gas (required by extreme ultraviolet lithography to make leading-edge DRAM memory chips at South Korea's Samsung and Taiwan's TSMC), 40% of krypton gas (for KrF lasers used in less leading-edge lithography) and 30% of xenon gas (used in etching processes).

Commodity products can be obtained elsewhere, but sources are concentrated geographically either by nature or by selection (through economies of scale).

In the case of neon, the main alternative source is China, but a consequence is that prices there have already quadrupled since last October.

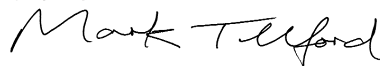
Regarding rare-earth metals, Russia supplies 40% of the world's palladium (used in catalytic converters as well as semiconductors) and 10% of nickel (used in lithium-ion batteries), exacerbating existing shortages and price-rises for lithium and cobalt (also used in electric vehicles). Russia and Ukraine also produce other electronic materials such as metals including copper and aluminium. Consequently, as a side-product of the refining of bauxite ore into alumina, both countries are producers of gallium (95% of which goes into compound semiconductors) — albeit minor producers compared with China's 80% share of global capacity.

In the case of electrical components, the halt in their production in Ukraine has led to stoppages at car manufacturing plants in West Europe. This has exacerbated the existing stoppages due to the shortage of silicon chips for automotive applications after the COVID-induced diversion of chip-making to consumer electronics and communications products at foundries in Taiwan.

Together with the heightened demand and hence pricing for raw materials from Russia-ally China, the concentration in Taiwan of foundries like TSMC for the mass production of silicon chips (and, increasingly, gallium nitride on silicon) has highlighted the vulnerability of other countries in not having control of their supply chain and manufacturing capacity.

The USA and Europe are already funding initiatives to reinvigorate onshore manufacturing, including Intel investing over $100bn in fabs in the USA and Germany for both its own products and foundry services, while Netherlands-based NXP has already (since 2020) been manufacturing its own GaN 5G RF devices on 6-inch silicon carbide (SiC) wafers in-house in a new $100m fab in Chandler, Arizona (after previously using a foundry). US-based Transphorm last August acquired its joint venture fab in Japan from partner Fujitsu. Fellow North American GaN device firms like GaN Systems and Navitas are using TSMC. However, GaN foundry services are also offered by US-based Wolfspeed and Qorvo, while GlobalFoundries is developing GaN-on-silicon for 5G and 6G RF devices. Such onshore options may become increasingly important as firms seek to secure their supply chains.

Mark Telford, Editor



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

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

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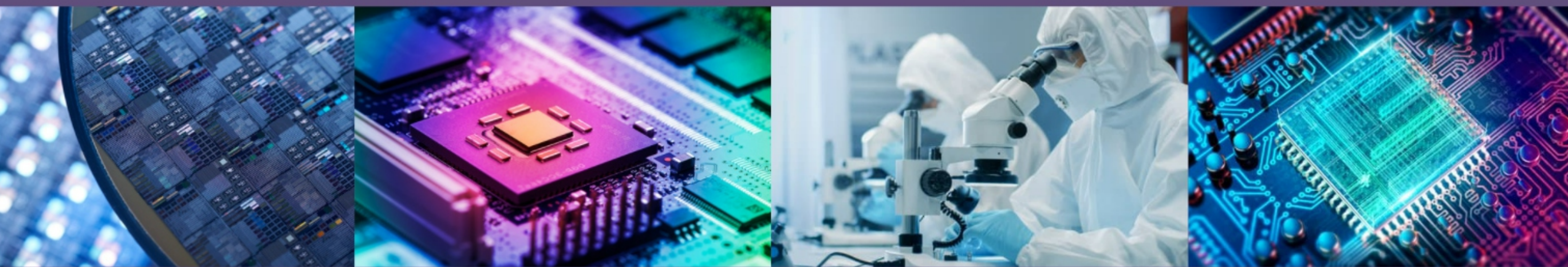

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Q4 smartphone production sees 9.5% quarter-on-quarter growth, driven by 66% growth for Apple

But Q4/2021 production down on Q4/2020 and Q4/2019

Global smartphone production was 356 million units for fourth-quarter 2021, showing a quarter-on-quarter (QoQ) increase of 9.5%, according to market research firm TrendForce.

Second-half 2021 saw demand injections related to the peak promotion season for e-commerce platforms and year-end holiday sales. These factors thus bolstered smartphone production and resulted in Q4/2021 seeing the highest QoQ growth rate for the year. Apple's new iPhones were the primary growth driver. On the other hand, the performance of a few smartphone brands were constrained by the shortage of some key components. Hence, total smartphone production for Q4/2021 was slightly lower than Q4/2020 or even Q4/2019.

Apple took production lead in Q4 with record 85.5 million units

After unveiling the iPhone 13 series in September, Apple started aggressively ramping up shipments of these new devices to meet market demand. Due to its fast-paced sales and marketing rhythms, Apple has been able to take first place in the quarterly ranking of smartphone brands by production market share for many fourth quarters, and Q4/2021 was no exception.

Besides maintaining its top position in the fourth-quarter brand ranking, Apple raised its quarterly iPhone production to a new record of 85.5 million units, a 66% QoQ increase.

Regarding pricing strategy, the prices of the new iPhone 13 models were reasonable for consumers, while price reductions for the older iPhone models were noticeable too.

Moreover, the capture of market share left by Huawei can be considered to be the main factor behind Apple's stellar performance in Q4/2021. Over time, orders for Huawei's flagship models (i.e. the P and Mate series) have been gradually replaced by iPhone orders.

Company	4Q21		1Q22E	
	Ranking	Market Share	Ranking	Market Share
Apple	1	24.0%	2	18.3%
Samsung	2	20.0%	1	21.8%
OPPO	3	13.5%	4	13.8%
Xiaomi	4	12.8%	3	15.5%
Vivo	5	8.4%	5	9.1%

Market share of top five smartphone brands, Q4/2021–Q1/2022 (estimated).

In terms of annual production, Apple reached 233 million units for 2021, up from almost 200 million units for 2020. Growth was mainly attributed to an expansion of Apple's market share in China from 10% to 16%.

Samsung took second place in the global brand ranking for Q4/2021 with 71 million units, a 2.9% QoQ increase. In Q2/2021, the spread of COVID-19 outbreaks in Vietnam affected smartphone production facilities in the country and reduced Samsung's capacity utilization rate. But, apart from that quarter, Samsung's performance remained stable for the other three quarters of last year. For the ranking of smartphone brands by annual production, Samsung was still the leader for 2021 with 275 million units.

Capture of market share left by Huawei can be considered to be the main factor behind Apple's stellar performance in Q4. Huawei's flagship models have been gradually replaced by iPhone orders

OPPO (including Realme and OnePlus) took third place in the ranking with a quarterly production of 48 million units, a 5.9% QoQ decrease, for Q4/2021. Xiaomi (including Redmi, POCO, and Black Shark) took fourth place with the production of 45.5 million units, a 2.2% QoQ increase. Fifth-ranked Vivo (including iQoo), on the other hand, reduced its smartphone production by 11.8% QoQ to 30 million units. As these three Chinese brands' target markets and product strategies show significant overlap, their control of key components that are currently in shortage will have a direct impact on their production volumes going forward.

Also, Honor (which was spun off from Huawei in early 2021 and underwent a period of corporate restructuring and component procurement in first-half 2021) experienced a meteoric rise in second-half 2021. Much like other Chinese brands, Honor adopts a sales strategy that primarily focuses on the Chinese market, meaning that its smartphone business will continue to affect OPPO, Xiaomi and Vivo, all of which place a top priority on domestic sales.

Annual smartphone production for 2022 to reach 1.381 billion, despite potential decline

Assuming that the global spread of the COVID-19 pandemic continues to slow, TrendForce expects annual smartphone production for 2022 to see a slight year-on-year increase

of 3.6% to 1.381 billion units.

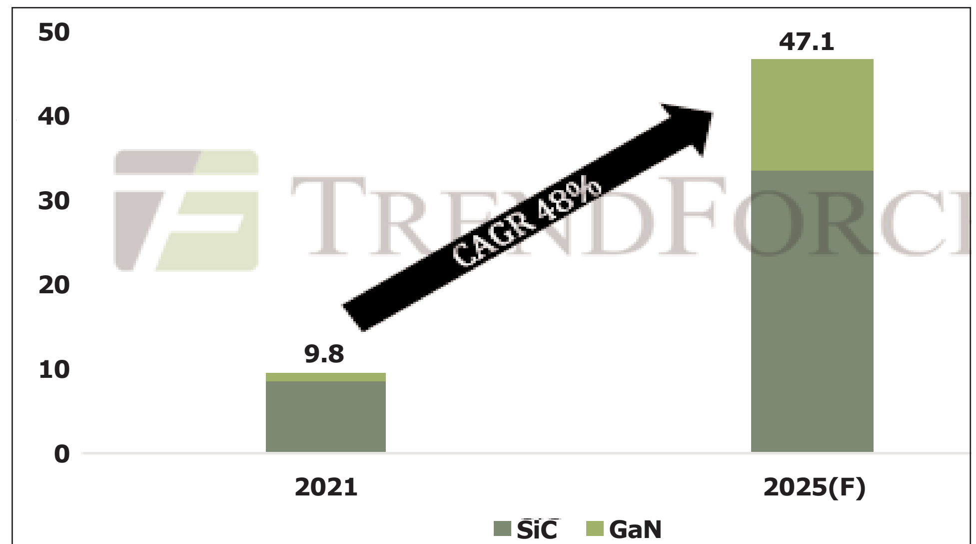
Not only is smartphone demand expected to decline in China (the largest consumer market in the world), but other markets will also exhibit only limited growth. Hence, the leading growth drivers will come from both cyclical replacement demand and new demand from emerging markets. Notably, in addition to factors such as foundry capacity allocation, global inflation and energy shortage, whether an economic recovery will bring about positive change for the smartphone market will continue to influence the overall performance of the industry. TrendForce therefore believes that annual smartphone production for 2022 may still face potential downside risks.

Regardless, the recent war between Russia and Ukraine has generated a host of issues including exchange rates, inflation and logistics problems that affect smartphone sales in Eastern Europe. With regards to the market share of smartphone brands in Russia and Ukraine last year, the top three brands by sales included Samsung, Xiaomi and Apple, with a combined 45 million units sold, accounting for 3% of the global total. Preliminary assessments indicate that the ongoing war will not have a drastic effect on smartphone production for 2022, although TrendForce also does not rule out the possibility that the resultant global economic problems may affect overall smartphone demand.

Third-generation power semiconductors growing at 48% CAGR from $980m in 2021 to $4.71bn in 2025

Mass production of 8-inch substrates starting in second-half 2022

As the materials with currently the most development potential, the output value of 'third-generation' power semiconductors — i.e. wide-bandgap (WBG) semiconductors with high-power and high-frequency characteristics, including silicon carbide (SiC) and gallium nitride (GaN), that are used mainly in electric vehicles (EVs) and the fast-charging battery market — is rising at a compound annual growth rate (CAGR) of 48% from $980m in 2021 to $4.71bn in 2025, reckons market research firm TrendForce.



Third-generation power semiconductor market forecast, 2021–2025 ($100m).

SiC is suitable for high-power applications, such as energy storage, wind power, solar energy, EVs, new energy vehicles (NEV) and other industries that utilize highly demanding battery systems. Among these industries, EVs have attracted a great deal of attention from the market. However, most of the power semiconductors used in EVs currently on the market are silicon based, such as Si IGBTs and Si MOSFETs. However, as EV battery power systems gradually develop to voltage levels greater than 800V, compared with silicon, SiC can produce better performance in high-voltage systems. SiC is expected to gradually replace part of the silicon base design, greatly improve vehicle performance, and optimize vehicle architecture. The SiC power semiconductor market is estimated to reach $3.39bn by 2025.

GaN is suitable for high-frequency applications, including communication devices and fast charging for mobile phones, tablets and laptops. Compared with traditional fast charging, GaN fast charging has higher power density, so charging speed is faster within a smaller package that is easier to carry. These advantages have proven attractive to many OEMs and ODMs, and several have rapidly started to develop this material. The GaN power semiconductor market is forecasted to reach $1.32bn by 2025.

TrendForce emphasizes that third-generation power semiconductor substrates are more difficult to manufacture and more expensive compared with traditional silicon substrates. Taking advantage of the current development of major substrate suppliers, companies including Wolfspeed, II-VI and Qromis have successively expanded their production capacities and will mass produce 8-inch substrates in the second-half 2022. The output value of third-generation power semiconductors is estimated to have room for continued growth in the next few years.

www.trendforce.com

Skyworks adds Iridium's chief operations officer to board

Telecoms executive brings technology, strategy & operations expertise

Skyworks has appointed Suzanne 'Suzi' E. McBride to its board of directors.

McBride is currently chief operations officer for Iridium Communications, a publicly traded operator of a global satellite communications network. Her previous experience includes a series of increasingly senior roles in technology and operations with Motorola, General Dynamics, OneWeb and Iridium.

"Suzi's 25 years of experience in wireless technologies will be a great asset to our board of directors," believes Skyworks' chairman, CEO & president Liam K. Griffin.

"During this time of increasing demand for ubiquitous connectivity, Skyworks is uniquely positioned to capitalize on the expansion of 5G and other wireless technologies," comments McBride.

McBride currently serves on the board of directors of Iridium and Descartes Labs, a privately held geospatial intelligence platform. She graduated from Columbia University and Claremont McKenna College with bachelor's degrees in industrial engineering and management engineering, respectively. She also received a master's in business administration from the University of Tennessee.

www.skyworksinc.com

Sivers completes acquisition of MixComm

MixComm to be part of Sivers Wireless business area

Sivers Semiconductors AB of Kista, Sweden (which supplies chips and integrated modules) has completed the previously announced acquisition of fabless semiconductor company MixComm Inc of Chatham, NJ, USA (with design centers in Oregon and California) to strengthen its position in 5G, SATCOM and radar markets for current and future high-frequency mmWave products. The acquisition provides a greatly increased customer base, expanded capacity, a broad IP portfolio and a strong presence across the USA, Europe and Asia.

The purchase has been satisfied through a cash payment of US$22.5m (about SEK212m at the current exchange rate), and the issuance of 39,187,320 new ordinary shares in the company, corresponding to a dilution of about 18.3% (based on the number of shares in issue after completion). The shares issued to the sellers are covered by a lock-up of 12 months for 50% of the consideration shares and 18 months for the remaining 50%. A further up to 6,993,007 newly issued shares may be issued to the sellers subject to the satisfaction of certain commercial customer milestones within nine months from signing.

The selling shareholders of MixComm include its founders, employees, Kairos Ventures (a US venture capital investor focused on identifying and commercializing scientific discoveries) and GlobalFoundries. Kairos will become a significant shareholder in Sivers after completion of the acquisition. Kairos Ventures' chief operating & financial officer Todd Thomson has also joined Sivers' board of directors, as approved at the EGM last November.

MixComm will be part of the Sivers Wireless business area within Sivers Semiconductors. Overall, the new expanded group is expected to create conditions for accelerated growth.

Through the merger, Sivers Wireless will increase its total number of design wins by about 70% to 44 and double the number of design wins that are expected to enter volume production within the next 12 months, from 8 to 16 in total. MixComm currently has 18 design wins, including one with a leading tier-1 5G infrastructure customer and a significant pipeline of potential new customer opportunities.

"We have now received regulatory approval from The Committee on Foreign Investment in the United States (CFIUS) to complete this transaction. We have seen very good progress within MixComm since we agreed the deal last October and are now looking forward to starting to deliver the very significant synergy benefits that we see from the combination," says Sivers Semiconductors' group CEO Anders Storm.

MixComm was founded in 2017 based on more than 10 years of development at Columbia University led by Dr Krishnaswamy (co-founder & chief technology officer) through externally funded research projects totalling $94m across all projects and participants). The firm is an active US participant in the 5G BFIC (repeaters/base stations), SATCOM and radar verticals. Most employees hold a PhD, and the company is the only mmWave company selected to join the 5G Open Innovation Lab founded by T-Mobile and Intel. The flagship BFIC SUMMIT 2629 was the recipient of numerous 'Best Products' citations in 2020, including 'The Broadband Innovation of the Year' from the Mobile Breakthrough Awards. MixComm has established partnerships with minority investor GlobalFoundries for RF-SOI fabrication, packaging and test services, and with Richardson RFPD for distribution and logistics globally. Both the GlobalFoundries and Richardson RFPD collaborations will continue under the Sivers Wireless brand and be expanded to all products by the company.

www.mixcomm.com
www.sivers-semiconductors.com

Skyworks appoints financial and operational expert to board

Guerin to help guide diversification across IoT and transition to 5G

Skyworks Solutions Inc of Irvine, CA, USA (which manufactures analog and mixed-signal semiconductors) has appointed Eric J. Guerin to its board of directors. Guerin currently serves as executive VP & chief financial officer for CDK Global, a publicly traded provider of integrated technology solutions to the automotive industry. Prior to joining CDK Global, Guerin served as division vice president and sector chief financial officer at Corning Glass Technologies (a division of Corning Inc).

"His blend of financial and operational expertise, together with his extensive engagements within Asia–Pacific markets, will be invaluable as Skyworks continues to enable a rapidly expanding set of applications and opportunities," comments Skyworks' chairman, CEO & president Liam K. Griffin.

"I look forward to leveraging my experience to help guide the company's ongoing diversification efforts across the Internet of Things and its sustained leadership in the global transition to 5G," says Guerin. "This is an exciting time to be aligned with a market leader like Skyworks as wireless connectivity transforms the way we work, play and educate."

Guerin currently serves on the board of directors of Natus Medical, a publicly traded provider of medical equipment, software and services. He received a bachelor's degree in accounting from The City University of New York, College of Staten Island, after which he was recruited to Johnson & Johnson, where he held various finance roles. Guerin also earned a master's in business administration from St. John's University and received his CPA and CMA designations (both inactive).

www.skyworksinc.com

Fraunhofer IAF director Ambacher steps down

Rüdiger Quay becomes acting executive director

After a total of 14 years (with just a brief interruption since 2007), professor Oliver Ambacher has stepped down as director of the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany. Succeeding him, professor Rüdiger Quay has been acting executive director since 1 January.

Based on its research into III–V semiconductor and synthetic diamond materials, Fraunhofer IAF develops devices for future-oriented technologies, such as electronic circuits for innovative communication and mobility solutions, laser systems for spectroscopic real-time sensing, novel hardware components for quantum computers and quantum sensors for industrial applications.

Epitaxy and technology equipment as well as measurement technologies are available in a 1000m^2 cleanroom, a 450m^2 metal-organic chemical vapor deposition (MOCVD) hall and another 4000m^2 of laboratory space. With its R&D work, Fraunhofer IAF spans the entire value chain — from materials research, design and processing to the realization of modules, systems and demonstrators.

Former Fraunhofer IAF director professor Oliver Ambacher (left) and (right) new executive director Rüdiger Quay. © Fraunhofer IAF.

During his tenure, Ambacher solidified the position of Fraunhofer IAF in III–V semiconductor research, as well as breaking new ground and focusing its expertise on emerging and promising research topics in quantum technologies. Under Ambacher, Fraunhofer IAF's research budget increased to €47m last year, staffing rose to more than 300, and the institute gained several new buildings.

Beyond his own institute, Ambacher has also made key contributions within the Fraunhofer-Gesellschaft — most recently opening up the strategic research field of quantum technologies. Largely due to his initiative, the first commercial quantum computer on German soil was set up in summer 2021 (together with IBM) and is now available to German science and industry.

As professor for energy-efficient radio-frequency electronics, Quay shares his predecessor's passion for resource-efficient electronics — a topic that plays a central role in research at Fraunhofer IAF and is reflected in the academic careers of both professors. In addition to their work at Fraunhofer IAF, both were appointed to a chair at the Department of Sustainable Systems Engineering (INATECH) at the University of Freiburg, where they train future experts in the field of particularly energy-efficient electronic systems.

In his many years of research, Ambacher has led numerous innovative projects of international scope and achieved scientific milestones that continue to significantly influence the semiconductor industry and second-generation quantum systems research. He is now passing the baton at Fraunhofer IAF to his colleague Quay.

www.iaf.fraunhofer.de/en

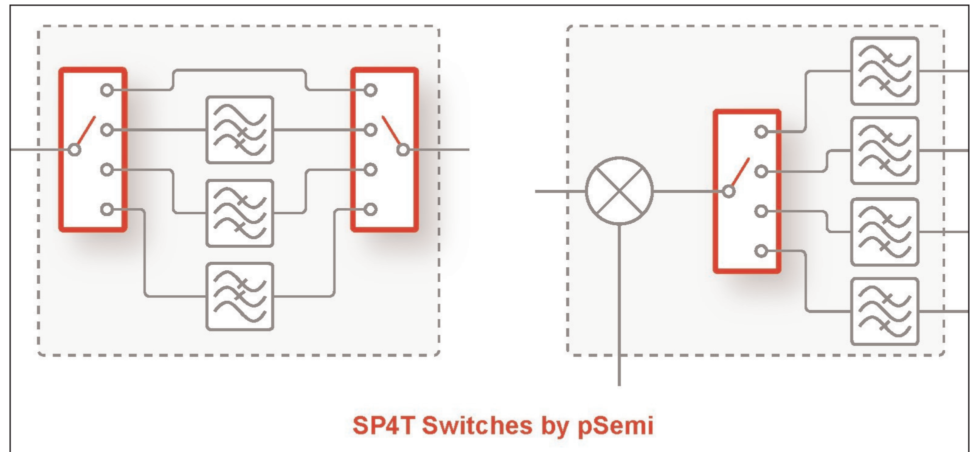
pSemi launches first SP4T switches for up to 67GHz

5G mmWave systems and short-range connectivity enhanced

Murata company pSemi Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — has expanded its RF SOI portfolio with the first SP4T (single-pole four-throw) switches for wideband and high-frequency applications up to 67GHz.

Designed to enhance 5G millimeter wave (mmWave) systems and short-range connectivity, the compact and energy-efficient switches offer what is claimed to be best-in-class insertion loss, linearity, switching time and power handling at FR2 frequencies.

pSemi now offers a family of mmWave SPDT and SP4T switches to help designers simplify layouts and improve overall system efficiency in test and measurement, wireless infrastructure, satellite and point-to-point communication applications.



pSemi's new SP4T switches, streamlining and simplifying filter bank designs.

Emergence of mmWave

With rising investments in augmented reality (AR), virtual reality (VR) and artificial intelligence (AI) devices and applications, mmWave frequencies are key to delivering faster data rates, increased throughput and lower latency in advanced communication networks. 5G mmWave and multi-band configurations introduce more complex signal transmission and denser antenna structures to support evolving cellular, satellite and unlicensed standards. Designers are overcoming these challenges by implementing phased-array antennas and optimized RF front-end architectures to maximize signal strength and throughput without adding noise or loss to the system.

"Demand for enhanced streaming and augmented-, virtual- and mixed-reality experiences are accelerating the commercialization of mmWave," says Vikas Choudhary, VP of sales & marketing. "pSemi continues to expand its portfolio of mmWave switches, digital step attenuators, beam-formers and up–down converters, and to invest in technology that supports customer needs as higher frequency spectrum is released," he adds.

With rising investments in AR, VR and AI devices and applications, mmWave frequencies are key to delivering faster data rates, increased throughput and lower latency in advanced communication networks

Broadband RF switches' features and benefits

Three UltraCMOS switches deliver RF performance, reliability and size in multiple product configurations to best meet challenging mmWave system designs from 9kHz to 67GHz.

Available in flip-chip die form, the PE42545 SP4T supports up to 67GHz and the PE42525 SPDT supports up to 60GHz.

Available in a small 3mm x 3mm LGA package, the PE42546 SP4T supports up to 45GHz.

Benefits include:

- low latency — extremely fast switching for rapid transmit and receive data patterns in advanced communication schemes;
- energy efficiency — highest power handling and lowest insertion loss to conserve transmit power and increase receiver sensitivity;
- wideband coverage — best-in-class return loss with proprietary design techniques delivers RF performance up to 67GHz.

Test & measurement — a mmWave SP4T case study

The test and measurement industry faces the unique challenge of needing to stay ahead of the 5G mmWave technology learning curve to deliver advanced testing solutions. Equipment must support higher power handling, high linearity, low insertion loss and fast switching to efficiently pressure test scenarios up to 67GHz under extreme conditions.

For test and measurement designers seeking to simplify complex broadband designs, a single PE42545 or PE42546 SP4T can replace multiple SPDTs used in cascaded filter bank configurations to reduce space and offer band-select paths with less insertion loss. Having access to scalable and reliable components ensures that designers can easily adapt system designs to different band configurations as 3GPP standards evolve in 5G, 5G-Advanced and 6G.

www.psemi.com/products/rf-switches/broadband-rf-switches/pe42545

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Soitec expanding SmartSiC wafer manufacturing for electric vehicles and industrial markets

Engineered substrate manufacturer Soitec has announced a new fabrication facility at its headquarters in Bernin, near Grenoble, France, primarily to manufacture new silicon carbide (SiC) wafers targeted at the electric vehicle (EV) and industrial markets. The extension will also support Soitec's 300mm silicon-on-insulator (SOI) activities.

The fab is to produce SmartSiC engineered wafers developed by Soitec at the Substrate Innovation Center at CEA-Leti in Grenoble, using Soitec's proprietary SmartCut technology.

Soitec notes that silicon carbide wafers adds value for industrial applications and EVs by increasing their driving range, shortening the charging time and diminishing their cost. With its SmartSiC products, Soitec is engaged with major SiC device makers and aims to generate first revenues in second-half 2023.

"By 2030, around 40% of all new cars will be electric," expects CEO Paul Boudre. "Our unique, highly performant, sustainable and cost-competitive SmartSiC solution addresses the industrial challenges, helps to optimize energy efficiency, and will accelerate the adoption of electric vehicles," he adds. "This investment is a major milestone for us, as SmartSiC is set to be another growth engine for Soitec and a driver of the transformation of the automotive and industrial markets."

www.soitec.com

Power Integrations introduces first automotive-qualified high-voltage switcher ICs with 1700V SiC MOSFET

Power Integrations of San Jose, CA, USA, which provides high-voltage integrated circuits for energy-efficient power conversion, has added two new AEC-Q100-qualified, 1700V-rated ICs to its InnoSwitch3-AQ family. The new devices are claimed to be the first automotive-qualified switching power supply ICs to incorporate a silicon carbide (SiC) primary switching MOSFET. Delivering up to 70W of output power, the new ICs are targeted for use in 600V and 800V battery and fuel-cell electric passenger vehicles, as well as electric buses, trucks and a wide range of industrial power applications.

Highly integrated InnoSwitch ICs reduce the number of components required to implement a power supply by as much as 50%, saving significant circuit-board space, enhancing system reliability and mitigating component sourcing challenges. Devices from the InnoSwitch family are now available with a choice of cost-effective silicon, high-efficiency gallium nitride (GaN) and high-voltage SiC transistors, permitting designers to optimize their power solution across a broad range of consumer, computer, communications, industrial and automotive applications.

"800V batteries are becoming standard for EVs," notes Peter Vaughan, director of automotive business development. "Multiple vehicle systems are connected to this powerful electrical source, yet delicate electronic control circuits require just a few volts for operation and communication. InnoSwitch devices allow the electronics to safely sip from the firehose of energy available on the main bus, using minimal board area and without wasting energy," he adds. "Most exciting is the opportunity to dramatically simplify the emergency power supply for the main traction inverter, which may be called upon at a moment's notice to operate from any voltage between 30V and 1000V. Our SiC-based InnoSwitch3-AQ devices handle this vast range with incredible ease."

Offered in a compact InSOP-24D package, the new ICs use a FluxLink feedback link, providing reinforced isolation up to $5000V_{RMS}$ for secondary-side control. FluxLink technology enables direct sensing of the output voltage, providing benefits such as accurate regulation and extremely fast transient response. The circuit will start from 30V without external circuitry — critical for functional safety. Additional protection features include input under-voltage, output over-voltage and over-current limiting.

The inclusion of synchronous rectification and a quasi-resonant (QR)/CCM flyback controller achieves greater than 90% efficiency, easily meeting the strictest OEM requirements. These new parts consume less than 15mW at no-load, suitable for reducing self-discharge in battery management systems.

The InnoSwitch3-AQ 1700V parts are also suitable for industrial markets, where the integrated solution replaces discrete controller-plus-MOSFET designs, saving space, time and cost while increasing reliability in applications such as renewables, industrial motor drives, battery storage and metering.

A reference design DER-913Q and hardware kit RDK-919Q are available for designers wishing to evaluate the InnoSwitch3-AQ 1700V IC. Devices are priced at $5.64 for part number INN3947CQ-TL and $9.02 for part number INN3949CQ-TL in 1000-unit quantities.

www.power.com

II-VI accelerates 150–200mm SiC substrate and epi manufacturing expansion

Substrate output to reach 1 million 150mm-equivalent units by 2027; Pennsylvania and Sweden to expand SiC epiwafer capacity

As part of its previously announced $1bn investment in silicon carbide (SiC) over the next 10 years, engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA is accelerating its investment in 150mm and 200mm SiC substrate and epitaxial wafer manufacturing with large-scale factory expansions in Easton, Pennsylvania, and Kista, Sweden.

To meet the accelerating global demand for SiC power electronics, II-VI will significantly build out its nearly 300,000ft^2 factory in Easton, to scale up production of its 150mm and 200mm SiC substrates and epiwafers. Easton's 150mm and 200mm substrate output is expected to reach the equivalent of 1 million 150mm substrates annually by 2027, with the proportion of 200mm substrates growing over time. The expansion of epi capacity in Kista is aimed at serving the European market.

"Our customers are accelerating their plans to intersect the anticipated tidal wave of demand for SiC power electronics in electric vehicles (EVs) that we expect will come right behind the current adoption cycle in industrial, renewable energy, data centers, and more," says Sohail Khan, executive VP, New Ventures & Wide-Bandgap Electronics Technologies. "The Easton factory will increase II-VI's production of SiC substrates by at least a factor of six over the next five years, and it will also become II-VI's flagship manufacturing center for 200mm SiC epitaxial wafers, one of the largest in the world," he adds.

II-VI will leverage its epiwafer technology developed in Kista. The firm says that this technology is differentiated by its ability to achieve thick layer structures in single or multiple regrowth steps, which is suited to power devices in applications above 1kV.

The Easton factory will be powered by an uninterruptible and scalable micro-grid based on fuel-cell technology to provide high assurance of supply.

www.ii-vi.com

NXP and Hitachi Energy collaborate on power modules

NXP Semiconductors N.V. of Eindhoven, The Netherlands has announced a collaboration with Hitachi Energy to accelerate the adoption of silicon carbide (SiC) power semiconductor modules in e-mobility. The project aims to provide more efficient, reliable and functionally safe SiC MOSFET-based solutions for powertrain inverters consisting of NXPs GD3160 single-channel high-voltage (HV) isolated gate drivers and Hitachi's RoadPak automotive SiC MOSFET power modules.

Compared with traditional silicon IGBTs, SiC MOSFET power devices offer electric vehicle makers the ability to increase the range and overall efficiency of their systems. Enabled by high-performance power semiconductor modules and isolated gate drivers, SiC MOSFET power devices offer faster switching speeds, lower turn-on resistance and reduced thermal dissipation that can help to drive down the size and cost of an electric vehicle's (xEV's) powertrain inverter and lower the required capacity of the battery pack, extending the vehicle's range.

Hitachi Energy's automotive power semiconductor module RoadPak delivers what is claimed to be excellent heat dissipation, low stray inductances, and long-term ruggedness to withstand the challenging automotive environment (key to unleashing the full capabilities and benefits of SiC MOSFETs). To attain optimal performance, the power module is paired with NXP's GD3160 single-channel, high-voltage isolated gate driver (with enhanced features for driving SiC MOSFETs devices rated to 1700V), enabling fast and reliable switching and fault protection.

"Working with Hitachi Energy has allowed us to highlight the efficiency and range benefits of SiC MOSFETs for e-mobility," says Robert Li, VP & general manager of NXP's Drivers & Energy Systems product line. "By pairing the GD3160 with the Hitachi Energy's RoadPak SiC module, we've delivered a solution that aims to reduce the transition time from evaluation to performance optimization of SiC MOSFETs used in traction inverters."

Hitachi Energy has been leveraging its technology and the experience gained in the industrial and transportation segments to develop its high-density RoadPak automotive SiC power modules for e-mobility applications. The RoadPak half-bridge power module incorporates 1200V SiC MOSFETs, integrated cooling pin-fins and low-inductance connections all in a small form factor. It can support applications from e-buses and electric passenger vehicles to high-performance Formula-E race cars.

The FRDMGD31RPEVM (the GD3160 half-bridge EVB customized for the RoadPak SiC module) is available now. Hitachi's 1200V RoadPak half-bridge SiC module has 580A, 780A and 980A options.

www.nxp.com/GD3160
www.hitachi.com/products/energy

Microchip unveils 3.3kV silicon carbide MOSFETs and Schottky barrier diodes

Greater efficiency and reliability extend options for high-voltage power electronics in transportation, energy and industrial systems

Microchip Technology Inc of Chandler, AZ, USA has expanded its silicon carbide (SiC) portfolio with the release of what is claimed to be the lowest on-resistance ($R_{DS(on)}$) 3.3kV SiC MOSFETs and highest current-rated SiC Schottky barrier diodes (SBDs) available in the market, enabling system designers of traction power units (TPUs), auxiliary power units (APUs), solid-state transformers (SSTs), industrial motor drives and energy infrastructure solutions to take advantage of ruggedness, reliability and performance. With the expansion of its SiC portfolio, Microchip says that designers are equipped with the tools to develop smaller, lighter and more efficient solutions for electrified transportation, renewable energy, aerospace and industrial applications.

Many silicon-based designs have reached their limits in efficiency improvements, system cost reduction and application innovation, says the firm. While high-voltage SiC provides a proven alternative to achieve these results, until now the availability of 3.3kV SiC power devices was limited. Microchip's 3.3kV MOSFETs and SBDs join the firm's portfolio of SiC solutions that include 700V, 1200V and 1700V die, discretes, modules and digital gate drivers.

The 3.3kV SiC power devices include MOSFETs with what is reckoned to be the industry's lowest $R_{DS(on)}$ of 25mOhm and SBDs with the industry's highest current rating of 90A. Both MOSFETs and SBDs are available in die or package form. These new levels of performance enable designers to simplify their design, create higher-power systems and use fewer paralleled components for smaller, lighter and more efficient power solutions, the firm says.

"We focus on developments that provide our customers the ability to quickly innovate systems and move their end products into a competitive advantage position faster," says Leon Gross, VP of Microchip's discrete product business unit. "Our new family of 3.3kV SiC power products allows customers to move to high-voltage SiC with ease, speed and confidence and benefit from the many advantages of this exciting technology over silicon-based designs," he adds.

Over the last three years Microchip has released hundreds of SiC power devices and solutions to production, ensuring that designers can find the appropriate voltage, current and package fit for their application requirements. The firm's devices are backed by its customer-driven obsolescence practice, which ensures that devices will continue to be produced for as long as customers need them, and Microchip can produce them.

Customers can combine Microchip SiC products with its other devices including 8-bit, 16-bit and 32-bit microcontrollers (MCUs), power management devices, analog sensors, touch and gesture controllers and wireless connectivity solutions to create complete system solutions at a lower overall system cost.

Development tools

The expanded SiC portfolio is supported by a range of SiC SPICE models compatible with Microchip's MPLAB Mindi analog simulator modules and driver board reference designs. The Intelligent Configuration Tool (ICT) enables designers to model efficient SiC gate driver settings for Microchip's AgileSwitch family of configurable digital gate drivers.

These 3.3kV SiC die and discrete devices in a variety of package options are available for order in production quantities.

www.microchip.com/en-us/products/power-management/silicon-carbide-sic-devices-and-power-modules

Infineon launches optimized 650V CoolSiC MOSFETs

D²PAK SMD 7-pin package with .XT interconnection technology allows improved switching behavior at higher currents and 80% lower reverse recovery charge and drain–source charge

Infineon Technologies has launched a new family of CoolSiC 650V silicon carbide (SiC) MOSFETs to deliver reliable, easy-to-use and cost-effective top performance. Building on Infineon's SiC trench technology and coming in a compact D^2PAK SMD 7-pin package with .XT interconnection technology, devices target high-power applications including servers, telecom, industrial switch-mode power supplies (SMPS), fast electric vehicle (EV) charging, motor drives, solar energy systems, energy storage, and battery formation.

The new products offer improved switching at higher currents and 80% lower reverse recovery charge (Q_{rr}) and drain–source charge (Q_{oss}) than the best silicon reference, it is said. The reduced switching losses allow high-frequency operations in smaller system sizes, enabling higher efficiency and power density. The trench technology is the basis for superior gate oxide reliability. Together with an improved avalanche and short-circuit robustness, this ensures the highest system reliability even in harsh environments. The SiC MOSFETs are suitable for topologies with repetitive hard commutation as well as for high-temperature and harsh operations. Due to a very low on-resistance ($R_{DS(on)}$) dependency with temperature, they show an excellent thermal behaviour, says Infineon.

Featuring a wide voltage range from gate to source (V_{GS}) from –5V up to 23V and supporting 0V turn-off V_{GS} and a gate–source threshold voltage ($V_{GS(th)}$) greater than 4V, the new family of ten new products also works with standard MOSFET gate driver ICs. Additionally, the new products support bi-directional topologies and full dv/dt controllability, offering reduced system cost and complexity, as well as ease of adoption and integration. The .XT interconnection technology significantly improves the package's thermal capabilities. Up to 30% extra loss can be dissipated compared with a standard interconnection.

Infineon's EasyPACK CoolSiC modules in 50kW charger

After launching the HYC150 and HYC300 in its hypercharger product line, alpitronic has introduced the HYC50 50kW DC electric vehicle charger. As the first wall-mounted DC charger in this power range featuring two charging ports that allow fast charging of one vehicle at 50kW or of two vehicles simultaneously at 25kW each, it is enabled by using EasyPACK CoolSiC MOSFET 1B and 2B modules from Infineon in combination with the EiceDRIVER X3.

"We offer first-class solutions such as our portfolio of EasyPACK 1B and 2B modules with the latest 1200V CoolSiC MOSFET technology to increase the efficiency as well as the power density," says Dr Peter Wawer, president of Infineon's Industrial Power Control Division. "Devices can be flexibly combined with suitable drivers to meet the requirements of each customer and their individual project," he adds.

"With Infineon's CoolSiC EasyPACK modules in combination with a perfect matching driver IC, we were able to significantly improve the efficiency of our new hypercharger," says alpitronic's co-founder & managing director Philipp Senoner.

By using CoolSiC technology, the HYC50 achieves up to 97% efficiency and enables a bidirectional design. The hypercharger is hence suitable for vehicle-to-grid (V2G) operation. A;so, with a compact footprint of 1250cm x 520cm x 220cm and weighing less than 100kg, it is suitable for indoor wall mounting, though it can also be mounted flexibly on a pedestal outdoors. The charger supports the charging standards CCS1 and CCS2 with a capacity of 150A, CHAdeMO with a capacity of 125A, as well as GBT.

In this design, Infineon's EasyPACK 1B and 2B modules, which include CoolSiC MOSFETs, an NTC temperature sensor and PressFIT contact pins, were able to increase power density by about 50%. Also, by using CoolSiC technology, the noise level was cut significantly from 65dB to less than 50dB.

Infineon also provided the matching drivers. The X3 driver IC particularly suits the modules in this design, offering advantages through its configurability and active and passive monitoring options. For example, it enables additional sensor points for operational monitoring, with several gate drivers providing extra temperature points as well as gate voltage monitoring. Thus, the temperature and voltage can be adjusted exactly according to the needs of the SiC MOSFETs, minimizing static conduction losses and avoiding overloads.

Further, the operating points in the field can be optimized by OTA (Over-the-Air) updates — these can also influence the parameters in the gate driver. Systems in different climates can hence be optimized for the corresponding environmental conditions.

The EasyPACK CoolSiC MOSFET modules will be available in first-half 2022, and the HYC50 in Q2/2022.

www.infineon.com/coolsic

ROHM's SiC MOSFETs chosen by electric vehicle firm Lucid for on-board charging

SiC MOSFET-switched OBC delivers up to 19.2kW AC charging, adding up to 80 miles of range per hour

Japan-based ROHM Semiconductor says that California-based luxury electric vehicle (EV) company Lucid is using its silicon carbide metal-oxide-semiconductor field-effect transistor (SiC MOSFET) in its first car, the Lucid Air, for which customer deliveries are now underway.

The Wunderbox, the main on-board charging unit in the Lucid Air, integrates a DC–DC converter and the bi-directional on-board charger (OBC), where a power factor correction (PFC) circuit is capable of operating at high switching frequencies due to the performance of the SiC MOSFET. The improved performance of ROHM's SCT3040K and SCT3080K SiC MOSFETs at high frequency and high temperature has helped Lucid to reduce the size of the design, and to reduce power losses, which results in high charging efficiency.

Produced at Lucid's new factory in Casa Grande, Arizona, the Lucid Air is a luxury sedan underpinned by race-proven technology, and was named the 2022 MotorTrend Car of the Year. Additionally, an article in InsideEVs confirmed the Lucid Air's charging capabilities. For example, when connected to DC fast chargers, they found it takes about 22 minutes to deliver a charge that will enable select Lucid Air models to cover 300 miles. The SiC MOSFET-switched OBC can deliver up to 19.2KW AC charging, adding up to 80 miles of range per hour.

"It was important for Lucid to form strategic alignments with key EV power device suppliers to ensure our future success," says Eric Bach, senior VP of product and chief engineer, Lucid Group. "ROHM is one of the world's leading suppliers of SiC technology, with strong technical support. We were impressed with ROHM's strategic investments to increase the production capacity of SiC products, and its development of next-generation technologies. Lucid values the close collaborative relationship with ROHM in this work."

"We are excited to help Lucid develop systems for electric vehicles that maximize the potential of ROHM's SiC MOSFETs," says Kazuhide Ino, ROHM's managing executive officer, CSO and director of accounting & finance headquarters. "ROHM will continue to strengthen its SiC device lineup, delivering power solutions — such as the charging systems featured in the Lucid Air — that contribute to technological innovation in next-generation automobiles," he adds. "New products soon to be added include gate driver ICs that maximize device performance."

www.lucidmotors.com
www.rohm.com/products/sic-power-devices/sic-mosfet

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McLaren Applied unveils 800V SiC inverter for fast charging and powertrain efficiency in EVs

Prototypes delivered to customers ahead of volume production in 2024

At the Future Propulsion Conference (FPC 2022) at the UK's National Motorcycle Museum on 2 March, McLaren Applied of Woking, UK, says it is advancing closer to full production of its Inverter Platform Generation 5 (IPG5) 800V silicon carbide (SiC) inverter.

Moving to the engineering verification phase, McLaren Applied is now supplying production intent design hardware to customers and partners for continued development and testing. Harnessing IPG5, OEMs can develop vehicles with greater ranges, faster charging times and better acceleration, at a comparable cost with improved sustainability benefits, the firm says.

McLaren Applied says that it is actively supporting the increasing demand for electrification and high-efficiency power electronics applications in the automotive market, as well as the commercial vehicle, aerospace and marine sectors. It has been developing inverter technology for over 10 years, through high-performance automotive and motorsport applications, culminating in a fifth-generation inverter that takes development from Formula 1 and optimizes the technology for the automotive market.

IPG5 can power electric motors to over 350kW peak (250kW continuous) at a weight and volume of 5.5kg and 3.79L, respectively. It has been designed for automotive applications (including direct drive) that are capable of operating high-speed motors efficiently and adhere to ISO 26262 ASIL-D standards.

The 800V architecture supports the next generation of electric vehicles (EVs), offering lighter electric cabling and ultra-fast charging. Through enabling a significant increase in switching frequency, silicon carbide allows the use of a faster, more efficient and lightweight drivetrain, including inverter, motor and battery systems. It also switches more efficiently than conventional inverters, producing less heat and enabling a smaller cooling system — all of which reduce the weight and cost of the drivetrain.

The increased drivetrain efficiency allows a reduction in battery size — typically the most expensive single component in a battery electric vehicle, which delivers further cost, weight and sustainability benefits, says McLaren Applied.

"We're delighted to advance to the next stage of development and to begin delivering prototypes to customers [ahead of volume production from 2024]," says non-executive chairman Nick Fry. "Across the industry, we're seeing rapid progression of technology — if OEMs want to remain competitive and deliver vehicles with greater ranges, faster charging times and better acceleration, they must make the transition to an 800V silicon carbide architecture," he believes.

The 800V architecture supports the next generation of EVs, offering lighter electric cabling and ultra-fast charging

Strategic agreement to develop and supply drivetrain components for BAK's Kincsem Hyper GT and SUV

McLaren Applied has announced a collaboration with BAK Motors (the Swiss-based parent company to new luxury automotive brand Kincsem) to develop and supply drivetrain components (including inverters and motors) for the Kincsem Hyper GT and SUV — said to be the world's first nanophotonic light-activated solid-state hydrogen hybrid hyper-car. BAK selected the IPG5 800V silicon carbide inverter for its powertrain efficiency and performance improvements, says McLaren Applied.

The Kincsem Hyper GT will pair McLaren Applied's drivetrain technology with a BAK-RICARDO hydrogen-powered hybrid engine, combining the instant torque and acceleration of an e-motor with the high-revolution scream of a hydrogen internal combustion engine. The same power unit will also feature in the forthcoming Kincsem Hyper-SUV.

The Kincsem Hyper-GT will be designed, engineered and built in Britain, with first production of the road-legal version commencing in 2024.

www.mclaren.com/applied/news/mclaren-applieds-

Navitas announces first 20-year warranty for GaN ICs

Warranty applies to all packaged GaNFast power ICs in mass production

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has announced a 20-year limited warranty for its GaNFast technology — 10x longer than typical silicon, SiC or discrete GaN power semiconductors — and a critical accelerator for GaN's adoption in data center, solar and electric vehicle (EV) markets, it is reckoned.

GaN runs up to 20x faster than silicon chips. Navitas' proprietary GaNFast power ICs integrate GaN power field-effect transistors (FETs) and GaN drive plus control, sensing and protection circuits. The result is said to be easy-to-use, high-speed, high-performance 'digital-in, power-out' building blocks that deliver up to 3x faster charging in half the size and weight, and with up to 40% energy savings compared with earlier silicon solutions.

Navitas says that the unprecedented 20-year limited warranty is founded on its holistic approach to product reliability through design, testing, characterization and certification. As a pioneer in GaN power ICs and a founding member of the industry's JEDEC JC-70.1 GaN standards committee, Navitas developed proprietary high-speed production and qualification testing to set standards in GaN reliability.

"With over 40 million units shipped, 174 billion hours in the field and zero reported GaN-related field failures, plus 5.8 billion equivalent device hours testing, Navitas is now able to offer a 20-year warranty for GaNFast power ICs," says Anthony Schiro, VP quality and sustainability. "As we describe in our sustainability report, each GaN IC saves 4kg of CO_2. So, the faster [that] customers can adopt GaN, the better it will be for our environment. GaN could save up to 2.6Gtons CO_2 per year by 2050," he reckons.

Navitas provides GaN ICs fast and ultra-fast chargers for consumer mobile applications, with customers including Samsung, Dell, Lenovo, Xiaomi, OPPO, LG and Motorola. With dedicated design centers for data center and EV, plus availability of high-power GaNFast power ICs, Navitas reckons that its high-volume production quality and commitment to long-term reliability are accelerating the adoption of GaN technology.

"As leading-edge customers like Enphase (solar), Brusa (EV) and Compuware (data center) confirm GaN's technical and environmental benefits over legacy silicon chips, they are laser-focused on critical, long-term reliability," says CEO & co-founder Gene Sheridan. "GaN power ICs have a 6x-lower FIT rate (failures in time) than silicon," he adds.

The 20-year limited warranty applies to all packaged Navitas GaNFast power ICs in mass production.

www.navitassemi.com

Navitas powers fastest smartphone-charging technology from realme

150W GaNFast charger powers realme GT Neo 3 smartphone from 0–50% in 5 minutes

Navitas Semiconductor says that its GaNFast technology has been selected to deliver a fast-charging solution for the realme GT Neo 3 smartphone series that saw its global launch at MWC Barcelona 2022 (28 February – 3 March). The new 150W charger supplied 'in-box' with the GT Neo 3 is the most powerful member of the new ultra-fast smartphone charger category enabled by GaNFast power ICs.

Powered by a Dimensity 8100 chip, the realme GT Neo 3 features up to 150W UltraDart Charging Architecture (UDCA), the industry's fastest and most powerful commercial charging solution. Advanced heat management and battery protection ensure cool, long-life operation.

The availability of a 150W charger, built around Navitas GaNFast power ICs, allows users to capitalize on this technology by charging the phone's 4500mAhr battery from 0–50% in in just 5 minutes. At only 58mm x 58mm x 30mm (101cc), the charger achieves 1.5W/cc power density.

"Our super flash charging technology delivers the world's fastest smartphone charging solution, providing users of the new realme GT Neo 3 with the flexibility and convenience of fully charging their phones in the shortest possible time," says Madhav Sheth, president of realme international business group and VP of realme. "Gallium nitride ICs have been fundamental to delivering this step change in performance while keeping charger weight and form factor as low as possible," he adds.

"This milestone in the ultra-fast charger sector [the world's first commercial solution for 150W smartphone charging] is powered by Navitas GaNFast technology, which has allowed realme to create a new 150W charging benchmark for efficiency, speed and form factor," says Navitas' CEO & co-founder Gene Sheridan.

www.mwcbarcelona.com

Wolfspeed adds to global operations leadership team to support rapid company growth

TI veteran joins as VP of enterprise supply chain & procurement

Wolfspeed Inc of Durham, NC, USA — which makes silicon carbide materials as well as silicon carbide (SiC) and gallium nitride (GaN) power-switching & RF semiconductor devices, for applications such as electric vehicles (EVs), fast charging, 5G, renewable energy and storage, and aerospace & defense — says that Jeff Ferraro has joined it as VP of enterprise supply chain & procurement. He joins from Texas Instruments and has more than 20 years of experience in the semiconductor industry, including supply chain and financial management. Ferraro will report directly to senior VP of global operations Rex Felton.

Jeff Ferraro. VP of enterprise supply chain & procurement.

"Jeff brings an unparalleled wealth of knowledge of operational logistics and expertise over his decades working in the semiconductor industry," comments Rex Felton, senior VP of global operations. "With an impressive background spanning the full range of operational efforts — finance, business planning, supply chain and logistics — he is the ideal fit to join our operations leadership team to support Wolfspeed as it leads the industry-wide transformation from silicon to silicon carbide."

At Texas Instruments, Ferraro previously held the titles of manager of business planning & operations, director of finance & operations, and most recently director of supply chain & logistics, in which he was responsible for a complex network of logistic operations supporting manufacturing to product distribution, including global import and export compliance.

The addition to Wolfspeed's team of semiconductor operations professionals, paired with the expansion of production capability for silicon carbide materials and devices in both New York and North Carolina, will support the company's rapid growth.

www.wolfspeed.com

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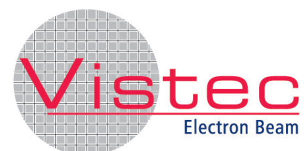

Vistec Electron Beam | www.vistec-semi.com

Teledyne e2v HiRel unveils space-screened versions of 650V, 60A GaN HEMTs

High-voltage packaged GaN HEMTs for hi-rel applications now available off the shelf with NASA Level 1 screening flow

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 added new space-screened versions of its 650V, 60A high-reliability gallium nitride (GaN) high-electron-mobility transistors (GaN HEMTs). The new parts go through NASA Level 1 screening flow and can be brought up to full Level 1 conformance with extra qualification testing, if desired. Typical applications include battery management, DC–DC converters, and space motor drives. Two new parts are available, both space-grade, 650V enhancement-mode, top-side-cooled GaN-on-silicon power transistors. The properties of GaN allow for high current, high voltage breakdown and high switching frequency, enabling high-efficiency and high-power-density designs. The two models are:

- TDG650E601TSP space GaN E-mode transistor with 900V transient drain-to-source maximum voltage;
- TDG650E602TSP space GaN E-mode transistor with 750V transient drain-to-source maximum voltage.

Each is available with options for EAR99 or European sourcing.

Teledyne e2v HiRel's GaN HEMTs feature single-wafer lot traceability, extended temperature performance from –55°C to +125°C, and low-inductance, low-thermal-resistance packaging.

"Our GaN HEMT product family has been very popular with customers, and we have had many requests for catalog versions with standard space screening," says Mont Taylor, VP of business development for Teledyne e2v HiRel. "Our new 650V, 60A parts offer 100% screening off-the-shelf, and we can do full level 1 qualification with customer SCDs."

The firm notes that GaN devices have revolutionized power conversion in other industries and are now available in radiation-tolerant, plastic-encapsulated packaging that has undergone stringent reliability and electrical testing to help ensure mission-critical success. The release of the new GaN HEMTs delivers the efficiency, size and power-density benefits required in critical aerospace and defense power applications, it adds.

Both new devices are available for ordering and immediate purchase from Teledyne e2v HiRel or an authorized distributor.

www.tdehirel.com

Teledyne e2v HiRel launches 100V high-speed 20MHz FET and GaN transistor driver flip-chip die

Teledyne e2v HiRel Electronics has launched the TD99102 UltraCMOS high-speed FET and gallium nitride (GaN) transistor driver, offering very high switching speed of 20MHz. The new flip-chip part is suitable for driving Teledyne HiRel's 100V high-reliability GaN HEMT devices in DC–DC, AC–DC converters, orbital point-of-load (POL) modules and space motor drives.

The TD99102 is an integrated high-speed driver designed to control the gates of external power devices such as enhancement-mode GaN high-electron-mobility transistor (HEMT) and power MOSFETs. The outputs of the TD99102 are capable of providing switching transition speeds in the sub-nanosecond range for switching applications up to 20MHz. The TD99102 is optimized for matched dead time and offers best-in-class propagation delay to improve system bandwidth, it is claimed. High switching speeds result in smaller peripheral components and enable innovative designs for high-reliability orbital motor driver and POL applications. The TD99102 is available as a bumped, flip-chip die to enable minimum design footprint required for high-speed switching power applications.

The TD99102 is manufactured on Peregrine's UltraCMOS process, a patented form of silicon-on-insulator (SOI) technology, offering the performance of gallium arsenide (GaAs) with the economy and integration of conventional CMOS. Featuring 100krad(Si) total ionizing dose (TID), single event latch-up (SEL) immunity and dead-time control, the new product offers 2A peak source and 4A peak sink current.

"We've been asked for drivers that get the most out of our 100V GaN HEMT transistors," says Mont Taylor, VP of business development for Teledyne e2v HiRel. "The TD99102's fast edge speeds and radiation tolerance make them ideal for the latest LEO and MEO constellations where efficiency is key," he adds.

The TD99102 is available for ordering and immediate purchase from Teledyne e2v HiRel or an authorized distributor.

Innoscience delivers 40V bi-directional GaN HEMT with low $R_{DS(on)}$ for smart mobile devices, chargers and adapters

Innoscience Technology of Suzhou, China, which makes 8-inch gallium nitride on silicon (GaN-on-Si) wafers for power switching applications, has launched the INN40W08, a 40V bi-directional GaN-on-Si enhancement-mode high-electron-mobility-transistor (HEMT) for mobile devices, including laptops and cellular phones. The INN40W08 HEMT has been developed using the firm's InnoGaN technology, which features ultra-low on-resistance.

"GaN technology has been adopted by manufacturers of mobile phone chargers over the last couple of years to deliver increased power and shrink device size," notes Dr Denis Marcon, general manager of Innoscience Europe and marketing manager for the USA and Europe. "However, Innoscience's significant breakthrough now makes it possible to introduce GaN HEMTs into mobile phone handsets as well, increasing efficiency and performance," he adds. "With Innoscience's huge available capacity, we provide the secure supply chain that customers nowadays expect."

Featuring a bi-directional blocking capability, the new INN40W08 GaN HEMTs have ultra-low on-resistance of just 7.8mΩ, achieved through the firm's InnoGaN patented strain-enhancement layer technology, which reduces sheet resistance by 66%. Gate charge (Q_G) is typically 12.7nC. The 5x5 grid wafer-level chip-scale package (WLCSP) measures just 2mm x 2mm. This small footprint enables INN40W08 GaN HEMTs to be integrated inside mobile phones. Applications include high side-load switching, over-voltage protection in a smart phone's USB port and multiple power supplies including chargers and adapters. Innoscience's GaN technology enables efficient and more compact over-voltage-protection (OVP) systems by replacing two silicon MOSFETs with one InnoGaN (or BiGaN) transistor. This saves on the overall OVP costs and makes the OVP unit smaller (very important, considering the space constraints on a mobile phone's circuit board).

Innoscience discusses innovations in GaN at APEC

At the Applied Power Electronics Conference (APEC 2022) in Houston, Texas (20–24 March), Dr Denis Marcon, general manager, Innoscience Europe, gave a presentation 'Applications, Technology Optimization and Manufacturing of 8-inch GaN-on-Si technology' discussing how Innoscience is addressing the needs of mass manufacturing GaN, the reliability of GaN and the advance tests that the firm has been performing on its devices. Marcon also gave some examples of applications that take advantage of the firm's GaN-on-Si normally-off (e-mode) device technology such as PD chargers, DC–DC converters for data centers and laser driver for light detection and ranging (LiDAR).

Innoscience's booth featured several low- and high-voltage demos, including a collaborations with specialized gate driver houses Heyday and MinDCet. Innoscience's GaN HEMT devices can be used in conjunction with other commercially available gate drivers from TI, On-Semi, STM, Joulwatt, Southchip, NXP, MPS, Meraki and Nuvoltatech. The devices range from low voltage (30–150V) to high voltage (650V) and are widely used in applications from USB PD chargers/adapters to data centers, mobile phones and LED drivers.

www.innoscience.com

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EPC showcases GaN for multiple applications at APEC

Demonstrations span industries including computing, communications and eMobility

At the IEEE Applied Power Electronics Conference and Exposition (APEC) in Houston, Texas (20–24 March), Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA delivered technical presentations, as well as a professional seminar on GaN technology and applications. The firm also demonstrated its latest enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and IC in a large variety of customer end-products.

48V DC–DC for high-density computing and automotive

The high-density computing and automotive markets are coalescing on the 48V bus, and GaN is the ideal solution at this voltage node, says EPC. The firm demonstrated an LLC design with power density of 5000W/in^3 for the high-density computing needs of power-hungry applications such as artificial intelligence (AI) and crypto mining.

For the automotive market, in-booth demonstrations showed how GaN enables 2kW bidirectional converters that increase efficiency, shrink the size, and reduce system costs for the next generation of mild hybrid and electric vehicles.

eMobility

GaN-based motor drives allow various applications such as warehouse autonomous robots, eMobility and drones to reduce size and weight, extend range, and increase reliability. EPC had examples of GaN-based motors capable of driving everything from eScooters to server fans and vacuum cleaners.

Fast charging

GaN-based USB-C PD 3.1 fast chargers can be up to 40% smaller and charge 2.5x faster than traditional silicon-based chargers. EPC is showing how GaN enables miniaturization, very high efficiency and excellent thermal performance for this high-volume application.

GaN integration

EPC's GaN experts were available to discuss the latest progress and roadmaps for GaN integration. Visitors to the booth could take the opportunity to work live with the web-based design tools available in the GaN Power Bench to accelerate their design cycles.

Technical presentations featuring eGaN FETs and ICs

- 'The Surprising Benefits GaN Brings to BLDC Motor Drives — Design, Performance, Cooling, and Reliability', Seminar instructors: Michael de Rooij Ph.D. and Marco Palma.
- 'Extending GaN Integration to Higher Power and Faster Speeds: An Examination of the Progress and Roadmaps for GaN Integration' by Alex Lidow Ph.D.
- '2 kW Bi-Directional Automotive 48 V-12 V DC-DC Converters Using eGaN FETs' by Yuanzhe Zhang Ph.D.
- 'PCB Layout for Chip-Scale Package GaN FETs Optimizes Both Electrical and Thermal Performance' by John Glaser Ph.D.
- 'Thermal Tool for Quick Estimation of Thermal Performance of eGaN FETs' by Assaad Helou Ph.D.
- 'Recent Advancements in the Understanding of Dynamic On-Resistance and Electromigration in Enhancement Mode GaN Devices' by Robert Strittmatter Ph.D.

www.apec-conf.org
www.epc-co.com

Nexperia showcases power electronics at APEC

Live demos and expo talks on GaN FETs, SiC diodes and MOSFETs

At the Applied Power Electronics Conference (APEC 2022) in Houston, TX, USA (20–24 March), Nexperia B.V. of Nijmegen, the Netherlands (a subsidiary of Wingtech Technology Co Ltd) demonstrated its latest developments in power electronics, spanning a range of recent innovations including:

Wide-bandgap

- a Ricardo electric vehicle (EV) inverter containing Nexperia's power GaN FET technology;
- a Shanghai E-Drive EV inverter containing Nexperia's power GaN FET technology in a copper-clip SMD package CCPAK;
- Nexperia's evaluation board for benchmarking dynamic performance of 650V SiC rectifiers.

Next-generation support tools for power design engineers

- precision electro-thermal models for MOSFETs enabling early design validation;
- interactive application notes and a MOSFET and GaN FET application handbook.

Nexperia's live expo talks focused on its expanding portfolio of power products:

Nexperia introduces Power GaN FETs

GaN applications director Jim Honea delivered a talk that provides a brief overview of Nexperia's high-voltage GaN FET technology and product portfolio, including the CCPAK copper-clip surface-mount package and some useful tips for successful applications.

Nexperia introduces SiC Schottky diodes

Technical applications manager Upal Sengupta gave a talk introducing Nexperia's SiC Schottky diodes that included a benchmarking performance comparison along with an efficiency analysis in an 800W PFC topology. Additional details about Nexperia's SiC diode portfolio and product roadmap were also presented.

www.nexperia.com

EPC and Analog Devices collaborate to deliver up to 2MHz switching frequency for high-density DC–DC converters

Reference design using new Analog synchronous GaN buck controller optimized to drive EPC's GaN FETs

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits for power management applications — has announced the availability of the EPC9160, a dual-output synchronous buck converter reference design board operating at 2MHz switching frequency that converts an input voltage of 9–24V to a 3.3–5V output voltage and delivers up to 15A continuous current for both outputs. Due to the high switching frequency, the converter size is very small, only 23mm x 22mm for both outputs, and the inductor height is only 3mm.

The high density and thickness of the design plus the 2MHz switching frequency make this solution suitable for automotive console applications, where 2MHz switching frequency is preferred, and computing, industrial, consumer and telecom power systems requiring small size and a very thin profile. eGaN FETs provide the fast switching, high efficiency and small size that can meet the stringent power-density requirements of these leading-edge applications, says EPC.

The EPC9160 reference design uses the EPC2055 enhancement-mode GaN FET and the LTC7890 two-phase analog buck controller with integrated GaN drivers.

The LTC7890 100V low-I_q, dual, 2-phase synchronous step-down controller is fully optimized to drive EPC eGaN FETs and integrates a half-bridge driver and smart bootstrap diode. It offers optimized near-zero dead-time or programmable deadtime and programmable switching frequency up to 3MHz. The quiescent current of 5μA (V_{IN} = 48V, V_{OUT} = 5V, CH1 only) enables very low standby power consumption and excellent light load efficiency.

The EPC2055 40V eGaN FET offers 3mΩ max $R_{DS(on)}$, 6.6nC QG, 0.7nC Q_{GD}, 1.3nC Q_{OSS} and zero Q_{RR} in a small 2.5mm x 1.5mm footprint and can deliver up to 29A continuous current and 161A peak current. The excellent dynamic parameters allow very small switching losses at 2MHz switching frequency.

The efficiency of the EPC9160 is greater than 93% for 5V output and 24V input. In addition to light load operating mode and adjustable dead-time, the board offers UVLO, over-current protection and power good output.

"GaN FETs ultra-low switching losses enable operations above 2MHz, with the new analog controller customers now having a full ecosystem able to work above 2MHz," says CEO Alex Lidow. "We are delighted to work with Analog Devices to combine the benefits of their advanced controllers with the performance of GaN to provide customers with the highest-power-density and low-component-count solutions that increases the efficiency, increases power density, and reduces system cost," he adds.

"Analog Device's LTC7890 is designed to fully exploit the high performance of EPC's eGaN FETs for high-power-density solutions" says Tae Han, senior product marketing manager at Analog Devices Inc of Wilmington, MA, USA. "The LTC7890 offers higher switching frequency and optimized dead-time that competes well above the current solution in the market while operating in very low power consumption," he adds. "With these new controllers, customers can take advantage of the very fast switching of GaN for the highest power density."

The EPC9160 demonstration board is priced at $300 each and is available for immediate delivery from distributor Digi-Key Corp.

www.analog.com
www.epc-co.com/epc/Products/DemoBoards/EPC9160.aspx

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GaN Systems highlights smallest GaN chargers at APEC

Rompower's 65W charger measures 30.5mm x35.0mm x 46.6mm; 100W charger provides >20W/in^3

At the 37th annual Applied Power Electronics Conference (APEC 2022) in Houston, Texas (20–24 March), GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) together with power conversion R&D company Rompower Energy Systems Inc of Tucson, AZ, USA displayed what are claimed to be industry firsts — the smallest 65W and 100W GaN chargers offering the highest efficiency and best power density:

- 65W AC–DC charger, with cased dimensions of 30.5mm x35.0mm x 46.6mm; highest efficiency at >94.5% @115V_{ac} and >95% @230V_{ac}; and highest power density at >22W/in^3.
- 100W AC–DC charger, with cased dimensions of 44.0mm x35.0mm x 67.0mm; highest efficiency at >94.5% @115V_{ac} and >94.5% @230V_{ac}; and highest power density at >20W/in^3.

"The technology advances in these chargers meet the newest demands in fast-charging applications where charger solutions must be small, cost-effective, and thermally efficient," says Rompower's founder & CEO Ionel (Dan) Jitaru.

Strong growth in demand for chargers is being driven by the consumer electronics industry from smartphones, PCs (desktops, notebooks and workstations), and other personal devices. In 2021 worldwide sales grew by 6% in smartphones to 1.4 billion units and by 15% in PC shipments to 341 million units, with revenues surpassing US$250bn.

GaN transistors allow chargers to operate more efficiently, resulting in significantly less power loss and heat. This enables the system components to be smaller and closer together, resulting in smaller, sleeker chargers with more power than larger models. The GaN Systems transistors can be switched at high frequency for maximum efficiency and power density, making them suitable for charging applications.

"GaN is revolutionizing the consumer and industrial charger markets by reducing size up to 4x while delivering on consumers' insatiable need for fast-charging," says GaN Systems' CEO Jim Witham. "We are proud to partner with industry leaders from Dell to Harman to Samsung, leading the charge for GaN in consumer markets. Today's collaboration with Rompower is the latest milestone on that journey."

At APEC, Rompower presented a seminar 'GaN impact on the AC–DC Power Adapters' highlighting GaN versus silicon for AC–DC adapter applications. Also, GaN Systems showcased Rompower's 65W and 100W GaN chargers and an array of GaN chargers for smartphone and laptop charging, up to 4x smaller than conventional chargers ranging from 45W to 240W.

www.apec-conf.org

GaN powers Samsung Galaxy S22+ and Ultra fast charger

45W charger nearly doubles power of previous generation

GaN Systems says that its high-efficiency semiconductor products have been selected to power the flagship Samsung Galaxy S22+ and Ultra smartphones, enabling the slim and powerful 45W charger to deliver on the efficiency and fast-charging promise of GaN. The 45W charger is claimed to set a new benchmark in power density and efficiency. The latest-generation charger nearly doubles the power of the previous generation while enabling super-fast charging.

GaN is reckoned to allow switching 20x faster than legacy silicon devices and 10x faster than silicon carbide (SiC). The inherent efficiency advantage of GaN is said to enable unrivaled form factors and power density for customers across consumer, enterprise, industrial and automotive markets. A common theme across all power markets is that customers want lower-cost systems that are smaller, lighter and consume much less power than legacy platforms. GaN System says that its reliability, quality and product lifetime enables it to be a supplier to technology companies like Samsung.

"Samsung's choice of our leading discrete solution for its flagship smartphone reinforces just how inextricably linked high-end consumer devices are with the cool efficiency and power of GaN," claims GaN Systems' CEO Jim Witham. "Samsung continues the trend of leading companies designing top-of-the-line consumer products around our unrivaled discrete offerings," he adds.

www.gansystems.com

GaN Systems showcases power electronics solutions

Solutions span fast chargers, Class-D audio, EV powertrains

At the 37th annual IEEE Applied Power Electronics Conference and Exposition (APEC 2022) in Houston, Texas (20–24 March), GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) showcased its lineup of power electronics solutions, including the following:

- GaN chargers: The firm showcased what are claimed to be the world's smallest 65W and 100W GaN chargers and a wide range of optimized chargers for smartphones, laptops and other consumer devices spanning from 45W to 240W from Dell, Philips, Harman and other leading brands. GaN Systems' array of charger reference designs that support faster time-to-market will be on display, including the 65W QR GaN charger, 100W Dual USB-C Intelligent PD GaN charger, and 250W AC/DC GaN adapter.
- GaN Audio: GaN Systems showcased the Syng Alpha Cell (one of TIME's 100 Best Inventions of 2021) and highlight solutions providing Class-D audio with products like Orchard Audio's Starkrimson Stereo Ultra amplifier and all-in-one Starkrimson Streamer Ultra, as well as the new 500W Heatsinkless Audio Amplifier from Axign and GaN Systems. Additionally, the firm will showcase its 400W Class-D audio reference design and its new 300W boost converter reference design for automotive, motorcycle and marine applications.
- EV power solutions: GaN Systems showcased onboard charger, traction inverter and DC-to-DC converter implementations. The firm is building on this with partners Vitesco Technologies and USI for next-generation powertrain solutions. "GaN transistors help to minimize heat losses, particularly the switching losses at the high switching frequencies we require," notes Dr Gerd Rösel, head of innovation in Vitesco's Electrification Technology business unit. "GaN components outperform silicon chips in every respect," he comments.
- Transistors, power module solutions and more: GaN Systems' newest generation of high-performance, lower-cost transistors will be shown. Several high-power and IPM form-factor power modules will be on display for applications in the industrial and EV segments that require much higher power.

To give an in-depth review of managing thermals in high-density applications, GaN Systems presented a technical session 'Thermal Design Considerations for GaN-Based Power Adapters with Multi-Heat Sources'.

"Efficient power generation, distribution and conversion are key factors in driving sustainability and reducing emissions, and GaN is more efficient and more cost-effective than both silicon and silicon carbide," says Paul Wiener, VP of strategic marketing. "The power industry is rapidly transitioning to GaN for best-in-class efficiency, design flexibility, costs, and more. We see rapid adoption across all of our target markets – automotive, consumer, enterprise and industrial."

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Transphorm exhibits and presents at APEC 2022

At the 37th annual IEEE Applied Power Electronics Conference and Exposition (APEC 2022) in Houston, Texas (20–24 March), Transphorm hosted in-production products from customers representing a broad range of markets.

Transphorm's product portfolio currently includes 650V and 900V GaN FETs in JEDEC- and AEC-Q101-qualified forms and various packages. The firm reckons that its portfolio's technical advantages are driven largely by its vertical integration. Uncommonly for the GaN semiconductor industry, this operating model allows Transphorm to control its devices' design, epitaxial wafer and manufacturing processes.

The firm hence claims 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 power-supply units, crypto mining rigs, electric vehicle (EV) converters, inverters for renewable energy, broad industrial systems, aerospace & defense systems, and others. Examples of these cross-industry products are on-site during the show.

Also, Transphorm partners with leading technology companies are offering complementary capabilities to fast-track development of GaN power systems. The firm says that these partnerships remove barriers to adoption, simplifying the design-in of its GaN FETs. Several of these development tools were on display.

During APEC, Transphorm staff gave the following presentations:

- 'Short-Circuit Protection for GaN Power Devices with Integrated Current Limiter and Commercial Gate Driver' by Davide Bisi, member of Technical Staff, Office of the CTO;
- 'GaN Four Quadrant Switches: Ready for Prime Time?' by technical fellow & principal scientist Rakesh Lal;
- 'No Two Wide Bandgap Technologies are the Same: Switching Advantages of SuperGaN FETs' by senior VP of technical marketing and business development Philip Zuk.

www.apec-conf.org

Boco's crypto-mining power supply using SuperGaN FETs

Transphorm's SuperGaN FETs are being used in the new 3.6kW power supply of Hangzhou Boco Electronics. The 12V AC-to-DC power supply achieves a peak efficiency of more than 96% and is designed to be used in rugged environments caused by ultra-demanding applications such as crypto-mining rigs and high-performance data-center systems. Driven by SuperGaN devices in a patented bridgeless totem-pole power-factor correction (PFC) topology, that power efficiency rating is nearly 1% higher or 36W lower power consumption than what Boco achieves in traditional PFC configurations. The totem-pole PFC topology, along with the FET's TO-247 package, also enables a reduction in the overall power system's component count, in turn reducing the overall system cost.

"Mining rigs run 24 hours a day, seven days a week. Given this, our customers seek higher-power, higher-efficiency, higher-reliability power supplies to support these intensive applications," says Boco's CEO Golden Yin. "We knew we could meet those requirements by matching our strong design capabilities with advanced GaN solutions. Whereas GaN was the right technology in general, Transphorm's SuperGaN products were the right devices. They proved to be better suited for the higher power ranges while offering the higher field reliability required by such industrial applications when compared to alternative options."

The device in the power supply is the JEDEC-qualified TP65H035G4WS, a normally-off 650V device with an on-resistance of 35mΩ. Part of the SuperGaN Gen IV product family, it offers what is claimed to be an industry-leading ±20V gate robustness with the industry's best noise immunity threshold of 4V.

With faster switching and lower losses, Transphorm's GaN replaces traditional MOSFETs used by Boco in similar incumbent power supplies. Further, it allows Boco to use the totem-pole PFC in lieu of an interleaving H (full bridge) PFC or interleaving DCM PFC. The system's resulting power density increased, allowing extra space for increased cooling air flow. Notably, development of the power supply took only six months, aligning with the ease of drivability and designability of Transphorm's devices.

"Power-hungry applications like crypto mining — which solve complex mathematical problems while processing massive amounts of data — are increasingly more expensive to support, from hardware to raw energy resources. In fact, mining farms that used to benefit from local government support and cheaper energy delivery through hydropower in China are now being forced to relocate, as a result of regulatory changes," says Kenny Yim, Transphorm's VP of Asia Pacific sales. "As a result, we're seeing manufacturers of related high-power application systems turn to GaN for remarkably better performance and efficiency to combat higher electricity prices. It's a trend we're proud to support as we continue to strengthen and enhance our GaN platform."

Transphorm says its role in Boco's product development process went beyond supplying transistors. Its technical support team collaborated with the Boco's engineering team on design reviews to ensure that the GaN technology was maximized for the highest performance output possible.

www.bocohz.com/en

Transphorm and TDK-Lambda add 12V and 48V modules to GaN-based 500W AC–DC power supply family

Second and third products in TDK's PFH series deliver 38% power density increase over silicon

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — says that TDK-Lambda Corp (a group company of TDK), which makes power conversion products for industrial and medical equipment, has expanded its GaN-based PFH500F product line.

The PFH500F-12 and PFH500F-48 are the second and third modules in TDK's series of 500W AC–DC power supply units (PSUs), offering 12V and 48V power outputs respectively. As with their predecessor, the GaN-based 28V PFH500F-28, these latest supplies deliver various GaN benefits to end applications including a 6% efficiency increase in a 13% smaller device package. Combined, these advantages yield a 38% power density improvement compared with the PFE500SA-12 and PFE500SA-48, TDK-Lambda's incumbent silicon-based 12V and 48V modules.

The PFH500F series uses 72mΩ, 8x8 PQFN GaN FETs (TP65H070LDG) from Transphorm. The high power density of these power transistors enabled TDK to cool the GaN power supplies via thin baseplates. In turn, TDK was able to produce a leaner, tightly contained power module capable of supporting a wide variety of broad industrial applications operating in harsh environments. Such applications include commercial off-the-shelf (COTS) power supplies, custom fanless power supplies, 5G communication, laser, digital signage/displays, and signaling.

PF500F GaN-Based Power Module Series

The 12V and 48V PFH500F modules were designed by the TDK-Lambda Americas team in Dallas, TX, USA and deploy a bridgeless totem-pole PFC (power factor correction) configuration. While the flagship 28V GaN power supply took about three-plus years to design, TDK's engineering team was able to adapt its learning to produce these latest models in a year.

"TDK's decision to launch the PFH500F product line as a GaN line was the result of carefully considering what our customers want and need," says Jin He, VP of engineering at TDK-Lambda Americas. "And, what our customers require are reliable power systems for use in rugged applications that can't afford to fail. By using Transphorm's GaN, we are able to confidently deliver that in increasingly smaller, higher-performing PSUs that can also inspire end-system innovation."

TDK-Lambda's PFH500F-12 and PFH500F-48 power modules are said to deliver the following advantages compared with the silicon-based PFE500SA-12 and PFE500SA-48:

- power efficiency of 92% (a 6% percent increase);
- power density >100W/in^3 (a 38% increase);
- PMBus monitoring and programming (read/write);
- board size reduction from 116.8mm x 61mm to 101.6mm x 61mm (a 13% reduction);
- reduced size of external capacitive components.

The PFH500F Series of modules was on display in Transphorm's booth at the 37th annual IEEE Applied Power Electronics Conference and Exposition (APEC 2022) in Houston, Texas (20–24 March).

www.apec-conf.org
www.jp.lambda.tdk.com/en
www.transphormusa.com/en/product/tp65h070ldg

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Cambridge GaN Devices debuts first commercial products

Marking its debut appearance at the Applied Power Electronics Conference (APEC2022) in Houston, TX, USA (20–24 March), fabless semiconductor company Cambridge GaN Devices Ltd (CGD) has emerged from stealth mode to launch its first portfolio of products, which are capable of reducing power losses by up to 50%. CGD has launched the ICeGaN 650V H1 series comprising four 650V products that utilise GaN-based technology.

Spun out of the University of Cambridge Department of Engineering's Electrical Power and Energy Conversion group in 2016 by Dr Giorgia Longobardi and professor Florin Udrea, CGD has spent the past six years in R&D to design, develop and commercialize power semiconductors products that use gallium nitride (GaN)-on-silicon substrates.

The firm has accumulated a portfolio of 39 patents and applications, 20 of which are said to be distinctive inventions, focused on faster, smaller and more economical devices designed to drive widespread adoption of GaN technology in consumer electronics and beyond. The 650V H1 product series represents CGD's commercial launch and is claimed to be an industry first, enabling the use of standard MOSFET drivers and no external components needed for protection. Engineers will be able to use CGD's GaN-based technology in applications currently run with silicon-based devices or with other GaN solutions.

CGD says that its patented ICeGaN (Integrated Circuit Enhancement Mode GaN) technology merges the ease-of-use benefits seen in cascode configurations with the simplicity of a single-die eMode (normallyOFF) high-electron-mobility transistors (HEMTs), as well as a number of integrated smart sense and protection features. All of this is embedded in a single die that is reckoned to deliver up to 50% power loss reduction compared with legacy silicon die. The technology is fully scalable on power and voltage for future developments, says CGD.

ICeGaN is an integrated solution based on GaN with an intelligent and self-protecting mechanism that enhances the functionality, versatility and reliability of the transistor. This GaN technology can be applied to any system that requires power and operates in the 650V market segment, says the firm. Initial applications include consumer electronic products such as mobile chargers, adapters for laptops, gaming and AIOs computers and, in general, SMPS (switched-mode power supplies) for consumer applications. The 650V H1 Series portfolio is also a first step into segments such as lighting and server power. Further expansion is planned towards high-power servers and telecom markets for data centers, photovoltaics (PV) inverters and renewable energy production, targeting electric vehicle/hybrid electric vehicle (EV/HEV) systems in the future.

CGD's long-term product strategy is also supported by several multi-partner UK- and EU-funded projects, the latest being ICeData, an initiative aiming to develop and commercialize highly efficient GaN-based ICs for use in data-center server power supplies. This specific project is funded by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS) within the Energy Entrepreneur Fund, which has selected leading UK technologies providing solutions for energy efficiency and reducing CO_2 emissions.

"Our GaN-based technology makes a difficult engineering challenge easy while operating at a high level of efficiency," says CGD's CEO & founder Dr Giorgia Longobardi. "This is due to the team's expertise in GaN and our profound knowledge of the material, the device physics, as well as our deep understanding of market requirements. Sustainability is a core tenet of our business and we are always researching innovative solutions with the aim of continuously lowering power losses in the electronic power industry to benefit a wide community of customers and end users," she adds.

"I have been working on power semiconductor devices for over three decades. My research at Cambridge University and with various companies has been focused on diverse materials such as silicon, gallium nitride, silicon carbide and diamonds and a variety of devices from HEMTs to IGBTs and from Superjunctions to FinFETs," notes founder & chief technology officer professor Florin Udrea. "There have been many wrong prognostics regarding the development of wide-bandgap products. But this time it is different: the time for GaN is now. The uptake in the market will be exponential for at least the next decade," he forecasts.

"The ICeGaN 650V H1 series is focused on making life easier for all those who have been trying to design-in GaN transistors and have dedicated significant R&D effort to figure out how to drive them," says Andrea Bricconi, VP of business development. "These four products can be seamlessly interfaced with gate drivers which make ICeGaN-based GaN HEMTs easy to use, like a silicon MOSFET," he adds. "No additional components are needed to drive ICeGaN, no clamping diodes for protection, no negative voltages are needed to TurnOFF the power transistor, and still the highest performance levels are guaranteed by GaN intrinsic properties. The wide range of R_{dsON}, from 55mΩ to 200mΩ, is offered in two of the most popular SMD packages, DFN5x6 and DFN8x8, which makes the portfolio perfectly suited for most low- and mid-power SMPS applications, while specific IC and packages solutions for high-power markets are in preparation," says Bricconi.

www.camgandevices.com

Germany's 'EdgeLimit-Green ICT' project gains funding for three-year implementation phase

Fraunhofers IAF & IIS and University of Freiburg work on energy-saving AlScN-based edge-cloud mobile radio base stations

Funded by the German Federal Ministry of Education and Research (BMBF) for three years as part of the 'Green ICT' initiative, Fraunhofer Institutes IAF (Institute for Applied Solid State Physics, in Freiburg) and IIS (Institute for Integrated Circuits, in Erlangen) — together with the Institute for Sustainable Systems Engineering (INATECH) at the University of Freiburg and multiple industrial partners — have begun the implementation phase of the project 'EdgeLimit-Green ICT', which aims to develop and test an energy-efficient edge-cloud system for mobile radio base stations by 2025, making use of aluminium scandium nitride (AlScN)-based components and demand-driven control.

EdgeLimit-Green ICT follows a successful preliminary project from October 2020 to June 2021 involving the investigation and design of innovative semiconductor technologies and application approaches for energy-efficient mobile radio systems. In summer 2021, through the BMBF's innovation competition 'Green ICT—Electronics for energy-saving information and communication technology', the project was selected among ten research groups to receive continued funding.

"Energy-efficient microelectronics, as we are developing in 'EdgeLimit-Green ICT', exemplifies how new technologies can become more powerful and at the same time conserve resources," notes project coordinator professor Rüdiger Quay, executive director of Fraunhofer IAF. "The novel power semiconductor components being developed by Fraunhofer IAF, in combination with the intelligent, AI-assisted networking and control of the antenna system designed by Fraunhofer IIS, promise to halve energy losses during millimeter-wave 5G transmission," he adds.

The industrial partners in the project network are supporting the project through collaborations in the development of novel high-frequency transistors (Nokia), circuit processing (United Monolithic Semiconductors GmbH, UMS), and the real-world evaluation and transfer of test results (Deutsche Telekom AG).

Savings due to energy-efficient AlScN components and intelligent cloud-edge implementation

On the one hand, the high energy-saving potential of the antenna system that will be developed in EdgeLimit-Green ICT results from the superior material properties of the power semiconductor aluminum scandium nitride. Fraunhofer IAF produces AlScN by metal-organic chemical vapor deposition (MOCVD) and uses the material in fabricating high-electron-mobility transistors (HEMTs). Due to its high current-carrying capacity, AlScN potentially allows significantly higher power density and gain compared with established semiconductors such as silicon, gallium arsenide (GaAs) or gallium nitride (GaN).

On the other hand, the savings result from efficient design of the electronics. "We are developing an innovative electronics architecture at Fraunhofer IIS to make possible intelligent networking and demand-driven control of the transmitter and receiver modules with the support of artificial intelligence (AI)," says Thomas von der Grün, head of Locating and Communication Systems Department at Fraunhofer IIS. "This provides for a partial shift of processing capacities from the central infrastructure (cloud) to the edge of the network and the implementation of data processing systems."

Overall, the combination of energy-efficient components and optimized organization should reduce energy losses in the remote radio head (RRH) implemented in EdgeLimit-Green ICT by at least 50%. For this purpose, researchers double the power efficiency at the amplifier level at new frequencies of 26–34GHz, halve the loss in power converters, and implement demand-driven system control.

www.iaf.fraunhofer.de

Toyoda Gosei makes record diameter GaN substrates for next-generation power devices

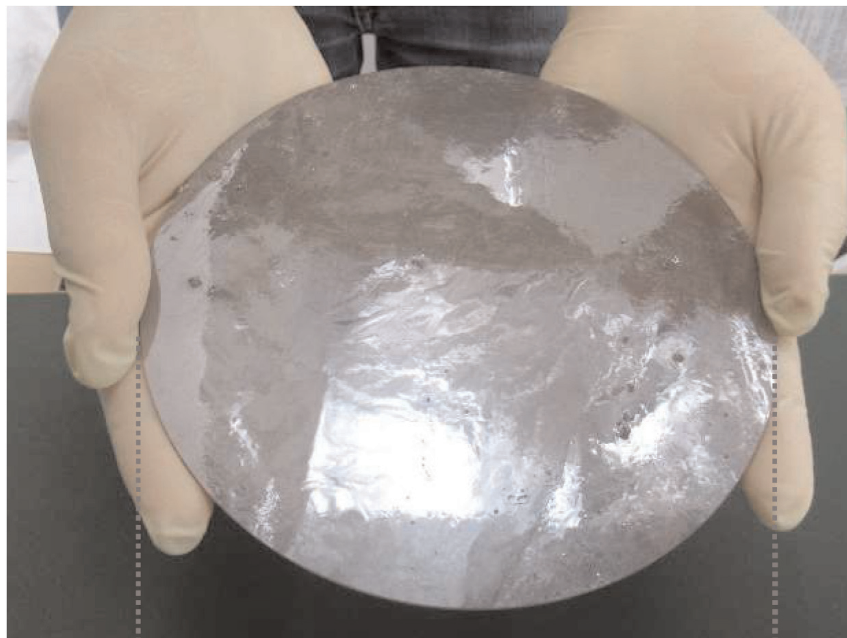
Sodium flux method used to exceed 6-inches

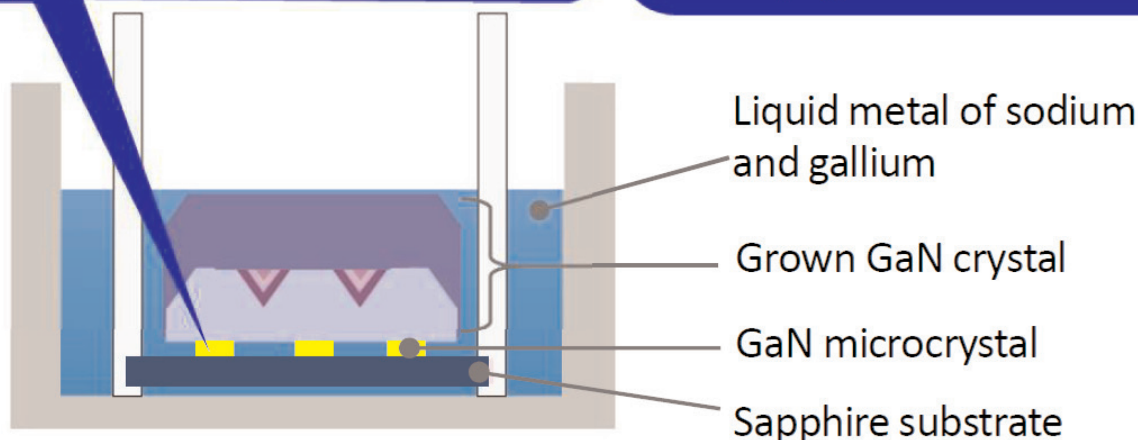
Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan, together with Osaka University, says that it has succeeded in increasing the diameter of substrates for gallium nitride (GaN) power devices, by leveraging its expertise in GaN semiconductors such as blue LEDs and ultraviolet (UV-C) LEDs.

The firm says that higher-quality and larger-diameter GaN substrates are needed in the development of GaN power devices in order to achieve higher productivity and hence cost reductions.

In a project headed by the Japanese Ministry of the Environment, Toyoda Gosei and Osaka University have employed a method of growing GaN crystals in a liquid metal of sodium and gallium (the sodium flux method) to fabricate a high-quality GaN substrate (GaN seed crystal) of record diameter of more than 6-inches. The researchers will next conduct quality assessments for the mass production of 6-inch substrates, and continue to improve the quality and increase the diameter (beyond 6-inches).

www.toyoda-gosei.com





Gallium oxide film grown on 6-inch wafers by HVPE

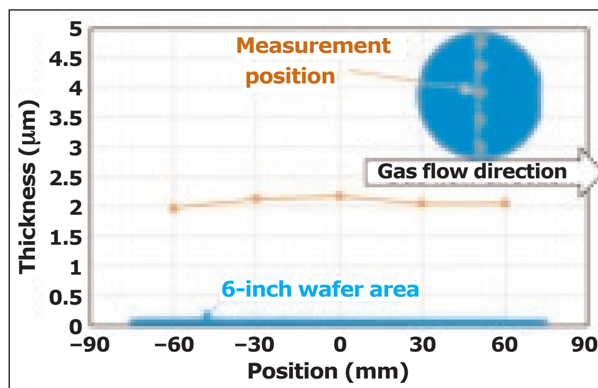
Nippon Sanso, Tokyo University of Agriculture and Technology, and Novel Crystal Technology target cost reduction for power devices

A joint effort between Tokyo-based Taiyo Nippon Sanso Corp (TNSC), Tokyo University of Agriculture and Technology, Novel Crystal Technology Inc of Sayama, Saitama Prefecture, Japan has succeeded in growing gallium oxide film on a 6-inch wafer by halide vapor-phase epitaxy (HVPE).

Gallium oxide (β-Ga_2O_3) has an even wider bandgap than silicon carbide (SiC) and gallium nitride (GaN), so transistors and diodes made with β-Ga_2O_3 have excellent performance characteristics as power devices, namely high voltage resistance and high efficiency (low loss). In mid-2021, Novel Crystal Technology Inc developed a 4-inch β-Ga_2O_3 epitaxial wafer grown by HVPE, which it now manufactures and sells. The β-Ga_2O_3 substrate that forms the base of the epilayer growth differs from SiC and GaN in that it can be manufactured using the melt growth method, which enables rapid formation of bulk crystals. Therefore, β-Ga_2O_3 wafers can easily be obtained in large diameter and at low cost, which is useful for reducing the price of power devices.

However, while the HVPE system used in β-Ga_2O_3 film growth has the benefits of low material cost and high-purity film, the HVPE system has only been built for small-diameter (2- or 4-inch) wafers and for single-wafer manufacturing. So, to reduce the cost of growth, it was essential to build a batch-type mass-production system capable of producing large-diameter (6- or 8-inch) wafers by HVPE.

Taiyo Nippon Sanso began developing a mass-production β-Ga_2O_3 epi growth system for large-diameter wafers under the Strategic Innovation Program for Energy Conservation Technologies ('Research and Development of Mass Production Epi Growth System Corresponding to Large Diameter Wafers for Next Generation Power Devices of Gallium Oxide') of Japan's New Energy and Industrial Technology Development Organization (NEDO). The program's incubation research phase (fiscal 2019), saw the development of external supply technology for metal chloride (raw material for HVPE). The practical application development phase (fiscal 2020–2021) saw the development of a 6-inch single-wafer HVPE system and growth processes to establish the basic technology for a mass-production system, followed by its evaluation. Now that the growth of a β-Ga_2O_3 film on a 6-inch wafer has been achieved, it is expected that, if β-Ga_2O_3 power devices become widely adopted, power saving should be possible for industrial motor control inverters, residential solar power generation system inverters, and next-generation electric vehicles, as well as other applications.



Thickness distribution of β–Ga_2O_3 film formed on a 6 inch test wafer.

Results

Nippon Sanso developed the 6-inch single-wafer HVPE system, and achieved growth of a β-Ga_2O_3 film on a 6 inch test wafer using a sapphire substrate.

Moreover, the optimization of growth conditions and the adoption of a proprietary raw material nozzle construction enabled verification of β-Ga_2O_3 growth on the 6 inch test wafer as well as uniform film growth, and the achievement of a β-Ga_2O_3 film thickness distribution of less than ±10%. This result established the technology for growing films on large-diameter substrates along with hardware design technology, enabling the creation of a platform for a β-Ga_2O_3 growth system. This in turn paved the way for a significant advance in the development of a large-diameter batch-type mass-production system.

Future plans

Nippon Sanso says that it will continue to develop mass-production systems for β-Ga_2O_3 growth under the NEDO project and, going forward, will develop high-quality β-Ga_2O_3 epi growth technology using 6-inch β-Ga_2O_3 wafers by evaluating the electrical characteristics and defects for β-Ga_2O_3 thin films. Moreover, after establishing β-Ga_2O_3 epiwafer mass-production technology, it aims to commercialize a mass-production system in fiscal 2024.

β-Ga_2O_3 epiwafers manufactured using the HVPE system are expected to be used mainly for Schottky barrier diodes (SBDs) and field-effect transistors (FETs), for which the market is expected to grow to about ¥59bn (according to the report '2020 Current Status and Future Prospect of Next Generation Power Devices & Power Electronics Related Equipment Market' from Fuji Keizai Co Ltd) by fiscal 2030. Looking ahead, we will contribute to the effort to save energy in next-generation electric vehicles etc., by realizing mass-production system, entering the β-Ga_2O_3 growth system market, and promoting the spread of Ga_2O_3 power devices.

www.tn-sanso.co.jp/en
www.novelcrystal.co.jp/2021/2595
www.nedo.go.jp/english/activities/activities_ZZJP_100039.html

AXT grows revenue 44% year-on-year, aided by market share gains

Growth of 15–20% in 2022 to be driven by 35–40% growth in InP

For fourth-quarter 2021, AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — has reported revenue of $37.7m, exceeding both the initial guidance range of $34-36m (provided on 27 October) and the increased guidance range of $36–$37m. Despite usually being a down quarter for AXT, this is up 9% on $34.6m last quarter and up 40% on $27m a year ago, representing an eighth consecutive quarter of growth and a fourth consecutive quarter over $30m.

Full-year 2021 revenue was $137.4m, up 44% on 2020's $95.4m (and up by more than 65% on 2019). InP substrate revenue grew by 41%, becoming the firm's single largest revenue contributor. GaAs substrate revenue grew by 38%, driven by a wide variety of applications. Germanium substrate revenue grew by 18%.

Growth is all organic, driven by market expansion and market share gains. "We grew in every revenue category across our portfolio without the help of price increases," notes chief financial officer Gary Fischer. "This underscores the momentum we are seeing in our business, with new applications coming to the market, major technology trends, and our own success in winning share at strategic customers."

By product category in Q4/2021, InP was $13.1m, GaAs was $11.3m, Ge was $4.2m. Total substrate sales were therefore $28.6m, up 9.2% on $26.2m last quarter and up 33% on $21.5m a year ago.

In addition, revenue was $9.1m from AXT's two consolidated raw materials joint venture companies: BoYu (which makes high-temperature pyrolytic boron nitride crucibles and pBN-based tools for organic light-emitting diodes) and JinMei (which supplies high-purity materials including gallium and germanium, as well as InP poly and other materials). This was up from $8.4m last quarter and $5.5m a year ago, after both BoYu and JinMei relocated their factory to AXT's campus in Kazuo in 2020 (enabling them to expand capacity in response to continuing strong market demand), aided by a recovery in pricing of raw materials such as raw gallium.

Of total revenue in Q4, the proportion from the Asia-Pacific region was 74.9%, Europe was 16.7% and North America was 8.4%.

For the fourth consecutive quarter, no customers reached 10% of revenue (compared with two a year ago), and the top five customers generated just 29% of total revenue (down from 37%). "Our continued revenue diversity demonstrates that our growth is not overly dependent on one large customer or application," says Fischer. "This is another factor contributing to our confidence that our growth has reached a point of sustainability and will continue throughout 2022."

On a non-GAAP basis, full-year gross margin grew from 31.9% in 2020 to 34.8% for 2021. However, quarterly gross margin has fallen further, from 33.9% a year ago and 33.8% last quarter to 32.4%. "Contributing factors were increasing raw material costs [i.e. raw gallium that JinMei has to buy] within a constrained environment of demand, lower yields in some of our products, and the decision to accept strategic lower-margin business in order to position ourselves competitively n advantageous markets and customers," says Fischer. "These factors offset the improvements made to gross margin at JinMei from expiring contracts [under which it had been selling materials at a pre-set price to several customers], as well as a new and promising raw material recycling program."

Quarterly operating expenses have risen further, from $6.6m a year ago and $7.7m last quarter to $8.1m, driving full-year OpEx up from $23.8m in 2020 to $30.4m for 2021. R&D remains one of the primary drivers of the increase. "We have two major programs that are ongoing: the development of 6-inch InP and the development of 8-inch GaAs," notes Fischer.

Net income was $4.1m, down from $5.4m ($0.13 per share) last quarter (although Q3 included two local government grants totaling $1m for facilities investments in the Kazuo region that did not repeat in Q4). Also, earnings per share of $0.09 exceeded the $0.06–0.08 guidance range. In addition, this was up on $2.8m ($0.06 per share) a year ago. Full-year net income hence more than tripled from $5.9m ($0.14 per share) in 2020 to $19.1m ($0.44 per share) for 2021.

In Q4, depreciation and amortization was $2m. Capital expenditure (CapEx) was $10.5m (up from $6.1m last quarter). Total stock compensation was $1.1m. During the quarter, cash, cash equivalents, and investments hence fell further, from $56m to $51.8m.

"2021 was a pivotal year for our business. We are hitting an inflection point in which applications that were once considered early-stage technologies are now moving to mainstream adoption," believes CEO Dr Morris Young.

The demand environment remains strong. For Q1/2022, AXT expects revenue to rise further to $38–40m, with net profit of $0.07–0.09 per share.

STAR Market listing update

In late December, AXT's China-based wafer manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd submitted its application to list its shares in an initial public offering on the Shanghai Stock Exchange's Sci-Tech innovAtion boaRd (STAR

Market). The application was formally accepted for consideration on 10 January, and AXT has received its initial comment letter. However, the process of going public on the STAR Market includes several periods of review and, therefore, is a lengthy process. Tongmei expects to accomplish this goal in second-half 2022.

Outlook for 2022

"With our current market drivers, we believe we can deliver revenue growth in 2022 of 15–20% of our 2021 results," says Young. "This is expected to come from market expansion, share gains, and customer wins," he adds. "With clear applications and design-win success, we believe we will grow our indium phosphide revenue in 2022 by 35–40%. We also believe that significant groundwork will be laid in 2022 for new applications in gallium arsenide. We are already seeing healthy growth in high-end LEDs, solid-state industrial lasers, and Wi-Fi for IoT applications, which we expect will continue," he adds.

"Recently, we have also seen demand for gallium arsenide substrates for power amplifiers in 5G handsets. This is a new market for us and one that is opening up to AXT as a result of both the increased demand in 5G handsets as well as the supply constraints in our competitors to meet customer needs. Though the gross margin profile of this application is lower than other areas of our business, the volume opportunity is attractive, and we believe we can drive healthy gross margin contribution in our business model in the coming years."

Significant groundwork will be laid in 2022 for new applications in GaAs. We are already seeing healthy growth in high-end LEDs, solid-state industrial lasers, and Wi-Fi for IoT applications, which we expect will continue. We have also seen demand for GaAs substrates for power amplifiers in 5G handsets. This is a new market for us

"Gross margin improvement is a top priority for AXT in 2022," says Fischer. "Like most businesses, we have seen a steady increase in costs relating to everything from wages to the materials required to manufacture our products. Those increases will likely continue to create some near-term offset in 2022. However, we think we can get back to 35% range this year," he adds. "Improvement will come through growing volume, favorable product mix, better pricing, and a strong focus on yield improvements and manufacturing efficiencies. We will see some incremental gross margin improvements as JinMei continues to work through some of the contracts that began creating a headwind in Q3."

"Our investments in capacity, R&D for larger-diameter substrates, and the STAR Market IPO of our Tongmei subsidiary give us significant competitive advantages in our ability to scale our business, and meet the needs of tier-1 customers and emerging high-volume applications," says Young. "We have a strong foundation in place and believe that the stage is set for another year of meaningful achievement in 2022," he concludes.

www.axt.com

5N Plus appoints president & CEO

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada says that its board of directors has appointed Gervais Jacques as president & CEO. Jacques has been interim president & CEO since 1 December 2021. He remains a member of the board.

5N Plus provides purified metals such as bismuth, gallium, germanium, indium, selenium and tellurium, and also produces related II-VI semiconducting compounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for the growth of crystals for solar, LED and eco-friendly materials applications. Sectors addressed include renewable energy, security, space, pharmaceutical, medical imaging, and industrial and additive manufacturing.

"Since his interim appointment late last year, Gervais has demonstrated his strong leadership skills, his passion for 5N Plus, and a clear vision for the future," comments Luc Bertrand, chair of the board. "A seasoned business executive and strategic thinker with over 30 years of industry experience [in metals], the board is confident that he is the ideal candidate," he adds.

"The last few months in this role have enabled me to gain additional insight and perspective into the challenges and opportunities that lay ahead," says Jacques. "I am eager to continue working with the strong team in place to execute our near-term priorities, including the integration of AZUR Space, and to drive future growth, while managing a complex global market and business environment."

Jacques is the former managing director and chief commercial officer of Rio Tinto Aluminum, where he led more than 6000 staff in five countries. He previously served as chairman of the International Aluminum Institute (the only Canadian ever appointed to this position) and as chairman of the Canadian Aluminum Association. Jacques has a degree in Chemical Engineering from Université Laval and completed a leadership and strategy program at the London Business School (England) in 2012.

www.5nplus.com

France funding Riber's 300mm pilot line for silicon photonics sector

ROSIE platform enables epi for perovskites and BTO/STO on silicon

As part of the call for projects 'Industry Stimulus Plan - Strategic Sectors' launched by the France's Ministry of Industry, Riber S.A. of Bezons, France — which designs and makes molecular beam epitaxy (MBE) systems and evaporators — has been awarded public funding to finance its 300mm pilot line.

ROSIE is a unique platform that enables epitaxy for perovskite materials and specifically BTO/STO (barium titanium oxide/ strontium titanium oxide) on silicon. This configuration makes it possible to address the core component of several emerging applications, including electro-optic modulators, electric vehicles (EV), 'beyond CMOS' and quantum computing.

Riber says that the French State's €1.1m subsidy has further strengthened its dedicated resources for implementing the ROSIE pilot line, which aims to provide the material and human resources needed for industry stakeholders to carry out small series, demonstrators and proofs of concept.

Based on the ultra-vacuum deposition technique and compatible with semiconductor industry standards (300mm), ROSIE will be focused on depositing very thin films of materials by epitaxy on silicon and will offer monoatomic precision capabilities in terms of control on a 300mm wafer.

ROSIE represents a total industrial investment of €3m over three years. Driving the development of silicon photonics, it should help to meet the current challenges concerning the integration and convergence of semiconductor sectors (silicon, III-V) to design new microprocessors that go beyond the current technological limitations and offer extremely high-performance switching speed properties with virtually zero optical losses. Scheduled to be operational by the end of 2023, the ROSIE pilot line has already received several expressions of interest from clients in Europe and the USA.

"Thanks to the French State's support, Riber is setting out its position as a vital industrial partner to further strengthen the semiconductor industry's competitiveness in Europe," says Philippe Ley, chairman of Riber's executive board. "This public support will help optimize and secure the industrial development of our highly strategic ROSIE pilot line," he adds. "Riber is moving forward with its ambition to work on innovative and disruptive technologies supporting the silicon industry."

www.riber.com

EPIR orders Riber MBE 32P MCT research system

System to be used to grow mercury cadmium telluride material

Riber has received an order from EPIR Inc of Bolingbrook, IL, USA (a subsidiary of Sivananthan Laboratories Inc) for an MBE 32P MCT research system to expand its manufacturing base.

EPIR develops HgCdTe (mercury cadmium telluride - MCT) semiconductors for infrared detection and imaging devices. The firm uses customized material growth technology, enabled by Riber's MBE equipment and including multiple epitaxial layers grown on either lattice-matched CdZnTe (cadmium zinc telluride) for high-performance applications or silicon substrates for a lower-cost approach.

"Riber was the main equipment provider for our MBE needs during the last two decades and this new acquisition is a testimony to the quality and reliability of the products it provides," comments EPIR's president Dr Silviu Velicu. "The new MBE 32 MCT system to be installed at EPIR will help us address increased commercial and government needs for high-quality HgCdTe material," he adds.

EPIR's chief operating officer Dr Paul Boieriu expects that HgCdTe with high purity, low defect densities and high uniformity over large areas will exhibit state-of-the-art performance shortly after the installation of the MBE 32P MCT system in early 2023.

"Our MBE 32 product range has been in existence for 40 years with an installed base of several hundred systems worldwide," notes Philippe Ley, chairman of Riber's executive board. "Among the wide range of materials that can be processed, the epitaxial growth of mercury-containing compounds is one of the most demanding thin-film depositions characterized in MBE. For four decades Riber's MBE 32P has excelled in the arena of MCT growth, where unrivalled reference quality material has been produced," he claims. "There is no more powerful endorsement than repeat system business, which we see here again as our company is graced with another 32P MCT order from EPIR, who we know have total confidence in transferring and enhancing existing processes from long established working reactors to our modern version of this legendary MBE system."

www.riber.com

Riber receives order from Arkansas for fifth MBE system

Compact 21 to deposit Si/Ge/Sn/Pb epi structures

Riber S.A. of Bezons, France — which designs and makes molecular beam epitaxy (MBE) systems and evaporators — has received an order for a Compact 21, 3-inch research system from professor Greg Salamo, director of Nanoscience and Engineering Institute at University of Arkansas in the USA. For delivery in 2022, this fifth Riber MBE system will complete the existing modutrac line. Apart from III-V nanoscale growths, the new reactor will also allow the study of epitaxial Si/Ge/Sn/Pb heterostructures focused on band engineering via Sn (tin) incorporation and strain manipulation.

"University of Arkansas Nanoscience and Engineering Institute is a 25-year-old Riber customer… Their high level of expertise, understanding and involvement in each discussion and at each step of the project has been really appreciated by all the Riber project team," notes Riber's CEO Philippe Ley. "The technological issues addressed here will enhance epitaxy processes and enable Arkansas' MBE-STM (scanning tunneling microscopy) facility to maintain state-of-the-art results," he believes.

The new system will allow Arkansas to develop new SiGeSnPb technology not possible with existing MBE systems, says Salamo. "Through many cycles of discussion, we arrived at a method to control the temperature of growth at low temperatures of 100–300°C, which will be tested with emphasis on our requested specs," he adds. "As in the past, when we work with Riber to integrate STM, Riber scientists were amazingly helpful, including modeling different designs, and we look forward to this and further collaborations with Riber."

www.riber.com

New Asian opto firm orders Compact 21 MBE system

Research reactor to develop electronic devices in new area for MBE

A recently established optoelectronics company in Asia has ordered a Riber Compact 21 MBE system, for delivery this year.

The equipment will be used to develop a class of electronic devices in a new application area for MBE that is thought to have large potential market opportunities in multiple industrial sectors.

Riber's Compact 21 R&D product range is the market's most versatile and complete with reference standard throughout III-V, II-VI, nitride & oxide materials.

Asian order for extra MBE 6000 production system

System to be used for producing microwave device materials

An industrial client in Asia has ordered an additional Riber MBE 6000 production system for a total of several million euros.

For delivery in 2022, the new system will reinforce the customer's existing fleet of reactors for producing microwave device materials.

Riber says that, with nearly 40 machines sold since its launch in 1999, the MBE 6000 is now established as the benchmark MBE system for the mass production of electronic and optoelectronic device material used in terrestrial telecoms (4G, 5G) and in fiber-optic networks.

www.riber.com

k-Space adds communication output feature in kSA BandiT software

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 — has added a new kSA BandiT software feature that produces a data stream that emulates the communication protocol of a widely used pyrometer.

One of k-Space's customers needed the ability to change the source that provides temperature data to their growth control software, as the BandiT system is capable of providing more accurate and lower-temperature data.

k-Space's software engineers worked with the customer to understand their needs and then implement the necessary communication protocol. The implementation was easy for the customer, the firm says, and they were able to continue their growth process with better temperature input and without changing their growth control software.

Enabling this communication interface simply involves selecting the emulator as the chamber interface in the kSA BandiT software.

www.k-space.com/product/bandit

Aixtron grows revenue 59% and orders 65% in 2021, driven by power electronics

Double-digit order and revenue growth expected in 2022

For fourth-quarter 2021, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has reported revenue of €180.9m (the highest for 10 years), up 38% on €130.8m in Q3 and up 67% on €108.1m a year ago.

Full-year revenue grew 59% from €269.2m in 2020 to €429m in 2021 (the highest since 2011), within the revised guidance range of €400-440m (which had been raised last June far above the initial guidance of €320-360m).

On a geographic basis, Asia fell from 73% to 70% of revenue and the Americas from 12% to 10%, while Europe rose from 15% to 20%.

"Given the constrained global supply chain and logistics, our team did a fantastic job in achieving exception output and results," comments CEO & president Dr Felix Grawert.

Of total revenue, €366.5m (85%) came from equipment sales (up 64% from €223m in 2020), while €57.6m came from spares sales (up 39.5% from €41.3m) and €4.8m from services.

"Demand growth is fueled by a broad base of application segments coming from the global mega-trends of sustainability, electrification, and digitization," says Grawert. "In some areas such as power electronics, compound semiconductors are moving from being specialty and niche material to become the workhorse in some of these segments of the semiconductor volume market."

Of the equipment revenue of €366.5m, metal-organic chemical vapor deposition (MOCVD)/ chemical vapor deposition (CVD) equipment for making gallium nitride (GaN)- and silicon carbide (SiC)-based power electronics devices doubled year-on-year to €139.7m, now comprising the largest share of equipment revenue (at 38%, up from 31% last year).

MOCVD equipment for making optoelectronics devices (telecoms/datacoms and 3D sensing lasers for consumer electronics, solar, and wireless/RF communications) grew by 87% year-on-year to €137m (37% of equipment revenue, up from 33% last year).

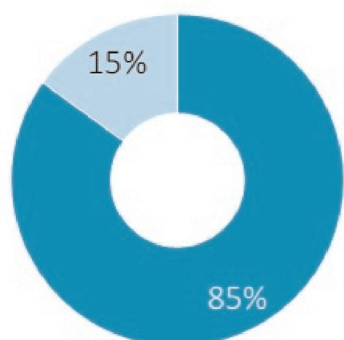
MOCVD equipment for making LEDs rose by 39% (although the share of equipment revenue fell from 27% in 2020 to 23% in 2021).

Quarterly gross margin has grown further, from 42% a year ago and 43% in Q3/2021 to 44% in Q4, due mainly to a higher mix of better-margin products. Full-year gross margin rose from 40% in 2020 to 42.3% in 2021 (exceeding the expected 40%, due mainly to the strong increase in the US$ exchange rate in Q4).

Quarterly operating expenses rose only slightly from €21m in Q4/2020 to €22m in Q4/2021, but full-year operating expenses rose from €73.5m in 2020 to €82.5m in 2021, due partly to higher variable-compensation expense plus €3.9m in one-time expenses for the restructuring and wind-down of Aixtron's South Korea-based organic light-emitting diode display (OLED)-focused subsidiary APEVA. In particular, sales, general & administrative (SG&A) expenses rose by €7.7m from €27.7m to €35.4m. In 2021, it became

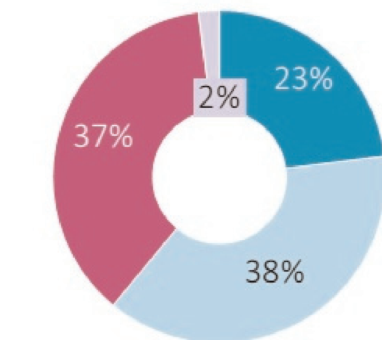
2021 revenue breakdown

FY/2021:
by equipment & after sales



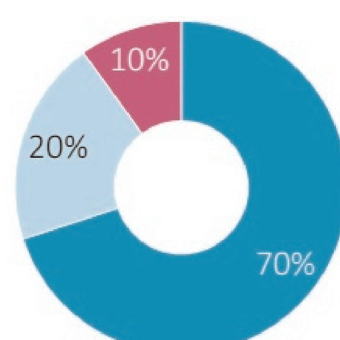
equipment | after sales

FY/2021:
by end application (equipment only)

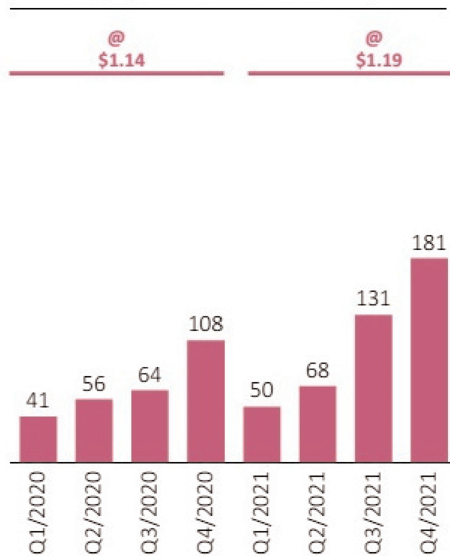


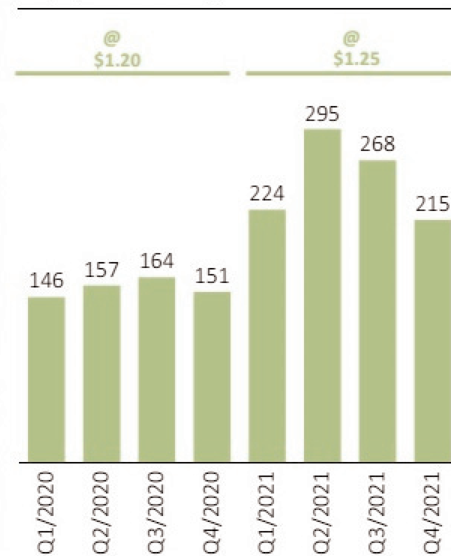
LED | Other incl. R&D | Power Electronics | Optoelectronics and Communications[2]

FY/2021:
by region



Asia | Americas | Europe





USD order intake and backlog were recorded at the prevailing budget rate (2019-2020: $1.20€; 2021: $1.25/€)
USD revenues were converted at the actual period average FX rate (2020: $1.14/€; 2021: $1.19/€)

apparent that the market will choose micro-LED technology for the development of next-generation displays even faster than originally expected, says Aixtron. APEVA's shareholders hence decided not to invest further.

Aixtron maintained its R&D spending at a high level of €56.8m (13% of revenue) in 2021, as the lower development expenses for APEVA's OLED technology were largely offset by increased spending for the development and completion of Aixtron's next-generation MOCVD equipment (for applications including power electronics and micro-LEDs).

Also as a result of restructuring APEVA, during 2021 Aixtron's total staffing fell from 728 to 718, despite strong growth in the number of employees in the core MOCVD business.

The quarterly operating result (EBIT, earnings before interest and taxes) has more than doubled year-on-year (up by 136%) from €24.5m (EBIT margin of 23% of revenue) in Q4/2020 then €36.2m (28% margin) in Q3/2021 to €57.9m (EBIT margin of 32%) in Q4/2021. Full-year EBIT rose almost threefold (by 184%) from 2020's €34.8m (EBIT margin of 13%) to €99m for 2021 (EBIT margin of 23.1%, exceeding the 20–22% guidance range, which had been raised last June from 18%).

"The 184% higher EBIT at 59% higher revenue in 2021 proves the strong operating leverage effect we have on higher revenues, translating over proportionately into bottom-line earnings," says chief financial officer Dr Christian Danninger.

Quarterly net profit has more than doubled from €24.9m (23% of revenue) a year ago and €31.4m in Q3/2021 (23% of revenue) to €51.9m (29% of revenue) in Q4/2021. Full-year net profit hence grew by 175% from €34.5m (13% of revenue) in 2020 to €94.8m (22% of revenue) for 2021.

Operating cash flow was €25.2m in Q4/2021. Full-year operating cash flow was €66.4m (up from just €23.3m in 2020). Capital expenditure (CapEx) was €4.3m in Q4 (making €17.7m for full-year 2021), largely comprising investments in next-generation MOCVD equipment for Aixtron's laboratories.

Free cash flow was hence €20.9m in Q4/2021. Full-year free cash flow was €48.7m (up from just €14m in 2020), due mainly to the increase in net income and a near doubling in trade receivables (from €41.3m to €81m, following the high volume of deliveries made in Q4).

Cash and cash equivalents (including financial assets) have hence still risen further, from €309.7m at the end of 2020 and €330.7m at the end of Q3/2021 to €352.5m at the end of Q4/2021, despite a €12m dividend payment in May.

Inventories rose from just €79.1m at the end of 2020 to €120.6m at the end of 2021 in preparation for the high number of deliveries planned in 2022.

Dividend payment raised for 2022

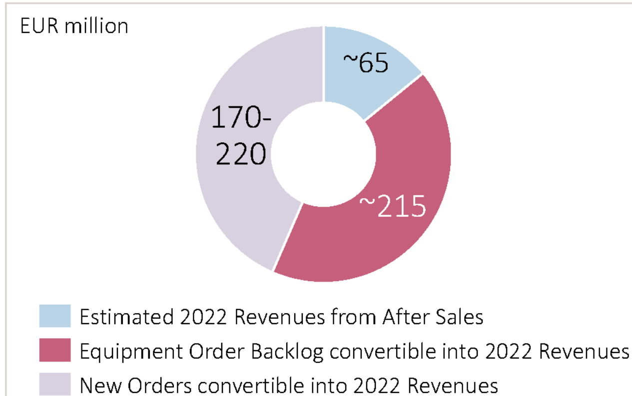
In view of the successful 2021 results, at the annual general meeting (AGM) of shareholders on 25 May Aixtron's executive board and supervisory board will propose to pay a dividend of €0.30 per share (up from €0.11 per share in 2021), a payout ratio of 35% of the firm's net income.

Order growth of 30% year-on-year driven by power electronics

Quarterly order intake has grown further, to €119.7m in Q4/2021, up 4.8% on €114.2m in Q3/2021 and 30% on €92.2m in Q4/2020, driven mainly by GaN and SiC power electronics applications tripling year-on-year to almost 45% of order intake. Demand for SiC deposition equipment developed positively, particularly in Q4 (when it comprised 15% of equipment orders, compared with

2022 Guidance[1]
based on current order situation and current environment and Budget Rate of 1.20 USD/EUR:

Total Order Intake (EUR million)	520 - 580
Revenues (EUR million)	450 - 500
Gross Margin (%)	~ 41%
EBIT Margin (%)	21% - 23%



GaN power comprising about a quarter of equipment orders). In addition, there was continued strong demand for the wireless and optical data communications sectors as well as LED display sectors (both fine-pitch and micro-LED). Full-year order intake was hence up by 65% from 2020's €301.4m to €497.3m for 2021 (the highest since 2011). This exceeds the revised guidance, which had previously been raised in June from €340–380m to €420–460m then again in late July to 440–480m.

Equipment order backlog has hence risen by 42% during 2021, from €150.9m to €214.6m.

Double-digit growth expected in 2022

Based on the order situation and the budget rate of $1.20/€ (versus $1.25/€ in 2021), Aixtron expects double-digit growth in full-year order intake to €520–580m for 2022.

Based on the equipment order backlog (convertible into 2022 revenue) of €215m as of 1 January, joined by a forecasted €170–220m in new order intake that should be convertible into revenue during 2022, plus a forecasted €65m in after-sales revenue, Aixtron expects double-digit growth in full-year revenue to €450–500m in 2022.

Full-year gross margin should be about 41% and EBIT margin 21–23% for 2022.

"This guidance include our R&D spending from the completion of the development of our next-generation products, as well as our activities that strengthen our organization in anticipation of further growth ahead of us," notes Grawert. "We had made our guidance based on the assumption that our business will not be impacted by any global crisis or pandemic."

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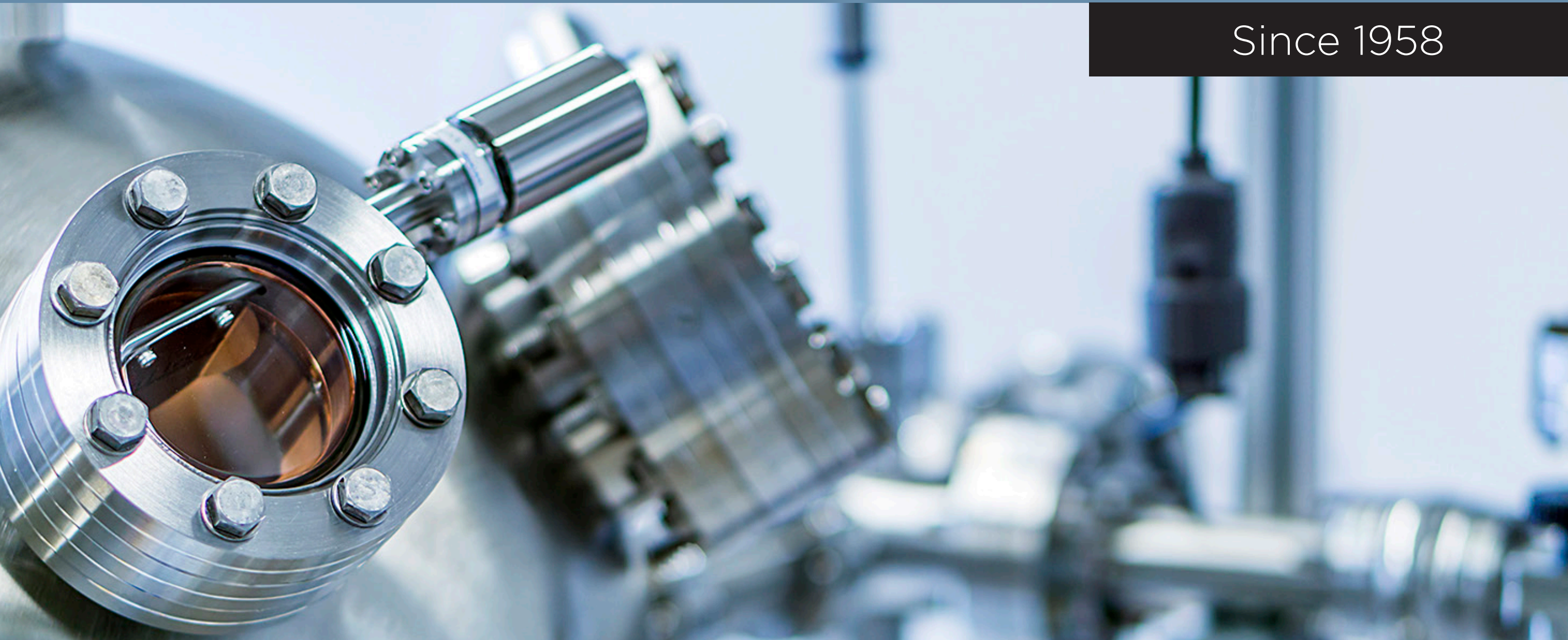

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EVG and Teramount collaborate on packaging technologies for photonic integrated circuits

Wafer-level optics helps solve challenge of connecting fibers to silicon chips for datacom and telecom applications

EV Group of St Florian, Austria — a supplier of wafer bonding and lithography equipment for semiconductor, micro-electro-mechanical systems (MEMS) and nanotechnology applications — and Teramount of Jerusalem, Israel (which provides scalable solutions for connecting optical fibers to silicon chips for data center, advanced computing, sensors and other datacom and telecom applications) are collaborating on implementing wafer-level optics to solve a major obstacle of silicon photonics, namely fiber chip packaging. The collaboration will leverage EVG's nanoimprint lithography (NIL) technology, expertise and services with Teramount's PhotonicPlug technology.

Under this collaboration, standard CMOS wafers that implement silicon photonics chips will be post processed using EVG's NIL technology to implement optical elements such as mirrors and lenses for Teramount's unique 'self-aligning optics'. This enables flexible beam extraction from the chips and easy connection to a large number of optical fibers. Furthermore, it enables wafer-level optical inspection capabilities for enhancing silicon photonics wafer manufacturing.

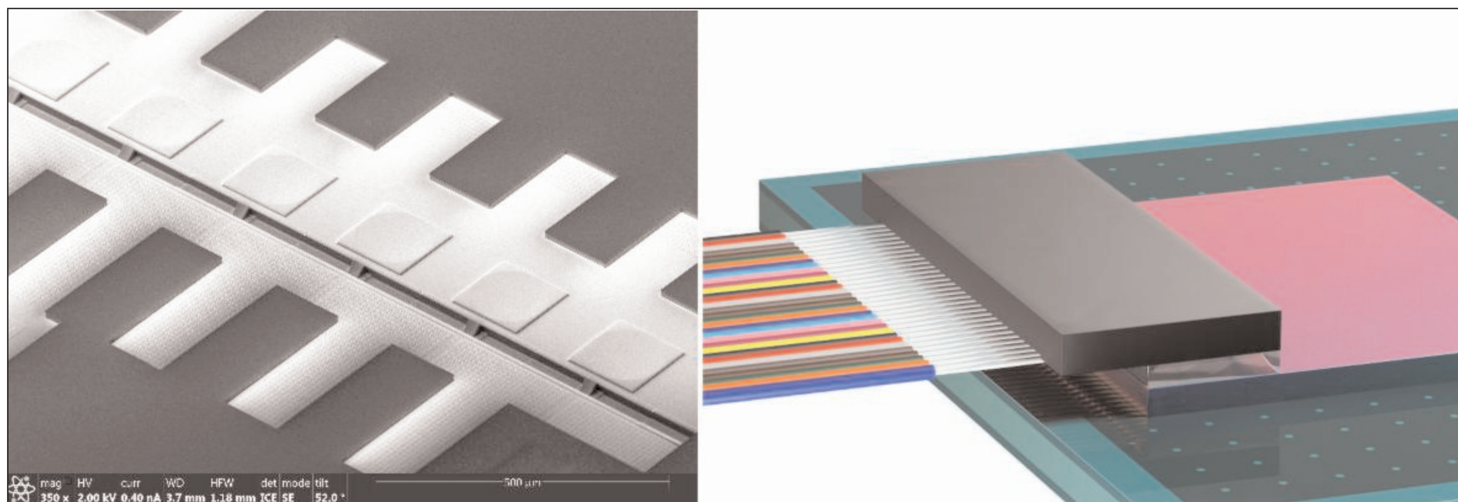
The collaboration is being carried out within EVG's NILPhotonics Competence Center, which provides an open access innovation incubator for customers and partners across the NIL supply chain to collaborate to shorten development cycles and time to market for innovative photonic devices and applications. Through the collaboration with Teramount, EVG provides process development and production services, as well as expertise in both CMOS and photonics manufacturing, accelerating the commercialization of Teramount's PhotonicPlug technology.

The need for high-speed data transfers in data centers, telecom networks, sensors and emerging applications in advanced computing for artificial intelligence (AI) is growing exponentially. This in turn is driving the importance of developing solutions that can cost-effectively scale up production of silicon photonics, which enable ultra-high bandwidth performance. The collaboration between EVG and Teramount aims to solve this problem.

"Our joint work with EVG has been very successful in producing this innovative synergy between wafer-level optics and silicon photonics wafer manufacturing," says Hesham Taha, CEO of Teramount. "By offering this capability to the industry, Teramount solves one of the major hurdles to further adoption of optical connectivity, which is critical for so many applications that require high-speed data transfers and low power consumption," he adds.

"Teramount's PhotonicPlug silicon photonics packaging technology is a truly novel approach to improving optical performance," comments Markus Wimplinger, corporate technology development and IP director at EVG. "This is just the latest example of innovative technology developed with the support of EVG's process and equipment know-how through our NILPhotonics Competence Center, where we help our partners and customers turn new ideas into innovative products."

www.EVGroup.com
www.teramount.com



Nanoimprint of wafer-level optics on silicon photonics wafer (left) for Teramount PhotonicPlug's scalable fiber connectivity (right).

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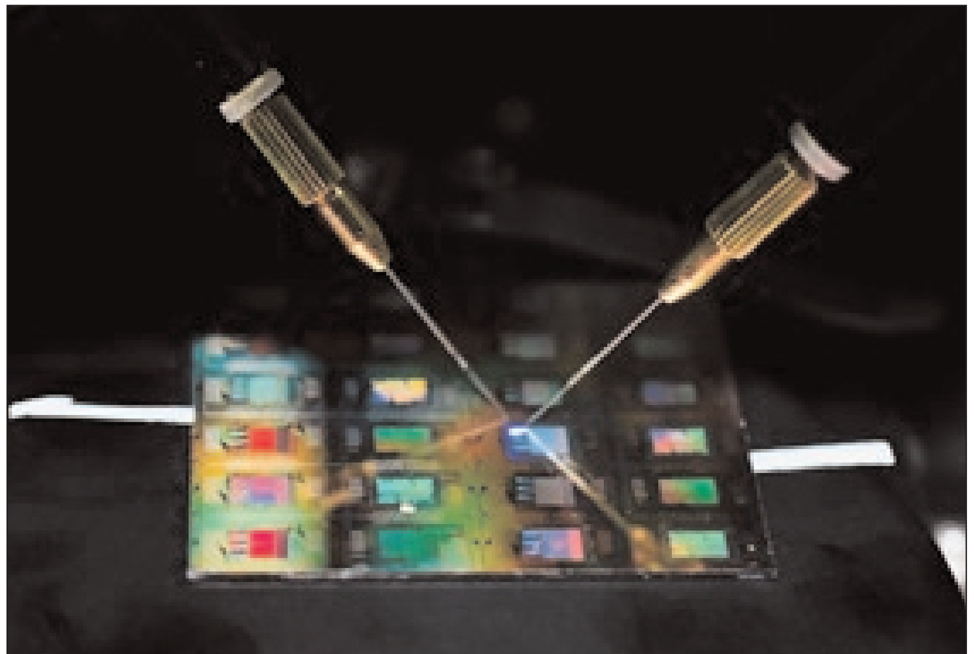
MICLEDI collaborating with GlobalFoundries on manufacturing micro-LED displays for AR glasses

Micro-LEDs demonstrated on proprietary 300mm wafer flow

MICLEDI Microdisplays B.V. of Leuven, Belgium, a fabless developer of micro-LED arrays for high-end augmented reality (AR) glasses, has announced a manufacturing collaboration with GlobalFoundries (GF) of Malta, NY, USA (which has operations in Singapore, Germany and the USA), aiming to enable AR glasses to achieve the brightness, resolution, power, size and economies of scale needed to become affordable for consumers.

MICLEDI's solution will be combined with GF's 22FDX feature-rich platform that provides the performance, ultra-low power and broad feature integration capability needed to fabricate MICLEDI's micro-LED arrays in mass production. Such companion integrated circuits, which can be customized for different customer applications, will provide the image processing, driver and control functions needed to complete the display modules using wafer-to-wafer hybrid bonding.



MICLEDI demonstrates micro-LEDs on its proprietary 300mm wafer flow.

The overall global AR market is estimated to be growing at a compounded annual growth rate (CAGR) of 31.5% from 2021 to $88.4bn in 2026 (according to MarketsandMarkets), as it becomes the next consumer platform.

"Demand for AR and VR products will soar as users experience more immersive augmented reality," reckons Ed Kaste, VP of Industrial and Multi-Market at GlobalFoundries. "MICLEDI's micro-LED solution, combined with GF's 22FDX platform, addresses the demanding needs of future AR glasses by providing ultra-high-resolution displays and advanced imaging technology that make stunning visual detail and color possible," he adds.

"We are pleased to collaborate with GF as we move from pilot-line manufacturing to mass production in a world-class fab," says MICLEDI Microdisplays' CEO Sean Lord. "To enable optimum micro-displays for AR, MICLEDI has developed a unique and innovative solution for micro-LED manufacturing integrating both the controller IC and emitter module to leverage GFs 300mm semiconductor manufacturing technology, capitalizing on manufacturing precision for product performance, high volume and low cost."

www.globalfoundries.com
www.micledi.com

Lumileds adds 3V and 6V options to LUXEON 2835 Commercial LED range

Lumileds LLC of San Jose, CA, USA is tripling the LUXEON 2835 Commercial 3V options for lumen and lumen/Watt in 80 and 90 CRI (color rendering index). It is also adding LUXEON 2835 Commercial 6V parts that allow for fewer parts and denser arrays when needed.

Globally, the 2835 LED is one of the most widely used LEDs — many billions are sold annually — and they find their way into an array of indoor applications and luminaires. So, customers are seeking differentiated performance options and reliability that allow them to finely tune offerings to achieve specific application, efficiency, and cost objectives, says Lumileds.

"Lumens, lumens per watt, and lumens per dollar are at the top of every OEMs list," notes product & marketing manager Ryan Dong. "In this regard, our performance is as good or better than any other," he believes. "And when it comes to critical technical specifications, we think LUXEON 2835 Commercial stands above the rest."

www.lumileds.com

Seoul Viosys seeks to enjoin sales of infringing UV LED products in Europe

Lawsuit filed in Hague District Court against FTHMM

Ultraviolet LED product maker Seoul Viosys Co Ltd (a subsidiary of South Korean LED maker Seoul Semiconductor Co Ltd) has filed a patent infringement lawsuit with the Hague District Court in the Netherlands, seeking to enjoin UV LED products in European countries.

The litigation arose from an earlier patent lawsuit filed by Seoul Viosys against FNAC Darty Group, a large European retailer, in France last September, when the Judicial Court of Paris ordered the search and seizure of evidence of suspected infringement. From that, Seoul Viosys learned that accused UV LED products are being imported and distributed from the Netherlands. To prevent the further distribution of infringing products across European countries, Seoul Viosys has filed a patent infringement lawsuit against Netherlands-based trading company FTHMM International B.V. in the Hague District Court of the Netherlands, seeking a preliminary injunction against the allegedly infringing UV LED products.

Seoul Viosys and US-based UV LED firm SETi claim to have co-developed and mass-produced the first UV LED that emits UV light with optical semiconductor technology. Seoul Viosys now claims to be the top producer of UV LEDs. As the market has expanded, however, so has the number of sales of infringing products, the firm says. It has hence expanded its enforcement and taken legal action to protect its intellectual property in South Korea, Japan, the USA and Europe. Seoul Viosys has won all 30 cases that it has brought over the last three years in six different countries, including its pursuit of a permanent injunction against the sales of infringing products in one of these cases.

"Seoul's UV LEDs will continue to lead the world in products for clean air and water, as well as sterilizing against dangerous contaminants like coronavirus," reckons Seoul Viosys' CEO Youngjoo Lee. "Seoul has not only increased the capacity of such products by five times, it has done so while producing products at significantly lower prices," he adds. "Seoul Viosys, SETi and Nitride Semiconductors Co Ltd., its strategic partner in Japan, have developed, owned and mass produced this technology for many years. No one else can develop optical semiconductor UV LED technology without using our fundamental patents," he claims. "When intellectual property is respected, the market will provide fair opportunities to all, including young entrepreneurs and small- to medium-sized enterprises around the world."

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BluGlass acquiring US laser production facility for $2.5m

BluGlass Ltd of Silverwater, Australia — which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs — has agreed to acquire the lease on a commercial 19,000ft^2 purpose-built laser diode production facility in Silicon Valley (Fremont, CA, USA) plus manufacturing equipment for US$2.5m (US$2.5m comprising US$2m cash and US$500,000 of new BluGlass shares). The acquisition should fast-track BluGlass' growth strategy, significantly increasing its laser manufacturing capacity and bringing forward higher-value product development timelines, says the firm.

To fund the acquisition and ongoing operation of the production facility (including adapting it for GaN laser production), BluGlass has secured Aus$3.4m via a placement of shares to new and existing institution funds and investors. The firm is also undertaking a non-renounceable 1:4 entitlement offer to raise up to a further Aus$7.5m to fund ongoing operations of the production facility and to enable shareholders to participate on the same terms as the placement.

"We plan to take advantage of a unique opportunity to acquire a full-suite commercial laser diode fab for a fraction of the circa US$40m it would cost us to build today," notes president Jim Haden. "The acquisition aligns and accelerates our longer-term growth plans, bringing core fabrication processes in-house to eliminate supply chain variability and improve the quality and consistency of our laser diodes. Importantly, it provides us with greater control over development roadmaps, enabling us to launch higher-value products sooner," he adds.

"In addition to more than quadrupling development, manufacturing turns and wafer capacity, our own fab enables us to halve production costs and has the potential to bring forward positive cashflows to 2024/2025. It triples our revenue generation capacity, and allows us to execute on our strategic vision of becoming the industry's easiest-to-use laser light by offering the most flexible and agile product development and manufacturing. As one of just four end-to-end gallium nitride laser diode manufacturers globally, we have a significant opportunity to build share within a fast-growing market expected to reach US$2.5bn by 2025," Haden continues.

"The acquisition will fast track our transition from a cutting-edge R&D company to a commercial provider of industry-leading GaN laser diodes," Haden believes. "Over the past year, we have attracted industry experts to our management and board, advanced our product development of multiple laser products and are delivering against a clear commercialization and growth strategy. A Silicon Valley-based fab increases our access to highly skilled semiconductor and GaN talent even further."

"We're encouraged by the strong ongoing support of our existing investors, and welcome new institutional funds to the register at a pivotal period for the company. BluGlass is focused on the commercialization of our first direct-to-market laser diodes," Haden says. "We have the right team and strategy in place and are now in the process of securing the final piece of the puzzle, a manufacturing fab to further expand our product offering and scale our operations."

www.bluglass.com.au

NUBURU appoints chief financial officer

High-power blue laser technology firm NUBURU Inc of Centennial, CO, USA (which was founded in 2015) has appointed Brian Knaley as chief financial officer, overseeing all aspects of finance and investor relations as the firm accelerates and implements its growth strategy to expand the presence of its blue laser technology across target markets.

With over 25 years of experience, Knaley is a three-time public company CFO. Most recently, he was CFO of CEA Industries Inc, a provider of architectural, engineering and mechanical services and products for the controlled-environment agriculture market, where he led efforts to raise $3m in a PIPE (private investment in public equity) financing as well as an uplist from the OTC markets to Nasdaq.

Previously, he was CFO at Proximo Medical, a start-up specializing in the commercialization of medical devices, where managed the accounting and finance functions (including financial control, cash maximization and tax and regulatory compliance). He also served as senior VP & interim CFO of ViewRay Inc, a global manufacturer of MRI-guided radiation therapy systems. Earlier in his career he was CFO at ARC Group Worldwide Inc, a global manufacturer of precision metallurgic products and advanced 3D printing. Knaley holds a BA in Accounting from Thomas More College and is a Certified Public Accountant (CPA).

"As we take the company to the next level, his leadership within the financial function will help scale our organization and drive commercialization efforts," says NUBURU's CEO, co-founder & chairman Mark Zediker.

"NUBURU is uniquely positioned to transform metal processing across a wide array of industries," believes Knaley.

www.nuburu.net

Luminar acquiring Freedom Photonics

Chip-scale laser technology extends firm's vertical integration for LiDAR

Following a multi-year collaboration, automotive technology company Luminar Technologies Inc of Orlando, FL, USA is acquiring Freedom Photonics LLC of Santa Barbara, CA, USA (which was founded in 2005 and manufactures photonic components, modules and subsystems for markets including automotive LiDAR, optical sensing, aerospace, industrial processing and data communications). The acquisition brings fundamental next-generation chip-scale laser technology, intellectual property (IP), and production expertise in-house for Luminar light detection and ranging (LiDAR) systems.

Luminar is vertically integrating across core LiDAR components that aim to enable low costs, supply chain security and improved performance. The transaction follows the acquisition of subsidiaries Black Forest Engineering for custom signal processing chips in 2017 and Optogration Inc in 2021 for receiver chips.

"Component-level innovation and integration is critical to our performance, cost and continued automotive technology leadership," says Luminar's co-founder & chief technology officer Jason Eichenholz. "Bringing Freedom Photonics into Luminar enables a new level of economies of scale, deepens our competitive moat and strengthens our future technology roadmap," he believes. "We've worked closely with the Freedom team for the past several years. They have proven to be the best in the world for breakthrough semiconductor laser chip technology, where both power and beam quality are needed simultaneously for true high resolution at long range."

The Freedom Photonics executive team will continue to lead and expand the business upon close of the transaction, which is expected in second-quarter 2022.

"Joining Luminar is the perfect opportunity for Freedom Photonics, providing us an accelerated path to at-scale commercialization of our world-class diode laser technologies," believes Freedom Photonics' co-founder & CEO Milan Mashanovitch. "In addition to helping extend Luminar's automotive industry leadership, we will continue to serve and grow our broad customer base across other key markets."

www.luminartech.com/

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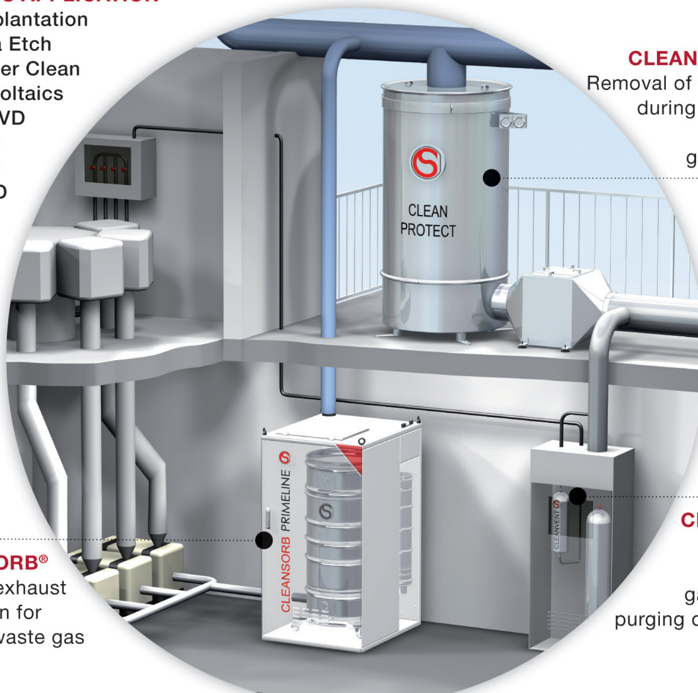

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Canada invests CDN$240m in semiconductor and photonics industries

CDN$90m funding for Canadian Photonics Fabrication Centre

Canada's government has announced the Semiconductor Challenge Callout, providing CDN$150m through its Strategic Innovation Fund to make targeted investments to build on Canada's domestic strengths associated with the development and supply of semiconductors. He also announced CDN$90m in funding for the National Research Council of Canada's Canadian Photonics Fabrication Centre (CPFC).

The Challenge represents Canada's initial commitment to investing in innovation projects that aim to reinforce and scale up the country's semiconductor ecosystem. The government is calling on businesses to identify ambitious, transformative proposals in the priority areas of research, commercialization, and expanded semiconductor manufacturing capacity. This aims to help the Canadian semiconductor industry enhance its role in the integrated North American information and communications technology supply chain.

Canada's government says that it is monitoring signs of strain in critical supply chains and infrastructure as the economy recovers. The government is also working closely with the USA and global partners to enhance supply chain security for key commodities and sectors.

Canada's semiconductor sector includes over 100 homegrown and multi-national companies conducting R&D. Its manufacturing base includes over 30 applied research labs and five commercial facilities in areas such as compound semiconductors, micro-electro-mechanical systems (MEMS) and advanced packaging.

The Canadian Photonics Fabrication Centre is a 40,000ft^2 facility with 11,000ft^2 of class-100/1000 clean-room space providing engineering and manufacturing services to academics and large-, medium-sized and small photonics businesses in Canada and internationally.

The investment in the CPFC will see critical upgrades of equipment, improving its capacity and capability to address the increasing complexity of leading-edge technology being brought to market by its clients. As a key asset to the Canadian photonics sector over the last two decades, the CPFC is the only compound semiconductor foundry in North America that is publicly operated and open to all for use. It has a track record of delivering photonics device fabrication services to the research and private sectors, helping to grow many Canadian small- and medium-sized enterprises in such industries as telecoms, environmental sensing, automotive, defence and aerospace.

"Our government wants Canada to be a strategic global leader in the semiconductor industry. That's why we're investing CDN$240m today to strengthen our semiconductor ecosystem, which will allow us to build a more innovative and resilient economy," says the Honourable François-Philippe Champagne, Canada's Minister of Innovation, Science and Industry. "By investing in Canada's semiconductor industry, we are making a firm commitment to businesses looking to invest in Canada. Whether it's high-value or large-scale manufacturing, we want to see Canada be home to the world's leading semiconductor manufacturers," he adds. "We are also proud to support the revitalization of the National Research Council's CPFC, which will enhance Canada's already impressive photonics sector."

www.ic.gc.ca/eic/site/125.nsf/frm-eng/LCOE-CBXKRY

Vector Photonics produces PCSEL arrays emitting four concurrent 1300nm wavelengths

Photonic-crystal surface-emitting laser (PCSEL) firm Vector Photonics of Glasgow, Scotland, UK has produced 1300nm, all-semiconductor PCSELs targeting 800Gb datacoms applications. The PCSEL arrays emit four concurrent 1300nm wavelengths, with a side-mode suppression ratio (SMSR) of about 35dB.

"Vector Photonics' 1300nm compound semiconductor lasers enable new levels of PCSEL commercialization for datacoms applications,"

says chief technology officer Dr Richard Taylor. "Unlike incumbent DFB [distributed feedback] and EEL [edge-emitting laser] data-center laser technologies, PCSELs deliver both the high speed and high power required, in the same device. PCSELs are surface emitting, with light coming from the top of the laser not the side, which vastly reduces packaging costs," he adds. "We now have four 1300nm wavelengths emitting from a monolithic PCSEL array, rather than four separate chips, simplifying post-production assembly and significantly reducing packaging costs."

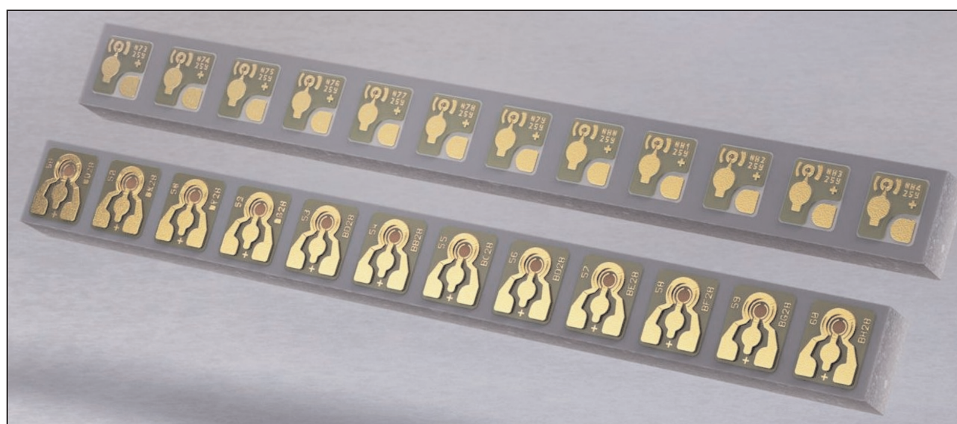
www.vectorphotonics.co.uk

TRUMPF unveils longer-wavelength VCSELs for datacoms

Wavelengths above 850nm offer increased performance and lifetime

At the Optical Fiber Conference (OFC 2022) in San Diego, USA (8–10 March), TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which manufactures vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets — showed its existing 850nm product portfolio and its future roadmap for longer wavelengths.

The company is hence introducing VCSELs with wavelengths above 940nm, addressing the market requirements for broader temperature ranges, higher product robustness and service life.



VCSEL and photodiodes operating at data rates up to 56Gbps are available as 1x1, 1x4 or 1x12 arrays. (Photo: TRUMPF.)

TRUMPF has also just completed its first multi-million-Euro investment tranche in its production site in Ulm, in order to upgrade its manufacturing platform and to support further business growth. The firm says that it is building on more than 20 years of experience in the market with the strategy of not only designing standard modules but also customized solutions for high-speed and high-performance VCSELs and photodiodes.

www.trumpf.com

TRUMPF presents controlled-polarized VCSEL

Fewer components needed and space within devices reduced

At the Photonics West fair 2022 in San Francisco in late January, TRUMPF Photonic Components presented a live showcase of VCSELs with controlled polarization for illumination applications.

The new VCSEL should lead to much smaller construction space needed in, for example, smartphones for 3D scene illumination. Together with Metalenz, a Boston-based pioneer in designing and commercializing meta-optics, TRUMPF demonstrates how future consumer electronic devices benefit from these smaller and smarter components. This technology progress is enabled through the development of VCSELs with stable polarization.

Extended VCSEL portfolio

At Photonics West, TRUMPF also presented its portfolio of single-mode and multi-mode VCSELs, which can be used for a wide range of advanced industrial and consumer sensing applications, from oxygen sensor to face recognition.

The portfolio includes a new single-mode VCSEL for highly precise time-of-flight sensors. With ViBO (VCSEL with integrated backside optics), TRUMPF showcased another new VCSEL solution that comes with monolithically integrated micro-optical elements. This technology benefits applications such as light detection & ranging (LiDAR) or augmented reality (AR) glasses, as ViBO comes with a significantly reduced footprint and offers great freedom in design, as tailored illumination profiles can be created.

VCSEL for industrial heating and data communication

The VCSEL heating systems showcased at the show enable direct heat treatment with fully controllable emission zones. They offer what is reckoned to be huge potential for various industrial applications – from more sustainable Li-battery production to local softening of metal automotive parts to photovoltaic applications. In the production of Li-batteries for example, they enable faster and more energy-efficient drying of active material and therefore a much more efficient production process. The modules are highly flexible and compact, enabling high efficiency and quality.

The portfolio of TRUMPF Photonic Components is completed by VCSEL and photodiode solutions for optical communications. Media transmission via fiber optical communication is a growing field, as the amount of data that has to be transferred is increasing. The solutions offer high date rates at low power consumption and low latency to fulfill the highest demands of data centers.

www.trumpf.com/VCSEL-solutions

EFFECT and Jabil to co-develop next-generation coherent optical modules

EFFECT's system-on-chip optical technology to combine with Jabil's high-volume manufacturing

EFFECT Photonics and Jabil Photonics, a business unit of manufacturing solutions provider Jabil Inc, intend to co-develop a next generation of coherent optical modules. The modules provide a solution for network operators and hyperscalers that want to take advantage of the high-end performance with QSFP-DD small footprint, low power consumption and cost, field replaceability and vendor interoperability for cloud data-center interconnects (DCIs).

The next-generation coherent optical modules address the need for the ever-increasing flow of data, ensuring continuity of service, security concerns, global expansion and the growing demands for sustainability. This opportunity brings together the core competencies of both companies in a collaborative effort to continuously introduce advanced optical technologies in a rapidly changing market. EFFECT will make available its system-on-chip optical technology and Jabil will leverage its track record of manufacturing coherent modules in very large quantities with extensive sourcing capabilities.

"One of the ambitions we have as an organization is to build strong partnerships to increase our ability to develop and deliver cutting-edge solutions for our customers," says EFFECT's chief commercial officer Harald Graber. "Hyperscalers are at the forefront of dealing with this seemingly never-ending growth in Internet traffic. This co-development with Jabil allows us to jointly innovate to get affordable, best-in-class solutions to market faster. Jabil will allow us to deliver reliably at a far greater scale to our global customer base," he adds.

"Pluggable coherent transceivers are at the heart of a paradigm shift, enabling new open architectures through disaggregation of switches, transceivers and optical line systems that are needed for the massive surge in data driven by cloud and 5G applications," notes Stefano Schiavoni, VP & general manager of Jabil's business unit. "Jabil Photonics is a key player in coherent pluggable transceivers with our own portfolio and proven capabilities to help build innovative solutions and achieve volume production quickly."

www.jabil.com

EFFECT Photonics and Aircision to co-develop coherent technology for free-space optics

EFFECT Photonics and Aircision (also of Eindhoven, The Netherlands) say that they are looking to push the boundaries of ground-to-ground free-space optics (FSO) technology by combining the advantages of integrated coherent photonics and free-space optics.

Founded in early 2019 on the HighTech Campus Eindhoven with support from the Eindhoven Startup Alliance and HighTechXL, Aircision is developing high-capacity FSO systems for ground-to-ground applications that can be deployed rapidly, cover long distances and are highly secure. In December, the firm demonstrated the capabilities of their first 10Gbps FSO system.

The key enabling technology for DWDM systems is full monolithic integration of all photonic components within a single chip and being able to produce these in volume with high yield at low cost. As a spin-off from the Technical University of Eindhoven (TU/e) that has developed highly integrated DWDM optical communications system-on-chip components using indium phosphide (InP)-based multi-channel photonic integrated circuits (PICs) for mobile networks and data-centers, EFFECT Photonics is able to deliver the flexible, pluggable optical transceiver that is a key component of Aircision's FSO system.

"We were impressed with the capabilities of the EFFECT Photonics 10G SFP+ devices that we tested. It was an easy decision to involve them in our development plans for our next-generation 100Gbps coherent transmission systems," comments Aircision's CEO & co-founder Luis Oliveira. "To keep up with the ever-growing demand for bandwidth across larger distances, Aircision is developing a 100Gbps coherent free-space optics system capable of transmitting up to 10km," he adds.

"As we look to applications outside of pure fiber-based communications, we liked the market use cases Aircision presented as well as the market traction they already have," comments EFFECT Photonics' director of product management Joost Verberk. "Our roadmaps follow a similar course, making a joint development program an interesting option."

Both Aircision and EFFECT are part of the PhotonDelta eco-system, a platform that is in place to accelerate developments such as this and to reduce the time-to-market of new applications.

www.aircision.com
www.effectphotonics.nl

EFFECT acquires Viasat's coherent optical DSP business

$20m Series C funding round raises total to $63m

At the Optical Fiber Communications conference (OFC 2022) in San Diego, CA, USA (6–10 March), EFFECT Photonics b.v. — a spin off from the Technical University of Eindhoven (TU/e) in The Netherlands that develops DWDM optical system-on-chip components using indium phosphide (InP)-based multi-channel photonic integrated circuits (PICs) for mobile networks and data-centers — announced that it had signed a definitive agreement to acquire coherent optical digital signal processing (DSP) and forward-error correction (FEC) technology as well as a highly experienced engineering team from global communications company Viasat Inc.

Viasat is a long-established player in DSP and FEC technology. With eight generations of design IP, it has a proven track record of delivering field deployments.

As a result of the acquisition, EFFECT Photonics will now own the entire coherent technology stack of all optical functions, including a high-performance tunable laser, together with DSP and FEC. The firm reckons that this will enable it to deliver on its aim to make high-performance coherent communications solutions widely accessible and affordable. Furthermore, it will enable longer-term economic and environmentally sustainable communications due to the ability to deliver high-end performance and reach within a small footprint and with lower power consumption, opening the way to drive coherent technology into new places.

The transaction is expected to provide the following customer benefits:

- EFFECT will be able to optimize the complete solution for any application addressing both existing challenges and new possibilities.
- With full ownership of the key optical, DSP and FEC functions, EFFECT can offer seamless integration, cost efficiency and security of supply.
- EFFECT will be an independent vendor able to offer a full portfolio of building blocks such as the tunable laser and DSP, and/or complete solutions, increasing the choice reduced by recent mergers and acquisitions in the industry.

EFFECT Photonics has also secured an additional $20m in Series C funding, bringing the total to $63m. Additionally, pursuant to the DSP acquisition agreement, Viasat will be joining EFFECT Photonics' supervisory board and hold a minority interest in the firm.

"This is a significant step in accelerating our ambition to make coherent optical communications ubiquitous and further drive our product portfolio growth. We look forward to welcoming the team of highly skilled and experienced design architects and engineers who will be joining us to drive the development of energy-efficient, high-performance and affordable coherent solutions," says CEO James Regan. "With all the recent changes in the industry landscape, this means that EFFECT Photonics is the only independent vendor able to deliver both the active optical components and the DSP. This will offer the market more choice and the ability to source superior solutions," he adds.

"Given the trend of the fiber-optic communications industry towards consolidation to provide vertically integrated end-to-end solutions, we believe that combining Viasat's assets and capabilities with the unique integrated photonics capabilities of EFFECT Photonics will create substantially more market opportunities and better products," reckons Viasat VP & business area leader Russell Fuerst. "By investing in this Netherlands-headquartered company, we will also further expand our presence in Europe and be able to partner with EFFECT to bring state-of-the-art integrated photonics to Viasat's own customers."

www.effectphotonics.nl

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POET begins trading on Nasdaq Capital Market

Firm maintains listing on TSX Venture Exchange

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 — says that its common shares have begun trading on the Nasdaq Capital Market under the symbol 'POET' as of the market opening on 14 March.

"Our trading today on the Nasdaq marks a significant milestone for POET," says chairman & CEO Suresh Venkatesan. "In addition to making shares of the company available to a broader set of prospective institutional investors, today's listing serves to elevate POET's overall visibility and increase market awareness of our highly differentiated POET Optical Interposer platform," he adds. "Together with our continued expansion of customer engagements and product commercialization, we believe trading on Nasdaq will further support our growing momentum as well as maximize value for shareholders."

The firm will continue to maintain its existing listing and trading symbol 'PTK' on the TSX Venture Exchange. For the avoidance of doubt, no action is required by existing shareholders associated with the Nasdaq listing.

200G FR4 Transmit & 400G FR4 Receive Optical Engines demonstrated at OFC 2022

At the Optical Fiber Conference (OFC 2022) in San Diego, CA, USA (8–10 March), POET gave live demonstrations of its recently announced 200G FR4 Transmit and 400G FR4 Receive Optical Engines.

"Our live demos attracted a variety of existing and potential customers, suppliers and business partners as the only company exhibiting chip-scale integrated FR4 optical engines," notes CEO Dr Suresh Venkatesan. "FR4 is a multiplexed standard that transmits and receives up to 2km, compared to its DR4 counterpart which supports a parallel four-lane standard limited to 500m. The number of fibers required is also a factor, with DR4 requiring eight per module and FR4 requiring only two per module," he adds.

"We had 40–50 meetings overall and are rapidly gaining traction with potential customers, including data-center operators, networking systems and artificial intelligence (AI) vendors and module companies," says president Vivek Rajgarhia. "Some of the more interesting partnering opportunities were with innovative device companies, looking to utilize POET's platform for the next generation of optical engines for transceivers and co-packaging applications," he adds. "The Optical Interposer is an integration platform that is agnostic to the material system that any given device is built from, meaning that we can select the 'best of breed' for the specific application rather than trying to do everything in silicon or any other material. This distinctive feature of the POET Optical Interposer technology, among others, means that we can address applications where conventional free-space optics or traditional silicon photonics cannot."

Also at OFC, Venkatesan gave a Technology Showcase presentation 'Hybrid Integration Platform for Co-Packaged Photonics Using POET's CMOS Based Optical Interposer'.

www.ofcconference.org

POET responds to Shenzhen COVID-19 lockdown

Singapore site and Super Photonics Xiamen JV tasked with continuing to build customers samples

POET Technologies has reported that, as a response to the temporary lockdown resulting from a COVID-19 outbreak in Shenzhen, critical development activities have been absorbed by Singapore and other locations.

"Over the past two years, we have established redundancy for critical activities in Singapore, Shenzhen and Allentown, Pennsylvania, both to accelerate development and to cope with COVID-19 lockdowns," notes CEO Dr Suresh Venkatesan. "On Sunday 13 March 2022 our operation in Shenzhen, China was notified that it would be shut down until at least 20 March, due to a COVID-19 outbreak in that city. We promptly tasked both Singapore and our joint venture Super Photonics Xiamen with the task of continuing to build samples for customers," he adds.

"Because we have been well prepared for such a contingency, we do not believe this temporary lockdown will have any effect on our planned delivery schedule to customers, prospective customers or business partners," concludes Venkatesan.

www.poet-technologies.com

POET launches 400G FR4 and 800G (2x400G FR4) receive optical engines

First single-chip version of FR4 RX optical engine available

POET Technologies Inc of Toronto, Ontario, Canada — a designer of photonic integrated circuits (PICs) for the data-center and telecom markets — has launched its 400G FR4 and 800G (2x400G FR4) receive (RX) optical engines based on the POET Optical Interposer hybrid silicon photonics platform.

The 400G FR4 receive optical engine PIC is claimed to be the industry's only chip-scale integrated (single chip) version of a FR4 RX optical engine available, with associated performance, power and cost advantages that apply to a dual 400G FR4 (for an 800G) receive solution as well. The advantages are derived from the POET Optical Interposer platform, which enables the integration of 'best of breed' photonic components onto a single chip passively (without any costly active alignment requirements). In addition, the products demonstrate four unique features that, when combined, result in a superior solution compared with either standard free-space optics or standard silicon photonics-based engines, it is claimed:

- four 100G or eight 100G (in the 2x400G configuration) 56 gigabaud (GB) photodetectors flip-chipped onto the Optical Interposer and coupled passively to vertical mirrors embedded in the Optical Interposer;
- a low-loss AWG (arrayed waveguide grating)-based quad-wavelength demultiplexer that is polarization independent (non-birefringent), temperature independent (athermal) and is monolithically integrated into the optical waveguide layer of the Optical Interposer (all features that are advantageous and superior to conventional silicon photonics optical engines, it is reckoned);
- input spot size converters integrated into the optical waveguide layer that precisely match the input mode size of a single-mode fiber, further enhancing its low-loss performance; and
- a small size (3.8mm x 10mm) form factor, which enables an 800G optical engine in a 2x400G configuration in both OSFP and QSFP-DD800 optical transceiver modules.

"We're excited to begin sampling and qualification of our 400G/800G FR receivers ahead of our original schedule," says chairman & CEO Dr Suresh Venkatesan. "Our advanced and proprietary hybrid silicon photonics platform technology is uniquely suited to provide the cost and performance required for 400G and 800G FR4 modules. The product represents a true 'semiconductorization' of photonic engines using traditional pick-and-place bonding equipment and passive alignment of photonics devices. With Super Photonics Xiamen (SPX), our joint venture with Sanan IC, we also provide the ability to rapidly scale production to meet the demands of this fast-growing market," he adds.

"This 400G receiver utilizes a truly game-changing technology that will make POET's approach of hybrid silicon photonics a force to reckon with in the 400G/800G FR4 module market," comments Ben Chen, chief technology officer of Surinno Photonics (formerly Hengtong-Rockley). "POET Technologies has been able to utilize its platform concept to provide easy-to-use optical engines for the data communications market with rapid deployment and demonstrations of 100G/200G TX–RX engines and also 400G FR4 engines."

Market research analyst LightCounting has forecasted that the market for 400G and 800G Ethernet transceiver modules will exceed $2bn annually by 2024. The 400G and 800G optical engines will be manufactured and provided by Super Photonics Xiamen.

Vice president of product line management appointed

POET has appointed Raju Kankipati as VP of product line management, heading up product management and sales & marketing.

Kankipati has more than 20 years of experience in optical transceivers, optical components, cloud data-center and optical networks. Most recently he was employed at MACOM, where he was the senior director of product management for optical components, including lasers, photodetectors, silicon photonics, and photonic solutions.

Prior to MACOM, he worked at Arista Networks as a senior product manager and engineering manager. During this time, he collaborated closely with data-center customers to bring unique switching products as well as optical transceivers to market, helping customers to deploy 40G and 100G products to enhance the scalability and efficiency of their networks.

Previous positions included product manager at Cisco and engineering and management positions at Opnext in Japan (now part of Lumentum).

He received his MBA degree from University of California Berkeley (Haas School of Business) and completed his Bachelor of Engineering degree in Electronics at Birla Institute of Technology and Science (BITS) Pilani, India.

www.poet-technologies.com

GlobalFoundries collaborating on silicon photonics for data centers

GF Fotonix platform combines 300mm photonics features and 300GHz-class RF-CMOS

GlobalFoundries (GF) of Malta, NY, USA (which has operations in Singapore, Germany and the USA) says that it is collaborating with firms including Broadcom Inc, Cisco Systems Inc, Marvell and NVIDIA, along with photonics companies including Ayar Labs, Lightmatter, PsiQuantum, Ranovus and Xanadu, to deliver feature-rich solutions to solve challenges facing data centers.

The more than 42 billion connected Internet of Things (IoT) devices generating ~177ZB of data annually — combined with the rise of power consumption in data centers — is driving the need for innovative solutions to move and compute data faster and more energy efficiently, notes GF. These key market trends and implications have catalyzed its focus on semiconductor solutions that harvest the potential of photons instead of electrons to move data and position GF in the optical networking module market that is projected to rise at a compound annual growth rate (CAGR) of 26% from 2021 to about $4bn by 2026.

GF has now unveiled its next-generation silicon photonics platform GF Fotonix. The firm says that it has active design wins with major customers, significant market share, and expects its growth in this segment to outpace the market.

GlobalFoundries is also partnering with Cisco Systems on a custom silicon photonics solution for data-center network (DCN) and data-center interconnect (DCI) applications, including an interdependent process design kit (PDK) in close collaboration with its GF manufacturing services team.

GF solutions to move and compute data at speed of light

GF Fotonix is a monolithic platform, reckoned to be the first in the industry to combine differentiated 300mm photonics features and 300GHz-class RF-CMOS on a silicon wafer, delivering what is claimed to be best-in-class performance at scale. GF Fotonix consolidates complex processes that were previously distributed across multiple chips onto a single chip by combining a photonic system, radio frequency (RF) components and high-performance complementary metal–oxide–semiconductor (CMOS) logic on a single silicon chip.

GF is the only pure-play foundry with a 300mm monolithic silicon photonics solution that has demonstrated the industry's highest data rate per fiber (0.5Tbps/fiber). This enables 1.6–3.2Tbps optical chiplets, which deliver faster, more efficient transmission of data, more efficiently with better signal integrity. In addition, the up to 10,000x improvement in system error rate enables next-generation artificial intelligence (AI).

GF Fotonix enables high integration onto a photonics integrated circuit (PIC) so customers can integrate more product functions and simplify their bill of materials (BOMs). End customers can realize greater performance through increased capacity and capability. The new solution also enables innovative packaging solutions, such as the passive attachment for larger fiber arrays, support for 2.5D packaging, and on-die lasers.

GF Fotonix solutions will be manufactured at the company's manufacturing facility in Malta, NY, with the PDK 1.0 available in April. Electronic design automation (EDA) partners Ansys, Cadence Design Systems Inc and Synopsys provide design tools and flows to support GF's customers and their solutions. GF provides customers with reference design kits, multi-project wafers (MPWs), testing, pre- and post-fab, turnkey and semiconductor manufacturing services to help them get to market faster.

In addition, for customers needing discrete, high-performance RF solutions for optical systems, GF is adding new features onto the GF SiGe platform. High-performance silicon germanium solutions from GF are designed to deliver the speed and bandwidth required to transport information through next-generation fiber-optic high-speed networks.

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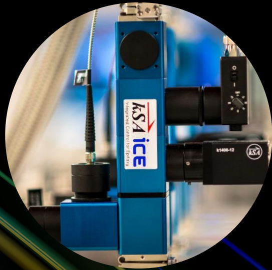

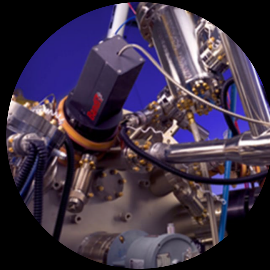

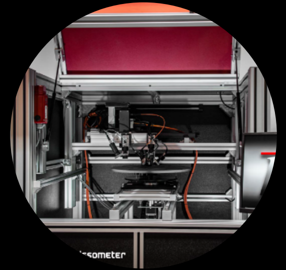

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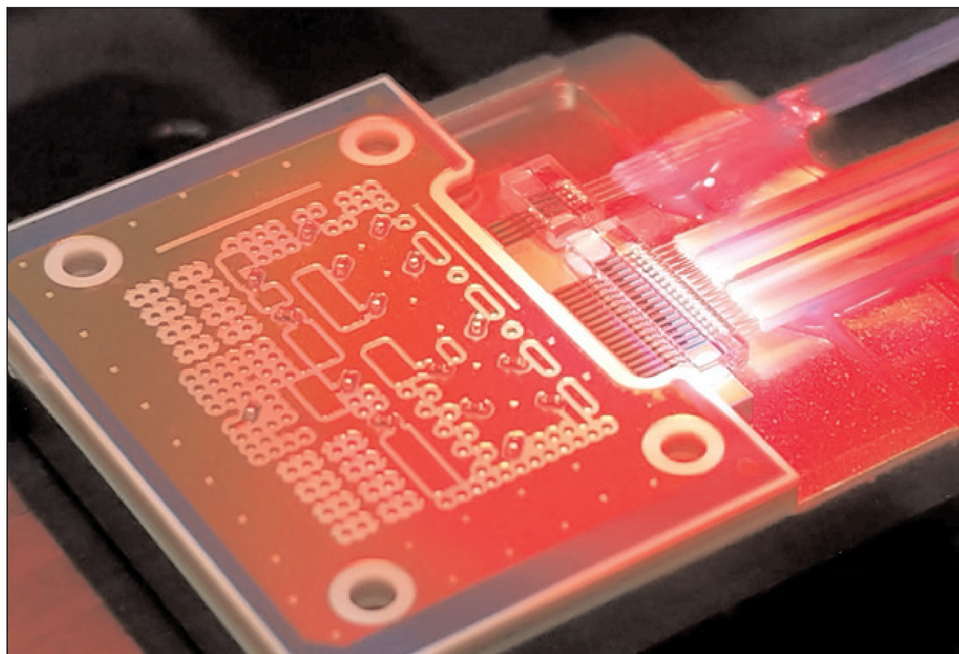
Ranovus delivers first monolithic 100G optical I/O cores for data centers based on GF Fotonix platform

Odin optical I/O cores target AI, cloud, metaverse and communications applications

At the Optical Fiber Communications conference (OFC 2022) in San Diego, CA, USA (8–10 March), Ranovus Inc of Ottawa, Ontario, Canada (which develops and manufactures multi-terabit photonics interconnect solutions for data-center and communications networks) announced the availability of its protocol-agnostic Odin 100G optical I/O cores based on GF Fotonix, the new next-generation monolithic platform of US-based GlobalFoundries. GF Fotonix is reckoned to be first in the industry to combine 300mm photonics and RF-CMOS features on a silicon wafer, delivering what is claimed to be best-in-class performance at scale.

Odin 100G optical I/O chiplets and IP cores can be integrated with processors, switches and memory appliances to enable new data-center architectures for machine learning (ML), artificial intelligence (AI), metaverse, cloud, 5G communications, and defence and aerospace workloads. Data centers are increasingly demanding efficient and cost-effective high-capacity interconnect solutions to meet the exponential growth in data-driven applications like ML/AI and metaverse. Odin 100Gbps optical I/O scales from 8- to 32-cores in the same footprint by combining Ranovus' 100Gbps-per-wavelength monolithic EPIC (electro-photonic integrated circuit) cores with its proprietary laser and advanced packaging technologies.

"We are delighted to share our multi-disciplinary silicon photonics IP cores and chiplets, and advanced packaging solutions with our customers who are driving the adoption of novel data-center architectures based on integrating best-in-class chiplets and co-packaged optics," says chief business development officer Hojjat Salemi.



An 8-core Ranovus Odin 100Gbps optical I/O with internal and external laser source options for high-capacity data-center interconnect.

"Our close collaboration with GlobalFoundries underlines our joint commitment to deliver a fully featured set of qualified IP cores and chiplets with OSAT-ready high-volume manufacturing flows and supporting ecosystem to enable the huge potential of monolithic silicon photonics."

Data centers are increasingly demanding efficient and cost-effective high-capacity interconnect solutions. Odin 100Gbps optical I/O scales from 8- to 32-cores in the same footprint by combining Ranovus' 100Gbps-per-wavelength monolithic EPIC cores with its proprietary laser and advanced packaging technologies

Ranovus has developed a highly flexible co-packaged optics architecture (Analog-Drive CPO 2.0) together with a tier-1 ecosystem for high-volume manufacturing of Odin chiplets. The first customer co-packaged solution with 800Gbps Odin optical I/O was also demonstrated at OFC, with samples based on the GF Fotonix platform shipping now.

"Data centers, computing and sensing applications require incredible processing, transmission and power efficiency as the world's data needs soar dramatically," comments Anthony Yu, vice president, Computing and Wired Infrastructure strategic business unit at GF. "Ranovus' IP cores, chiplets and advanced packaging solutions, combined with GF Fotonix, provide customers a complete solution to develop the chips needed to solve some of the biggest challenges facing data centers today."

www.ranovus.com/ranovus-with-amd-cpo

Ranovus and TE Connectivity demo first monolithic 800G optical interconnect with fine-pitch socket for co-packaged optics and optical module applications

Ranovus extends partnership with TE Connectivity with Odin 800G monolithic optical engine and CPO 2.0 platform

At the Optical Fiber Communications conference (OFC 2022) in San Diego, CA, USA (8–10 March), Ranovus Inc of Ottawa, Ontario, Canada (which develops and manufactures multi-terabit photonics interconnect solutions for data-center and communications networks) and TE Connectivity (which designs and makes sensors and connectors) have announced that their strategic collaboration has delivered the world's first Co-Packaged Optics (CPO) platform based on Ranovus' Odin 800Gbps Analog-Drive CPO 2.0 architecture with TE's CPx fine-pitch socket interposer technology. The CPO implementation, the result of a three-year development cooperation between Ranovus and TE, showcases a fully operational co-packaged optical assembly that has been socketed onto a package substrate typical of what is required for a full CPO solution.

Ranovus' Odin silicon photonics engine is a low-latency, high-density, protocol-agnostic optical engine that delivers massive optical interconnect bandwidth with what is claimed to be industry-leading cost and power efficiency. The Odin engine scales from 800Gbps to 3.2Tbps in the same footprint by leveraging Ranovus' 100Gbps-per-lambda monolithic electro-photonic integrated circuit (EPIC) cores, laser platform, and advanced packaging technologies. The Odin engine addresses the critical need by hyperscalers for power-efficient, high-throughput and high-density optical interconnect that can flexibly be integrated into next-generation data-center solutions.

"Following on our Odin Analog-Drive CPO 2.0 plaftorm and strategic partnership announcements at OFC 2021, we are pleased to demonstrate the flexibility of our Odin 800Gbps optical interconnect platform in combination with the novel CPx fine-pitch socket interposers, with superior signal integrity, developed by TE," says John Martinho, senior VP R&D at Ranovus. "We have been at the forefront of the co-packaged optics initiative since 2018 and are thrilled to be able to offer our customers the flexibility of co-packaging our Odin IP cores with TE's fine-pitch sockets for both CPO and optical module applications."

Co-packaged optics is an approach that provides Nx100Gbps PAM4 optical input/output (I/O) for Ethernet switch and ML/AI silicon in a single packaged assembly to significantly reduce the cost and power consumption of the complete system.

"It is gratifying to see the progress that Ranovus and TE have made in advancing the co-packaging state-of-the-art with this fully functioning co-packaging assembly," comments TE technologist Nathan Tracy. "Ranovus' low-power, high-performance ultra-dense Odin silicon photonics engine fully leverages TE's CPx fine-pitch electrical interconnect socket technology by taking advantage of the density and excellent signal integrity performance," he adds. "Co-packaging is all about pushing the technology envelope, and both Ranovus and TE have continued to do that in ways that can enable power reductions and density gains with a serviceable integrated assembly that can enable practical implementations."

TE's CPx co-package fine-pitch socket interposer technology can enable integration of miniature optical engine form factors in extreme close proximity to a packaged ASIC die. This can provide an excellent signal integrity transition to the ASIC, as required for minimal equalization or in the case of an analog-drive architecture, reducing the need for complex equalization.

Predicted at OFC a year ago, Ranovus and TE co-packaging technologies are now being trialed with the industry's thought leaders in operating demonstrations. As the industry works to develop solutions that can enable power-saving co-package optics and analog-drive architectures, Ranovus and TE are demonstrating that the future is here now.

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Lumentum & Ayar team on CW-WDM MSA-compliant external laser sources for co-packaged optical interconnects

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes photonic products for optical networks and lasers in industrial and consumer markets) and Ayar Labs of Santa Clara, CA, USA, whose integrated optical I/Os are targeted at artificial intelligence (AI), cloud, high-performance computing (HPC), 5G, and light detection & ranging (LiDAR), have entered into a strategic collaboration agreement to deliver CW-WDM MSA (continuous-wave wavelength division multiplexing multi-source agreement)-compliant external laser sources in high volume. These light sources are critical to power Ayar Labs' optical I/O solution, which are said to deliver breakthrough bandwidth, energy-efficiency and latency benefits for computing and networking over existing short-reach copper links.

The CW-WDM MSA was formed to standardize WDM CW sources in the O-band for emerging advanced integrated optics applications that are expected to move to 8, 16 and 32 wavelengths. Such higher wavelength counts are needed for emerging applications such as silicon photonics (SiPh)-based high-density co-packaged optics, optical computing, and AI, and enable a leap in performance, efficiency, cost and bandwidth scaling compared with previous technology generations.

"Co-packaged optics to replace traditional copper interconnects is a massive new market opportunity broadly recognized by the industry and one that Lumentum is well positioned to address with our proven laser technologies and manufacturing scale," believes Walter Jankovic, senior VP & general manager of Datacom at Lumentum. "Ayar Labs is a leader in the development and commercialization of this market opportunity, and we believe that, working together, we can accelerate this technology transition for the benefit of all," he adds.

"Since our founding [in 2015], Ayar defined optical I/O as the disruptive transition from copper and electrons to fiber optics and photons for short-reach data communication," says Ayar Labs' CEO Charles Wuischpard. "Ayar Labs' patented silicon photonics technology and new industry standards like the CW-WDM MSA are critical to this transition, as is the development of the manufacturing, supply chain and packaging ecosystem to cost-effectively deliver the solution at scale in the millions of units," he adds. "Lumentum is one of the largest and most efficient laser manufacturers in the world, and will provide the proven capability to address the volume, quality and reliability requirements of our optical I/O solution."

Last year, Ayar Labs demonstrated its 64-wavelength WDM optical source running at temperatures up to 100°C. The latest announcement follows news in late February of a strategic collaboration between Ayar Labs and Hewlett Packard Enterprise (HPE) for next-generation data-center architectures and networking with optical I/O, along with related news from GlobalFoundries for a first-of-its-kind silicon photonics manufacturing platform GF Fotonix, needed to address market demand for these solutions.

Ayar Labs and Lumentum are Promoter Members of the CW-WDM MSA, and GlobalFoundries and HPE are Observer Members.

www.cw-wdm.org
www.lumentum.com

Lumentum receives Best Comprehensive Performance Award from ZTE

Optical transport and transmission solutions recognized for best-in-class quality, outstanding delivery and excellent performance

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes photonics products for optical networks and lasers for industrial and consumer markets) says that ZTE Corp, a provider of telecoms, enterprise and consumer technology solutions for the mobile internet, presented it with the Best Comprehensive Performance Award during the 2022 ZTE Global Partners Day.

The award was based on Lumentum's "overall quality, leading technology, best-in-class performance, and agile response to deliver critical optical transport and transmission components," says Eric Zhang, ZTE's general manager of administration. "This award represents the culmination of Lumentum's contributions and value to build the digital infrastructure that enables our vision to provide connectivity and trust everywhere," he adds.

Lumentum received the award for supplying "high-quality, high-performance, cost-effective integrated optical communications solutions to support large-scale telecom networks and data-center interconnect applications and its overall responsiveness and on-time delivery".

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HP and Ayar Labs to co-develop silicon photonics-based optical I/O for HPC and AI

HPE's venture arm invests in chip-to-chip optical connectivity firm Ayar

Texas-based Hewlett Packard Enterprise and chip-to-chip optical connectivity firm Ayar Labs of Santa Clara, CA, USA have unveiled a multi-year strategic collaboration to develop silicon photonics-based optical I/O technology, supporting future requirements for high-performance computing (HPC) and artificial intelligence (AI) solutions.

The two organizations also announced that HPE's venture arm Hewlett Packard Pathfinder has made a strategic investment in Ayar Labs to accelerate the development and adoption of joint future technologies. As part of the collaboration, HPE and Ayar Labs will partner on photonics research and commercial development, building a joint ecosystem of solution providers, and customer engagements.

The collaboration will focus on Ayar Labs' development of high-speed, high-density, low-power optical-based interconnects to target future generations of HPE Slingshot, the industry's only high-performance Ethernet fabric specifically designed for HPC and AI solutions. By combining these technologies, the teams are positioned to design next-generation high-performance networking solutions and novel disaggregated system architectures that are critical for increased flexibility, efficiency, performance and throughput to support data-intensive demands of future workloads.

"We continue to invest in and develop our HPC and AI technologies to further boost application performance for our customers and help them unlock greater value from their research, engineering and business initiatives," says Justin Hotard, senior VP & general manager, HPC and AI, at HPE. "By partnering with Ayar Labs, we will advance innovation for the HPC and AI market, and leverage their expertise in optical I/O in future generations of HPE Slingshot to deliver unprecedented bandwidth and speed, at lower levels of power and latency, to meet requirements for growing demands in scale and performance."

Addressing future of HPC and AI application performance with optical interconnect

As the industry enters the exascale era (representing an increase in performance and advanced capabilities for HPC and AI), electrical-based networking offerings will eventually reach bandwidth limits, creating challenges in latency and overall application performance. To prepare for and address these future challenges, HPE and Ayar Labs plan to develop capabilities that leverage silicon photonics-based optical I/O technology to integrate with HPE Slingshot, a purpose-built HPC and AI interconnect designed for next-generation technologies, such as the upcoming US Department of Energy exascale supercomputers.

Optical I/O uniquely changes the performance and power trajectories of system designs by enabling compute, memory and networking ASICs to communicate with dramatically increased bandwidth, at a lower latency, and at a fraction of the power of existing electrical I/O solutions. The technology is also foundational to enabling emerging heterogeneous compute systems, disaggregated, pooled designs, and unified memory architectures that are critical to accelerating future innovation.

"HPE is the leader in advanced systems architectures for HPC, AI, and networking," says Ayar Labs' CEO Charles Wuischpard. "This collaboration will accelerate the introduction of a whole new class of system architectures that overcome the existing limitations of traditional interconnects, ushering in a new era for efficient scalable high-performance computing," he believes.

"Ayar Labs represents an exciting investment opportunity for Hewlett Packard Pathfinder as we closely support HPE's HPC and AI initiatives," comments Paul Glaser, VP & head of Hewlett Packard Pathfinder. "Ayar Labs' optical I/O technology is highly differentiated and critical to the evolution of high-performance computing architectures."

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Lumentum demonstrates and previews innovations

Firm demos live 400G coherent transmission and co-packaged optics

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes photonics products for optical networks and lasers for industrial and consumer markets) participated in partner demonstrations and highlighted its portfolio of future-ready solutions at the Optical Fiber Communication conference (OFC 2022) in San Diego (8–10 March) at both the Lumentum booth and partner booths.

400G coherent transmission demonstrations

Lumentum demonstrated its flex-coherent 400G CFP2-DCO modules that enable next-generation optical transport networks and data-center interconnects with NTT Network Innovation Laboratories and Telecom Infra Project (TIP).

NTT demonstrated live 400Gbps coherent transmission using a C+L-band line system that will incorporate Lumentum's pluggable 400G CFP2-DCO modules (a cost-efficient solution to the ever-increasing demand for capacity).

Additionally, TIP demonstrated reliable optical communication links in next-generation networks using Lumentum's 400G CFP2-DCO modules in a 400Gbps OpenROADM interoperability demonstration.

Demonstration of high-power lasers for co-packaged optics

In the Optical Internetworking Forum (OIF) booth, Lumentum showcased its 1310nm distributed feedback (DFB) laser technology with a high-power continuous-wave (CW) prototype, operating at 200mW optical power, enabling OIF's multi-vendor, co-packaged optics demonstration.

Direct detect tunable transceivers

- New 25G T-SFP28 tunable transceivers: Emerging applications, such as 5G wireless front-haul, require high-performance tunable transceiver technology at 25GB/s. Lumentum is positioned to address this market with its latest 25G T-SFP28 product, now available to sample. The firm's T-SFP28 incorporates SmartTunable technology to simplify field deployment tasks and leverages its installed manufacturing capacity to meet the anticipated rapid growth from 5G applications.
- Industry-first SmartTunable multi-source agreement (MSA): Lumentum has formed the SmartTunable MSA with other industry suppliers to enable standardization and interoperability between multiple vendors. The SmartTunable MSA (https://smarttunable-msa.org) will be released in the coming weeks and will accelerate the adoption of direct detect tunable transceivers.
- Secure high-volume manufacturing capacity: Lumentum has established and qualified high-volume T-SFP+ manufacturing capabilities in multiple geographically diverse locations, addressing customers' needs for supply security. To meet the needs of new, rapidly growing applications for direct-detect tunable transceivers, including fiber deep and 5G wireless front-haul architectures, Lumentum is continuing to add additional production capacity in its multiple manufacturing locations.

Innovative transport solutions enable high performance and capacity

- 16x26 TrueFlex contentionless wavelength-selective switch (WSS): Building on Lumentum's 8x26 WSS solution enabling next-generation scalable network architectures, the 16x26 contentionless WSS leverages further innovations in switching technologies and manufacturing automation to

►

Lumentum gives presentations at OFC

At OFC, Lumentum gave the following presentations on next-generation solutions and trends in the optical communications industry:

- 'Time to Face the Cost Per Bit "Crunch": Trends and Expectations for the Next Decade' — Workshop, by chief technology officer Brandon Collings;
- 'Disaggregating Lasers — Why, Where and When? Is Paradigm Shift from Pluggable Optics to Co-Packaged Optics Inevitable in the Next Generation of Datacenters?' — Workshop, by Ted Schmidt, senior director, Next-Generation Applications.
- 'Just in Time or Just in Case: Building a Resilient Supply Chain in a Post-COVID World' — Optica Executive Forum — Business Fireside Chat, by president & CEO Alan Lowe;
- 'Over 100 mW Uncooled Operation of SOA-Integrated 1.3-μm Highly Reliable CW-DFB Laser' – Session M4D: 'Semiconductor Lasers — Technical Paper and Presentation', by optical engineer Shoko Yokokawa;
- 'Role of Coherent System in the Next DCI Generation' – Track D1: 'Advances in prototype and product developments of components and subsystems for data centers and optical networks' — presentation by Dan Tauber, director, Systems Engineering.
- 'Tunable Optical Transceivers for 5G Fronthaul' — Panel 'Evolution of Optics for Mobile (MOPA)' by David Lewis, technologist, Optical Communications.
- 'Technology Challenges for 3.2TB/s Coherent Transceivers' – Panel 'Building the Next Generation 3.2T Transceiver', by Beck Mason, senior VP & general manager, Telecom Transmission.

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deliver the same performance and form factor as its predecessor but is now optimized for even larger 16-degree nodes. Samples are committed to lead customers and the product will be in mass production in early 2023, supporting C, L and extended-C band wavelength plans.

- Enhanced high-port-count TrueFlex Twin WSS platforms: In its third generation, the Twin WSS platforms feature greater performance and improvements related to core technology, manufacturing processes, and supply chain robustness to cost-effectively scale manufacturing. The platforms support multiple port configurations ranging from Twin 1x9 up to Twin 1x35 and spectral bands of 5THz (C, L), 6THz (extended C, extended L) up to 10THz (integrated C+L) while delivering a uniformly high standard of performance. By maintaining form-factor compatibility with current products, the latest platforms assure existing customers a seamless migration path to refresh and revitalize customer systems' over their lifecycle for the next decade.
- ROADM node-on-a-blade: To further pave the way for significant cost and space savings in next-generation networking equipment, Lumentum has developed a ROADM node-on-a-blade by integrating optical switching, amplification and monitoring functionality from across multiple degrees onto a single line-card. This disruptive step in the physical partitioning of ROADM nodes is supported by reliability data gathered from billions of hours of field operation of the discrete components. Commercial deployment of the first customer-specific ROADM node-on-a-blade designs will occur in 2022 with additional custom designs of increasing complexity to follow.

Enhanced high-performance datacom laser chips at higher volumes

- 100G and 200G PAM4 externally modulated lasers (EMLs): To enable next-generation hyperscale data centers to scale to higher speeds and network capacity, Lumentum is significantly expanding its manufacturing capacity for its latest high-performance 100G and 200G EML chips. Lumentum's EML chips allow customers to deliver high-speed modules at high volume while maintaining high-quality link performance at a low cost and power per bit. Samples of the 200G EMLs are available now.
- 100G PAM4 directly modulated lasers (DMLs): For demanding and cost-sensitive applications, Lumentum has optimized its DMLs for 400G DR4/FR4 and 800G DR8/PSM8, improving bandwidth by about 10% from previous generations. These compact chips deliver increased device count per wafer and lower complexity compared with EMLs, enabling cost-effective solutions to compete with silicon photonic (SiPh)-based transceivers. Beta samples are now available.
- CW lasers: To enable SiPh-based transceivers for next-generation data-center applications, Lumentum is sampling its uncooled and high-output-power 75mW CW laser. This laser leverages the firm's indium phosphide (InP) technology platform to integrate a semiconductor optical amplifier on chips, achieving the needed high output power at high temperature to cover 4x100G lanes with a single CW laser.
- Vertical-cavity surface-emitting lasers (VCSELs): Lumentum's 850nm VCSELs for 25G NRZ-per-lane and 50G PAM4-per-lane applications are in volume production now with high production capacity for high-volume transceiver applications. In addition, the firm's 940nm VCSELs and indium gallium arsenide (InGaAs) photodiode pairs enable low-cost, high-performance active optical cable (AOC) applications. Lumentum's 50G VCSELs are available to support 800G-SR4.2 transceivers. Samples for all four SWDM4 wavelengths of the firm's VCSELs are also available.

www.lumentum.com

Thailand's Prime Minister's Industry Award for Productivity

Thailand's prime minister Prayut Chan-o-cha has presented Lumentum with the 2021 Prime Minister's Industry Award in the Productivity category.

The award recognizes Lumentum's achievements in integrating efficiency and effectiveness into its manufacturing processes, emphasizing continuous improvement at its Thailand facility.

Since 1981, the annual Prime Minister's Industry Award has honored outstanding enterprises — of any size in any industry — that have proven business achievements and contributions to the benefit of Thailand's society and economy. Award winners are selected based on management capability, business performance, innovation, technology, economic and social impact, and corporate governance.

"This recognition demonstrates our ingrained culture of continuous improvement and our zero-defect mindset," says Chris Parsons, senior VP of Asia Operations and Services at Lumentum. "We leverage Kaizen and innovation to drive efficiency through the product lifecycle, from product concept to the manufacturing processes."

This is the second major award for Lumentum's Thailand Navanacorn factory after being presented with the 2020 Prime Minister award for Outstanding Achievement in Quality Management. The newly developed site is the quickest ever to be recognized with this award and in its first attempt.

Source Photonics demonstrates 50G PAM4 SFP56 transceivers for 5G front-haul

At the Optical Fiber Communication conference (OFC 2022) in San Diego (8–10 March), Source Photonics Inc of West Hills, CA, USA (which provides optical connectivity products for data centers, metro and access networks) is giving a live demonstration of its 50G SFP56 transceivers with industry partners (specifically, Viavi's 50G ONA-1000 optical traffic testing solutions).

Source Photonics officially launched the 50G PAM4 SFP56 product portfolio for 5G front-haul networks last September. As global operators accelerate the deployment of 5G networks, promote the differentiated application of 5G multi-services, and release more spectrum resources, 5G networks present higher bandwidth requirements for front-haul. Currently, the 25Gb/s eCPRI interface is the most widely used solution for 5G front-haul networks. When the 5G spectrum bandwidth exceeds 100M, one base station requires 6x 25Gb/s eCPRI interfaces and a total of 12x 25Gb/s SFP28 optical modules. The 50G SFP56 achieves 50% port savings by upgrading the rate of one transceiver to 50Gb/s, creating flexibility for further improvement of wireless forward bandwidth.

To meet the most pressing bandwidth requirements of global customers, Source Photonics has introduced 50G LR and FR PAM4 SFP56 optical modules, which support 10km and 2km, respectively. The product meets the range of industrial-temperature applications with power consumption as low as 1.5W. This series of products uses the 25G distributed feedback (DFB) laser developed in-house by Source Photonics to provide low power consumption, short latency and cost-effective transceiver solutions for 5G front-haul networks.

Leveraging in-house vertically integrated optics and ICs, these modules support interoperability with previous generations of 25G SFP28 and 10G SFP+ optical transceivers. Both modules comply with the corresponding 50GBASE-R specifications (as defined in the IEEE standards) and offer 50G PAM4 electrical and optical interfaces.

Source Photonics says that it has conducted in-depth cooperation with leading 5G equipment manufacturers, and qualification is progressing smoothly. The 50G LR SFP56 and 50G FR SFP56 are the most urgent general-purpose applications today. The development of 50G Bidi SFP56, 50G WDM SFP56 and other related products has also been launched, which will provide more diversified, more flexible and more cost-effective products.

www.ofcconference.org
www.sourcephotonics.com

MACOM demos TIA and laser driver interoperability with Broadcom 100Gbps VCSEL, photodetector and PAM-4 DSP up to 1.6Tbps

At the Optical Networking and Communications Conference (OFC 2022) in San Diego, MACOM Technology Solutions Inc of Lowell, MA, USA collaborated to give a live demonstration of interoperability of Broadcom's vertical-cavity surface-emitting laser (VCSEL), photodetector and PAM-4 DSP (digital signal processor) with MACOM VCSEL driver and transimpedance amplifier (TIA) for 100Gbps-per-lane multi-mode fiber (MMF) applications.

The pairing for this 100m MMF demonstration includes MACOM's MATA-39434 4x100Gbps PAM-4 TIA and MALD-39435 4x100Gbps PAM-4 VCSEL driver along with Broadcom's VCSEL (AFCD-V84LPx), photo-detector (BPD3056-4) and 7nm Portofino DSP (BCM878xx) for 100Gbps/lane up to 1.6Tbps short-reach modules (SFP, QSFP, OSFP, QSFP-DD) and COB on-board optics.

MACOM's chipset delivers IEEE standard specified performance and enables low power consumption, best-in-class linear performance, low noise and low latency for short-reach MMF applications. The firm's devices are also targeted for the upcoming Terabit BiDi MSA (multi-source agreement) specification supporting 1.6Tbps per module.

"Our customers require high-performance solutions to enable their data-center applications," says Marek Tlalka, senior director, High-Performance Analog, MACOM. "This collaboration builds on our recently demonstrated single-mode interoperability offering the industry another proof point towards the interoperability of optics and DSPs with MACOM's laser drivers and TIAs and a path to shorter design cycles for high-speed optical module manufacturers," he adds.

"Broadcom's 100Gbps PAM-4 DSPs, VCSELs and photodetectors along with MACOM's TIAs and laser drivers provide industry-leading performance at the lowest power for short-reach, high-speed optical modules," claims I-Hsing Tan, director of product marketing, Optical Systems Division, Broadcom. "Displaying leading performance at 100m for MMF applications highlights Broadcom's interoperability with various components needed to develop industry-leading optical modules."

www.macom.com
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Scintil unveils III-V-augmented silicon photonic IC

Scintil Photonics of Grenoble, France and Toronto, Canada, a fabless developer of silicon photonic integrated circuits (integrated laser arrays, 800Gb/s transmitters and receivers, tunable transmitters and receivers), unveiled a prototype III-V-augmented silicon photonic integrated circuit (IC) at the Optical Fiber Communication conference (OFC) in San Diego (8–10 March).

The augmented silicon photonic IC is a single-chip solution comprising all the active and passive components made from standard silicon photonics available in commercial foundries, with III-V optical amplifiers/lasers integrated on the backside of advanced silicon photonic circuits.

Scintil says its solution can boost communications in data centers, high-performance computing (HPC), and 5G networks (prime users of optical transceivers). The optical transceiver market is expected to rise at a compound annual growth rate (CAGR) of 14% from 2021 to $20.9bn in 2026.

"The close collaboration with our commercial foundry was key to achieving this fabrication milestone, resulting in unprecedented levels of integration and performance," says president & CEO Sylvie Menezo. "Scintil is already working with three leading-edge customers; it is fundamental to them that we can prototype and produce in commercial high-volume silicon foundries, using multi-customer standard processes."

Technical features and key benefits

The 1600Gb/s prototype IC integrates silicon modulators and germanium photodetectors supporting 56GBaud PAM 4, with integrated III-V-optical amplifiers. The IC technology offers the capability of delivering sustainable bit rates through parallelization and the increase of baud rates at a competitive cost per gigabit per second.

The IC leverages wafer-scale bonding of III-V materials on silicon for integrating optical amplifiers/lasers.

The benefits in solving some key industry challenges are said to include:

- dramatically reducing the number of components and active alignments, resulting in better cost-efficiencies;
- addressing both the pluggable transceiver market and co-packaged/near-packaged optics requirements for bringing the optical chip close to high-performance processing units (XPU) in data-center environments;
- intrinsic hermeticity removing the need for hermetic packages.

Menezo participating as a speaker during the OFC symposium on 'Emerging photonic interconnects and architectures for femtojoule per bit intra data center links networks'.

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NeoPhotonics demonstrates InP components capable of 120Gbaud operation supporting 800G LR, ZR and ZR+ transmission

Component and module technology enabling 800G+ performance in hyperscale data-center and telecom networks

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications — has used its indium phosphide (InP)-based coherent receiver and coherent modulators, coupled with its ultra-narrow-linewidth tunable lasers or distributed feedback (DFB) lasers, to demonstrate 120Gbaud operation in applications ranging from 800G LR transmission to 400G long-haul transmission.

The next-generation DSP baud rate will be based on 120+Gbaud, and potential applications include 800LR (≤10km), 800ZR for DCI (≤100km), 800ZR+ for metro-core (≤1000km), and 400Gb/s ultra-long-haul transmission. Demonstrations of this level of performance are reported and listed below, showing that corresponding high-speed optoelectronic components are available to match the DSP baud rate and to enable pluggable or embedded modules at these data rates.

Using its InP-based coherent driver modulator (CDM) and intradyne coherent receiver (ICR) with more than 60GHz bandwidth, NeoPhotonics has experimentally demonstrated the feasibility of the following transmission systems at 120+Gbaud:

- Long-haul: 400Gb/s over 1500km standard single-mode fiber erbium-doped fiber amplifier (EDFA)-only transmission system with a superior required optical signal-to-noise ratio (OSNR) of 16.7dB at OFEC threshold;
- Regional/metro-core: 800Gb/s (with probabilistic shaping) over 1000km standard single-mode fiber EDFA-only transmission system with a superior required OSNR of 24.3dB at OFEC threshold;
- ZR DCI: 800ZR over a single-span EDFA-based 100km standard single-mode fiber with a superior required OSNR of 25dB at OFEC threshold and a transmitter output power of −6dBm; and
- Unamplified LR: 800LR over an unamplified 10km link with a 9dB link budget, and 800Gb/s 'coherent lite' over an unamplified 1km link with a budget of 5.2dB, both using low-latency forward-error correction (FEC) with a bit-error rate (BER) threshold at 4×10^{-3}. The latter used self-homodyne coherent detection so as to significantly simplify the DSP and remove wavelength locking between transmitter and local oscillator.

"We are pleased to take this opportunity to highlight the progress we have made in pushing our high-performance indium phosphide integration technologies to even higher speeds and over longer distances to enable new potential applications in cloud and data-center applications," says chairman & CEO Tim Jenks. "These 120Gbaud components coupled with our ultra-narrow-linewidth external-cavity 'nano' tunable laser or our distributed feedback lasers, along with concurrent DSP advances, could enable pluggable modules to operate at 800G for applications within and between data centers, as well as to extend the speed and reach of embedded telecom systems," he adds.

Aspects of these demonstrations were discussed in the following presentations at the Optical Fiber Communications Conference and Exhibition (OFC 2022) in San Diego, CA (8–10 March):

- Dr You-Wei Chen, 'Intra-Data Center 120Gbaud/DP-16QAM Self-Homodyne Coherent Links With Simplified Coherent DSP';
- Marcel Boudreau, 'Laser and Gain Sources for Highly Integrated Photonic Circuits', Panel W1B: 'Progress and Roadmap in Silicon Photonics Foundries and Supply Chains';
- chief technology officer Dr Winston Way, 'From Long-Haul to Intra-Data Center: Coherent Transceiver's Spectacular Journey', Market Watch Panel V: 'Evolution of Coherent Transceiver Architectures for Specific Applications'.

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NeoPhotonics samples Open ZR+ QSFP-DD transceivers

Small-form-factor pluggable modules for metro-regional applications to enhance performance in hyperscale data center and telecom networks

NeoPhotonics Corp of San Jose, CA, USA — a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications — has announced sample availability for its Open ZR+ QSFP-DD transceivers.

Based on NeoPhotonics' optical components, ultra-low-noise tunable lasers and proven 400ZR design, the Open ZR+ version of the QSFP-DD uses the Marvell Deneb coherent digital signal processor (CDSP) to incorporate industry-standard open forward-error correction (OFEC). NeoPhotonics is a contributor to the Open ZR+ multi-source agreement (MSA), which defines interoperability specifications for OpenZR+.

By using OFEC, the required optical signal-to-noise ratio (rOSNR) capability of NeoPhotonics transceivers is improved beyond traditional 400ZR CFEC (concatenated forward-error correction), allowing for multiple span coverage in amplified networks. This may be applied to metro and IP-over-DWDM networks with extended-reach scenarios, with data-rate coverage from 100Gb/s to 400Gb/s.

In addition, there are a number of applications where the fiber reach may not exceed the OIF ZR specifications but, because of older fiber, patch panels and other impairments, the link loss and impairment budgets could exceed that of a standard 400ZR link.

In these cases, NeoPhotonics' Open ZR+ module can be used for 400G upgrades, where standard solutions are not practical. More background information on coherent communications in pluggable modules can be found in a series of 'Trends and Technology' presentations on the NeoPhotonics website.

"NeoPhotonics has developed an Open ZR+ solution to take advantage of the benefits of IP-over-DWDM and because many customers are interested in utilizing small-form-factor coherent modules deeper into their networks," says chairman & CEO Tim Jenks. "Our Open ZR+ QSFP-DD transceivers combine an extended network reach and interoperable OFEC with our proven optical component and transceiver designs to address these needs," he adds.

"The transceivers also augment our proven 400ZR solutions, which have multiple design wins at cloud and data-center switch customers, with new Open 400ZR+-compliant QSFP-DD and OSFP modules. The ability to transmit 400Gb/s over distances as long as 800km and more in a cost-effective manner is a real game changer," concludes Jenks.

www.neophotonics.com

NeoPhotonics shipping 53Gbaud PAM4 driver ICs for 100G and 400G hyperscale data-center networks

More than 1 million single and quad drivers shipped

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications – says that it has shipped more than 1 million single and quad drivers for PAM4 transceivers used in hyperscale data-center networks.

NeoPhotonics' 53Gbaud PAM4 driver IC is a linear, differential driver based on gallium arsenide (GaAs) and optimized for 1 x 100Gbps, 4 x 100Gbps and 8 x 100Gbps PAM4-based applications. The drivers are in volume production and provide a high RF output voltage swing with high linearity and are suited to modulating silicon photonics Mach-Zehnder modulators (MZM) used in 400G data-center transceivers, while maintaining what is claimed to be exceptional quaternary transmitter dispersion eye closure (TDECQ).

NeoPhotonics' linear drivers feature high output voltage >3.4V_{ppd}, low crosstalk, high gain, high bandwidth of >35GHz (supporting 53Gbaud) and low total harmonic distortion (THD) to enable what is claimed to be best-in-class PAM4 performance.

"We are pleased to have achieved multiple design wins for our family of 53Gbaud suite of drivers and are now shipping them in high volume," says chairman & CEO Tim Jenks. "We have been shipping GaAs drivers for nearly a decade and have a deep technology base. We started with 10Gbps devices, and are now shipping devices for 400Gbps transceivers," he adds. "We continue to improve our product performance and have recently introduced versions of the driver that deliver more than 20% power reduction. Furthermore, we are currently developing next-generation versions that we believe will feature 50% power savings verses the current generation."

Ultra-narrow-linewidth laser launched for LEO satellites

Radiation-tolerant coherent low-noise tunable laser has enhanced flexible software

NeoPhotonics has launched a radiation-tolerant version of its Nano ultra-pure-light tunable laser, for use in low-earth-orbit (LEO) satellite communications applications.

NeoPhotonics' existing Nano-ITLA (integrated tunable laser assembly) is in high-volume production for terrestrial fiber-optics applications and is used by many of the leading optical networking companies in their most advanced coherent pluggable modules and high-speed embedded systems. The new radiation-tolerant laser introduces enhancements including an adaptive approach to achieve extended-lifetime operation of the proven Nano laser hardware in a radiation flux environment to enable reliable operation in space without compromise to performance and stability.

Multiple companies are now deploying or developing constellations of low-earth-orbit satellites to bring high-bandwidth communications to areas not currently served by wireless infrastructure. These constellations consist of thousands of satellites which must have high-bandwidth connections between them to avoid service drop-outs. These satellite-to-satellite communications links are now shifting from microwave to coherent optical technology, taking advantage of the vast increase in transmission capacity developed for terrestrial fiber-optic communications, where 800Gbps is now regularly transmitted on a single wavelength.

While coherent communications technology is now highly advanced, space is a hostile environment for the electronics and related hardware used in telecommunications, largely due to radiation impacts from galactic cosmic rays, high-energy particles from the sun, and particles trapped by the earth's magnetic field. Special 'radiation hardened' electronic devices, which are more robust than those typically used on the ground, are often used to mitigate these issues, but they can add significantly to cost. For the lasers used in coherent communication, the control electronics are often more vulnerable to these radiation effects than the laser itself.

One example of the laser control subsystem electronics that is particularly vulnerable to ionizing radiation is the memory (RAM and FLASH) that microprocessors rely on. While radiation effects on memory can be lessened by using special packaging or by more expensive hardware components, the effects of ionizing radiation on memory corruption can also be mitigated by incorporating radiation-tolerant software enhancements, resulting in greatly improved reliability, recovery and resilience, as has been demonstrated during laboratory testing designed to simulate low-earth-orbit conditions.

"NeoPhotonics has been a leader in the design, development and high-volume production of ultra-narrow-linewidth tunable lasers for coherent communications over the last decade, and we are excited to offer our high-performance to the exciting new application of satellite communications," says chairman & CEO Tim Jenks. "We have used our long experience and deep understanding of lasers technology to develop an innovative software-centric approach to radiation tolerance that speeds time to market, while maintaining performance and limiting costs."

www.neophotonics.com

NeoPhotonics transceivers included in OIF 400ZR interoperability demonstration

QSFP-DD and OSFP modules interoperate with multiple vendors' products

At the Optical Fiber Communication conference (OFC 2022) in San Diego (8–10 March), NeoPhotonics Corp of San Jose, CA, USA — a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications — says that its OSFP and QSFP-DD 400ZR transceivers were included in the OIF 400ZR interoperability and CMIS demonstrations.

At this year's OFC, OIF hosted its largest demonstration of interoperability to date, featuring five key technology areas — 400ZR optics; co-packaging architectures; common electrical I/O (CEI) channels; FlexE (Flex Ethernet) definitions and Common Management Interface Specification (CMIS) implementations. The interoperability demos were both live and static during OFC.

"Interoperability is a key element to enable widespread adoption of 400ZR," says chairman & CEO Tim Jenks. "Our successful interoperability with different manufacturers' modules, switches, routers and test equipment helps to establish and expand the 400ZR eco-system," he adds.

www.ofcconference.org

NeoPhotonics' full-year 400G-and-above product revenue up more than 70% to $148m

Total Q4 revenue up 18% year-on-year despite supply chain shortages

NeoPhotonics Corp of San Jose, CA, USA — a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications — has reported full-year revenue of $290.3m for 2021, down 22% on $371.2m in 2020 as it replaces the revenue base of its largest customer in 2020. However, revenue from customers other than Huawei grew by 17% year-on-year.

Fourth-quarter 2021 revenue of $80.6m was down 3.7% on $83.7m last quarter, but that reflected "operational challenges as the full force of industry-wide IC chip supply shortages [primarily analog and power semiconductors] impacted our top-line revenue by more than $15m," says chairman & CEO Tim Jenks.

Also, Q4 revenue was up 18% on $68.2m a year ago, due to growth in 400G-and-above-capable products. "Our products for 400G-and-above applications grew 9% sequentially, comprising 56% of total revenue [and 51% for full-year 2021, after growing by more than 70% to $148m], despite this product group being the most impacted by supply chain chip shortages," says Jenks.

During Q4/2021, NeoPhotonic announced the following product milestones:

- general availability of 400ZR QSFP-DD and OSFP compact coherent transceiver modules;
- three Cloud and data-center switch customer design wins for 400ZR coherent DCO modules;
- shipment (cumulatively) of more than two million ultra-pure light tunable lasers;
- demonstration of 400Gbps transmission over 1500km by the firm's CFP2-DCO transceiver module;
- launch of a new frequency-modulated continuous wave (FMCW) laser which, together with a high-power semiconductor optical amplifier (SOA), is used in coherent LiDAR (light detection and ranging) applications for autonomous vehicles (AVs) and for precision industrial instruments.

On a non-GAAP basis, full-year gross margin fell from 31.3% in 2020 to 25.4% for 2021. Fourth-quarter gross margin was 26.6%, down from 29.4% last quarter (although that included $2.5m, or 3.1 percentage points, of incremental costs related to purchasing product on the spot-buy market to help ensure supply for 2022). Also, Q4/2021 gross margin was up from 24.7% a year ago.

Quarterly operating expenses remained roughly flat over the last year at $23.3m, representing a cut from 34.8% to 28.9% of revenue. Full-year operating expense were roughly flat year-on-year at $92.4m.

Full-year 2021 saw an operating loss of $18.6m, compared with an operating profit of $23.9m in 2020. Likewise, Q4/2021 saw an operating loss of $1.8m, cut from $6.9m a year ago but a set-back from a profit of $1.3m last quarter, due to lower revenue and increased costs (both as a result of supply chain constraints).

NeoPhotonics expects the impacts of chip shortages in the supply chain to continue for at least the next two quarters. Our business remains on a strong growth path, as demand continues to increase and our backlog has expanded to record levels with nearly a year of visibility

Quarterly net loss was $3.4m ($0.06 per share) in Q4/2021, more than halving from $7.2m ($0.14 per share) a year ago but compared with a net profit of $0.78m ($0.01 per share) last quarter. Full-year net loss was $21.5m ($0.41 per share) for 2021, compared with a net profit of $16.7m ($0.31 per share) in 2020.

Full-year adjusted EBITDA fell from $43.3m in 2020 to $2.9m for 2021. However, although it was down from $6.7m in Q3/2021, quarterly adjusted EBITDA of $2.3m in Q4/2021 is an improvement on –$4.7m a year ago.

During the quarter, cash and cash equivalents, short-term investments and restricted cash hence rose by about $1m to $106m.

NeoPhotonics expects the impacts of chip shortages in the supply chain to continue for at least the next two quarters. However: "Our business remains on a strong growth path, as demand continues to increase and our backlog has expanded to record levels with nearly a year of visibility," notes Jenks.

Proposed acquisition by Lumentum

On 4 November, NeoPhotonics said that it had entered into a definitive agreement to be acquired by Lumentum for $16 per share in cash (a total equity value of about $913m). "Lumentum is an ideal partner to serve our customers on a larger scale," believes Jenks.

The transaction remains on track, having been approved by stockholders at a special meeting on 1 February and following the expiration of the waiting period under the Hart–Scott–Rodino Antitrust Improvements Act of 1976 (as amended). The remaining requirements for closure of the transaction are customary closing conditions set forth in the merger agreement and approval from the State Administration for Market Regulation (SAMR) of the People's Republic of China. The transaction is expected to be completed in second-half 2022.

www.neophotonics.com

Acacia launches 400G QSFP-DD pluggable coherent optical modules that expand transceiver applications

50,000 ports shipped of Greylock DSP powering Acacia's 400G portfolio

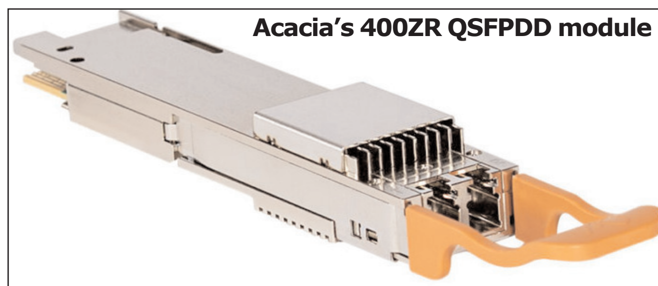
Acacia Communications Inc of Maynard, MA, USA (now part of Cisco) — which develops and manufactures high-speed coherent optical interconnect products — is adding to its portfolio of 400G coherent pluggable solutions, based on its Greylock 7nm digital signal processor (DSP), with the new Bright 400ZR+ and ER1 400G pluggable coherent optical modules.

Early adopters of Acacia's 400G pluggable product family have been driving strong demand that has resulted in over 50,000 port shipments, with more than 20,000 shipped during Cisco's fiscal second-quarter (ending 29 January). The aggressive ramp of these products has been faster than any previous coherent technology generation, says the firm. Early demand has been driven largely by metro data-center interconnect (DCI) use cases, but service providers are actively working to deploy this technology in a wide range of applications. With the new modules, Acacia has developed a portfolio of solutions that further address the varying needs of network operators, while driving economies of scale on a common technology platform.

The 400G coherent pluggable market is one of the most important developments in optical networking currently, says Acacia. Analysts such as Cignal AI have stated that sales of 400ZR and OpenZR+ are ramping rapidly, while Heavy Reading's Sterling Perrin claims that "The advent of coherent pluggable optics at 400G is one of the key enablers that was needed to propel IP and optical integration into the mainstream."

New modules expand 400G QSFP-DD applications and reduce cost, power consumption and network complexity

The Bright 400ZR+ QSFP-DD pluggable coherent optical module with



Acacia's 400ZR QSFPDD module

high optical performance is designed for seamless deployment in reconfigurable optical add-drop multiplexer (ROADM) line systems.

For customers primarily targeting filtered (AWG-based DWDM) point-to-point applications, the 400ZR and OpenZR+ modules are an effective pluggable solution. Acacia's Bright QSFP-DD module is designed to expand the applications for this technology by addressing a variety of ROADM architectures such as those with colorless multiplexing. With greater than 0dBm transmit optical power and high transmit optical signal-to-noise ratio (OSNR), the Bright 400ZR+ gives network operators more flexibility to address a range of brownfield and greenfield applications utilizing the high-density QSFP-DD form factor.

"Colt has successfully deployed 400G ZR+ on our IQ Network packet router backbone. High-launch-power 400G ZR+ optics would be an important step change for IPoDWDM deployments," comments Danny Pinto, associate director, Packet Networks Engineering at Colt. "This would enable IPoDWDM uses cases in meeting optical requirements of ROADM-based optical solutions and brownfield deployments," he adds.

The Bright 400ZR+ QSFP-DD module also supports OTN framing that can enable circuit emulation and pseudowire functionality over packet networks, offering even greater flexibility for network operators who want to deploy this pluggable technology.

"Products like Acacia's high-transmission-power QSFP-DD modules and third-party vendor-agnostic SDN could open the door for deeper packet and optical integration in telco networks," says Juan Pedro Fernandez-Palacios, head of Transport at Telefonica CTIO.

For upgrading from 100G to 400G with 40km reach

The 400G ER1 QSFP-DD pluggable coherent optical module has a rich feature set including client multiplexing and interoperability based on both OIF and OpenZR+ protocols. Acacia's ER1 400G module is reckoned to be a cost effective and flexible solution for unamplified 40km point-to-point applications in access, campus and 5G network applications.

Leveraging proven expertise

Acacia says that, to develop its new 400G QSFP-DD modules, it leveraged its proven expertise in optical integration and packaging. The firm's expertise with high-performance silicon photonic integrated circuits (PICs) and low-power DSPs has helped to enable the introduction of 3D Siliconization. Acacia's 3D Siliconization applies integration and 3D stacking techniques to enable a single device that includes all the high-speed optoelectronic functions necessary for coherent communications. This device, which includes the DSP, photonic integrated circuitry, drivers and transimpedance amplifiers (TIAs), is manufactured using standard electronics packaging processes. Advantages of 3D Siliconization include the reduction of electrical interconnects while improving signal integrity, resulting in improvements in performance, cost, reliability, power and size.

www.acacia-inc.com/product/silicon-photonic-integrated-circuits-pic

Open Eye Consortium releases 400Gbps and 800Gbps long-reach and short-reach specs

The Open Eye Consortium multi-source agreement (Open Eye MSA) has announced the public availability of its 100Gbps-per-lane, long-reach, single-mode specification and MSA internal availability of its 100Gbps-per-lane, short-reach, multi-mode specification. The specifications are optimized for low-power, low-cost solutions enabling hyper-scale 400Gbps and 800Gbps data-center connectivity. The new specifications complement the Open Eye MSA's previously released single- and multi-mode specifications.

The Open Eye MSA aims to accelerate the adoption of PAM4 optical interconnects scaling to 50Gbps, 100Gbps, 200Gbps, 400Gbps and 800Gbps by expanding upon existing industry standards to enable optical module implementations using less complex, lower-cost, lower-power and optimized analog clock and data recovery (CDR)-based architectures in addition to existing digital signal processing (DSP) architectures.

The public release of the 100Gbps-per-lane single-mode specification is targeted for 4x100Gbps WDM modules for 3km-reach applications (400G-FR4-3). The specification enables the use of analog-based and DSP technologies to deliver lower-cost, lower-power and lower-latency optical modules to address growing hyperscale data centers and artificial intelligence (AI)-clusters requirements.

The 100Gbps-per-lane multi-mode specification is targeted for 400Gbps SR4-Lite and 800Gbps SR8-Lite applications. Optimized for lower-power and lower-cost solutions for high-volume hyper-scale data centers, the new specification defines 50m reach at 850nm vertical-cavity surface-emitting laser (VCSEL) wavelength over OM4 fiber, as well as 30m-reach at 940nm VCSEL wavelength over OM4 and OM5 fiber.

In addition to these released specifications, the MSA has commenced work on multi-lane, 100Gbps-per-lane, 3km parallel single-mode (PSM) fiber specifications optimized for hyperscale cloud data-center connectivity. The MSA welcomes input from the end-user community on these new specifications.

A white paper is available to view and download for interested parties to learn more about the Open Eye's MSA mission and latest technical information.

www.openeye-msa.org

OIF launches CEI-224G framework project white paper for next-generation data-rate systems

As the industry looks towards higher data rates and increased throughput for the next generation of systems based on 224Gbps per lane, new specifications and technologies are required. The Optical Internetworking Forum (OIF) has announced a framework document representing its efforts to identify the hardware interconnection application spaces where the communications and computer industries could benefit from interconnection definitions or Implementation Agreements (IA).

The CEI-224G framework project has resulted in a white paper summarizing the consensus findings and guidance for new OIF project starts for future CEI clauses addressing specific 224Gbps reaches and architectures. Further, it identifies key technical challenges for next-generation systems, defines electrical interconnection applications, and discusses some of the interoperability test challenges. This provides the OIF and other industry standards bodies with a common language and understanding of the development projects required for next-generation data-rate systems. It also establishes baseline materials that will enable 1.6/3.2Tbps-rate architectures and lower-cost, lower-complexity 800Gbps and 400Gbps architectures.

"As demonstrated in the past, most recently at 112Gbps, OIF plays a key role in driving industry activity to identify and develop critical technical solutions that will enable next-generation data rates to be cost-effectively deployed in future equipment and networks," says OIF president's Cathy Liu of Broadcom.

Service providers, network customers and data-center operators have communicated that higher data rates like 224Gbps are required for client- and line-side links to support higher volumes of traffic on the core and backbone networks. These next-generation data rates need to be implemented while also addressing power consumption, density, performance, reach and cost challenges.

"224Gbps is going to bring many difficult challenges for the industry to address to achieve practical implementations in an interoperable way," says OIF's VP of marketing Nathan Tracy of TE Connectivity. "This framework project and its resultant white paper align OIF members and industry on many of the key hurdles," he adds. "Overcoming obstacles can be achieved by having consensus amongst a broad cross-section of component, subsystem and system suppliers to leverage new technologies that drive signaling, architecture and integration developments."

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InGaAs/colloidal nanocrystal infrared detector

Synergistic hybrid extends detection wavelengths from 1.6μm to 2.0μm.

Researchers in France have combined indium gallium arsenide (InGaAs) III–V nanowires with colloidal mercury telluride (HgTe) II–VI nanocrystals (NCs) to create a photodiode sensitive to light in the 1.6-2.0μm short-wavelength infrared (SWIR) range [Adrien Khalili et al, Appl. Phys. Lett., v120, p051101, 2022].

The team from Sorbonne Université, ONERA-The French Aerospace Lab, and University Lille, comment: "For a long time, the design of IR sensors has opposed narrow-bandgap III–V semiconductors against their colloidal II–VI counterpart. Here, we demonstrate that Van der Waals heterostructures can be obtained from these two types of semiconductors."

Typical Van der Waals heterostructures include graphene and transition-metal dichalcogenides. It is hard to see how these structures can be scaled up to mass production from laboratory-scale flakes measuring at most a few tens of microns. By contrast, large-production-scale III–V materials are basic to ubiquitous light-emitting diodes and laser diodes.

Narrow-gap nanocrystals such as HgTe are used to absorb the infrared tail of the solar spectrum in photovoltaic devices and in infrared cameras.

The InGaAs nanowires were produced using selective-area molecular-beam epitaxy on indium phosphide substrate. The mask was plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide, resulting in an array of 200 nanowires of 200μm x 130nm dimensions with 500nm pitch. The wires were coupled with a few nanowires in the perpendicular direction to reduce the resistance (Figure 1). The n-type doping level of the array was $5x10^{18}/cm^3$.

Gold was deposited to give source/drain metal electrodes with the source connected to the nanowires. A silica patch (purple false color in Figure 1) was placed over the connection between the source and the nanowires, separating the electrode from the HgTe NC layer. The drain was not connected to the nanowires.

The device was then coated with a 200–400nm HgTe NC layer. The target NC diameter was 8nm, which gives a 2μm wavelength band edge. This was red-shifted relative to that of the InGaAs nanowires, 1.6μm. Peak photoluminescence was around 1.7μm (≈700meV). The film becomes conductive through ligand exchange reactions, giving a 2μm cut-off.

Separate electrical measurements on the InGaAs and HgTe materials gave ohmic behavior. Hall measurements on the InGaAs resulted in $3000cm^2$/V-s electron mobility. Field-effect analysis of the HgTe NC material showed conduction only by thermally activated holes.

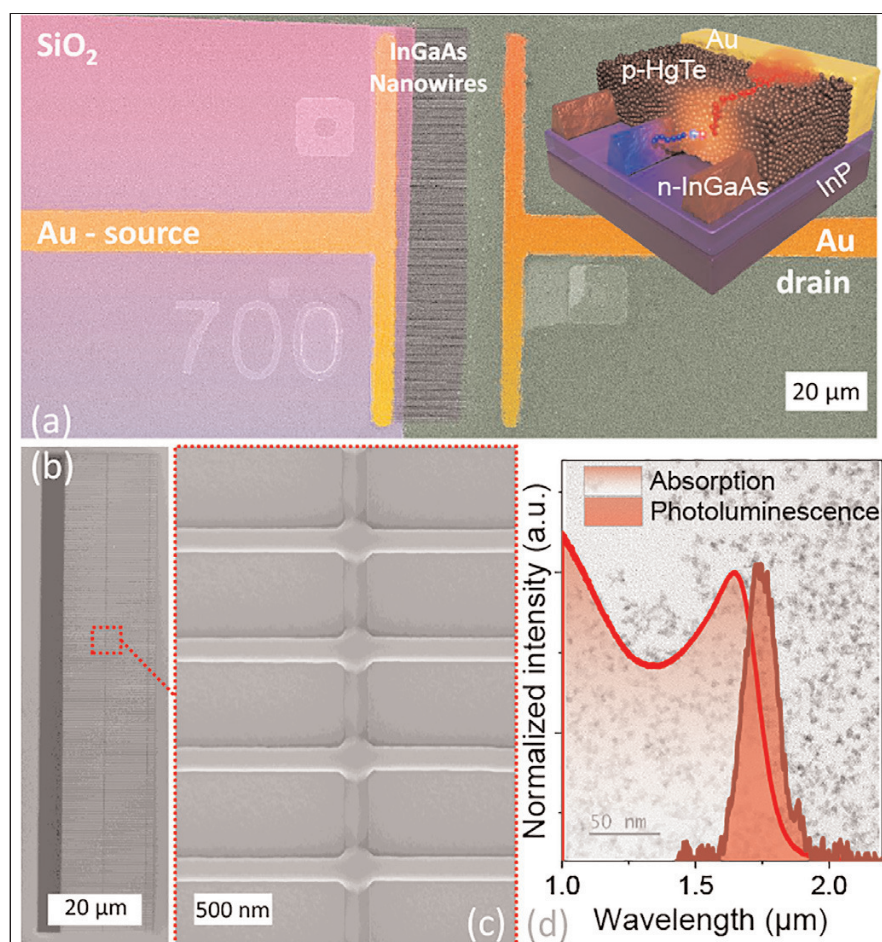

Figure 1. InGaAs wires/HgTe NCs hybrid device. (a) False color microscopy image of patterned nanowires. Right inset: schematic device with HgTe nanocrystal film. (b) Scanning electron microscope image of InGaAs wire array. (c) Zoomed InGaAs wire array image. (d) Normalized absorption and photoluminescence spectra of HgTe nanocrystals. Background: transmission electron microscope image of HgTe nanocrystals.

The activation energy was ≈200meV.

The InGaAs nanowire/HgTe NC film combination gave a diode structure with a strongly rectifying current-voltage characteristic. The activation energy of the charge transport increased to 400meV (down to 200K), suggesting strong reduction of dark current through device cooling.

Under illumination there was no open-circuit voltage (V_{OC}) observed. "This lack of V_{OC} prevents device operation under 0V bias," the team comments.

The researchers attribute the zero V_{OC} to shunt resistance in NCs along the nanowires. "This can come from hole conduction beginning at the interface between the wire and the nanocrystals up to the contact electrode and from a possible recombination of photo-generated carriers when the latter travel along the long n-type wires," they explain.

However, the strong rectification and low dark current allows the reverse bias to reach −4V, in contrast to other diode structures involving HgTe NCs, which are limited to reverse biases smaller than 0.4V, due to a loss of current-voltage asymmetry.

Photocurrent spectroscopy and simulation analyses suggest that the HgTe nanocrystal film accounted for the bulk of the photon absorption. InGaAs nanowires behaved as a unipolar barrier extracting photoelectrons.

The team comments: "This simple strategy expands the spectral response of the InGaAs by 400nm (from 1.6 to 2μm cutoff wavelength)."

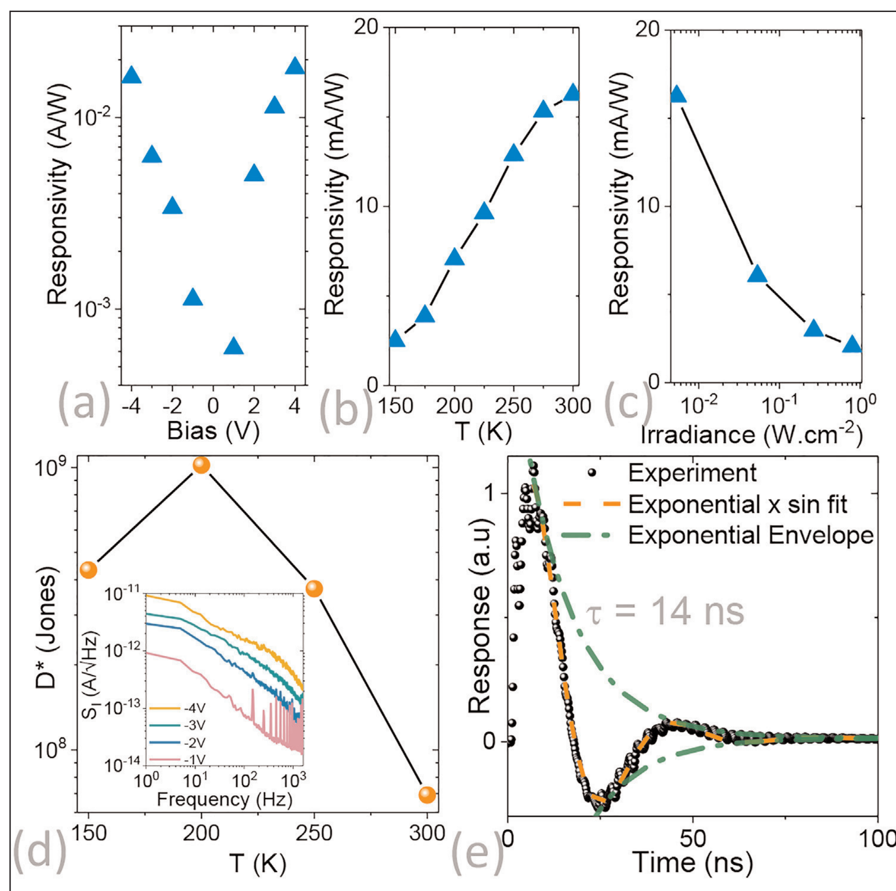

Figure 2. Photodetection performance of hybrid structure. (a) Responsivity at 300K as function of applied bias, under 1.55μm 5mW/cm^2 laser-diode illumination. (b) Responsivity as function of temperature at −4V bias. (c) Responsivity as function illumination power at -4V bias. (d) Specific detectivity at −4V bias as function of operating temperature for 1kHz signal. Inset: noise current spectral density as function of signal frequency with device under various biases. (e) Photocurrent response to 1ns pulse at 1.57μm wavelength. Fit provided by ≈14ns exponentially decaying sine wave, accounting for imperfect impedance matching of device with acquisition oscilloscope.

The infrared response was measured under a variety of biases, temperatures, illumination powers, and modulations (Figure 2). The responsivity at 300K reached 16mA/W at −4V bias. Although the response was only weakly dependent on bias sign, the dark current was minimized with reverse bias, and hence is preferred. Although cooling to 200K reduced the response by a factor of 2, the dark current was reduced by three orders of magnitude.

Charge conduction in the nanocrystal layer is thought to occur by a thermally activated hopping mechanism. The researchers add: "Under illumination, the carrier density is set by the incident photon flux, and thus the temperature dependence of the response is mostly the result of the thermal activation of the carrier mobility."

The noise behavior seems 1/f limited, rather than white (shot and thermal). This suggests that the source is the nanocrystal layer, rather than the InGaAs nanowires. This resulted in a specific detectivity of $7x10^7$Jones at room temperature, and 10^9Jones at 200K (Figure 2d).

Although the detectivity does not reach the level of state-of-the-art diodes based on HgTe nanocrystals, up to 10^{11}Jones at room temperature, the result is comparable to a reported device consisting of HgTe nanocrystals on graphene (10^8–10^9Jones).

The team comments: "Certainly, our approach suffers from the lack of V_{OC} preventing the zero-volt operation. On the other hand, thanks to its planar geometry, that is associated with a weaker capacitance than the vertical geometry diode, fast operation can be achieved."

In fact, the 14ns decay response to 1ns pulses (Figure 2e) is two orders of magnitude lower than reported values for vertical diodes. "In this sense, the weaker signal-to-noise ratio is balanced by a higher device bandwidth," the team comments.

The researchers hope future work will "combine the architecture with gate control and light management to further enhance the signal-to-noise ratio". ■

https://doi.org/10.1063/5.0076708

Author: Mike Cooke

Intermediate anneal therapy for quantum wells

Light-emission enhancement can be achieved for InGaN laser diodes and LEDs by reducing the density of recombination centers.

China' Institute of Semiconductors has used an intermediate annealing process between growing quantum wells (QWs) and barriers to improve the performance of indium gallium nitride (InGaN) laser diodes (LDs) and light-emitting diodes (LEDs) [Feng Liang et al, Optics Express, v30, p3416, 2022].

Although the wavelengths of the reported devices were in the III–nitride violet ~400nm-wavelength comfort zone, it is hoped with development to extend the wavelength range down to near-infrared (~700nm). Already III–nitride light-emitting devices power laser display, laser lighting, laser processing, laser medical treatment, and underwater communication applications. Improving the well/barrier interface by using annealing should enhance luminous efficiency, further increasing the deployment of III–nitride technology.

Table 1. Laser diode electrical characteristics.

Ramp-up (s)	100	600	1000
Threshold current (mA)	325	225	252
Threshold current density (kA/cm^2)	1.8	1.3	1.4
Light output power at 1A (W)	0.51	0.74	0.68
Slope efficiency (W/A)	0.76	0.95	0.91

Table 2. LED well/barrier characteristics from x-ray analysis.

Ramp-up (s)	100	600	1000
Barrier thickness (nm)	11.5	11.7	11.6
Well thickness (nm)	5.44	5.37	5.33
Well In content	6.40%	6.31%	6.28%

The researchers applied a thermal annealing step of several seconds between the InGaN well and GaN barrier metal-organic chemical vapor deposition (MOCVD) growth sequences (Figure 1). The MOCVD process used trimethyl-gallium (TMGa) and trimethyl-indium (TMIn) precursors, along with ammonia (NH_3) for the nitrogen component. The well was capped with GaN before annealing to avoid decomposition and escape of the volatile indium atoms from the InGaN material.

The annealing step consisted of a variable ramp to 880°C, 20-seconds annealing, and 100-seconds ramp-down. The ramp-up time ranged between 100 and 1000 seconds.

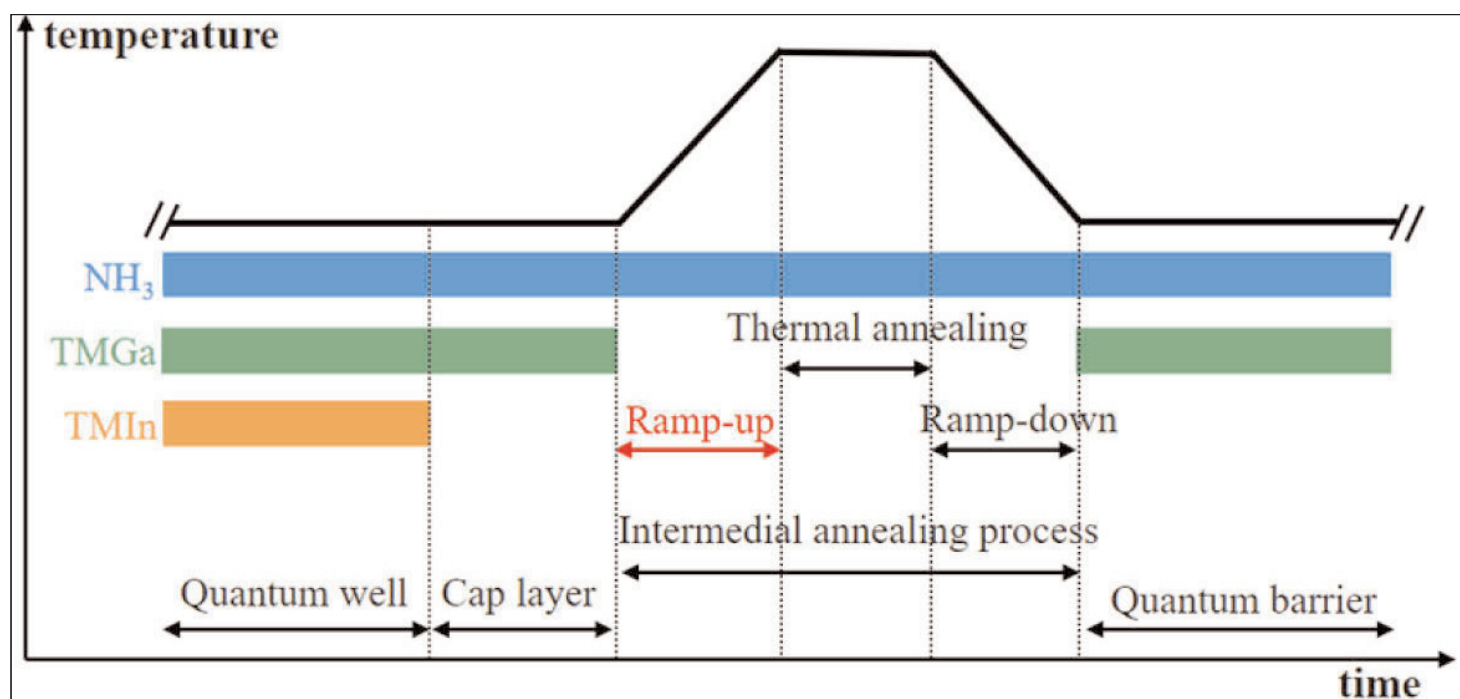

Figure 1. Time-dependent temperature process and gas flow schemes during MQW growth.

The team produced multiple quantum well (MQW) samples for laser diodes and LEDs, and single quantum well (SQW) material for interface characterization. The LED and SQW material was grown on sapphire, while more expensive GaN substrates were used for the laser diode devices. The layer sequence for the LED/SQW material began with undoped GaN buffer, n-type GaN, and MQW/SQW. The LED samples were completed with a p-GaN contact layer, and the SQWs with a GaN cap.

The laser diodes required a more complex structure: n-type cladding, lower waveguide, MQW (2 wells), upper waveguide, electron blocking, p-cladding, and p-GaN contact. This material was fabricated into 1200μmx15μm-long ridge-waveguide laser diodes with titanium/platinum/gold and palladium/platinum/gold bottom and top n-/p-electrodes, respectively. The front and back facets of the laser diode were coated to give 10% and 90% reflectivity, respectively.

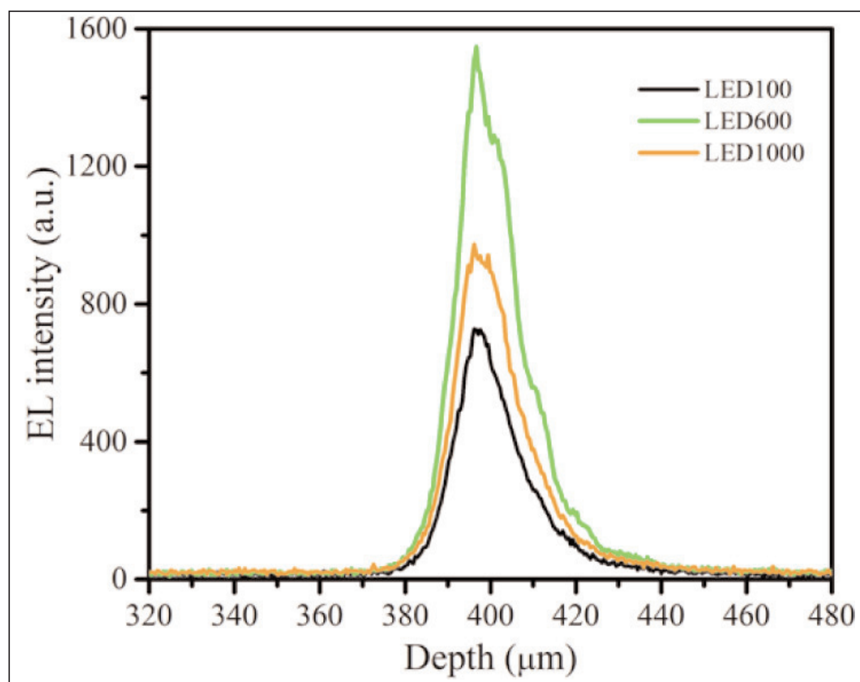

Figure 2. Electroluminescence spectra of 100 (LED100), 600 and 1000-second ramp LEDs under 100mA forward direct-current.

The threshold for lasing depended on ramp-up time with the values for devices with 100-, 600- and 1000-second ramps of 325, 225 and 252mA, respectively. Further investigations (Table 1) confirmed the superior performance of the 600-second ramp-up regimen with the light output power reaching 0.74W at 1A injection. The researchers believe that the annealing between wells enables atoms to rearrange into a more thermodynamically stable state through inward diffusion and surface desorption. However, if the ramp-up is too long, the material degrades, creating recombination centers that sap conversion of the electrical input power into light.

Structural characteristics of the MQW were derived on the LED samples using x-ray diffraction (XRD) analysis (Table 2). It was found that the longer ramp-up times reduced both the indium content and thickness of the wells. This is a not too surprising result since the longer exposure to raised temperature would be expected to increase indium desorption. The impact on the LED emission wavelength was minimal with all devices showing a peak at ~399nm in the violet range. Again, the 600-second ramp-up resulted in the most intense light output for a given injection current (Figure 2).

Temperature-dependent photoluminescence studies of the LED material suggested the presence of two types of recombination center: one with a low activation energy (14–15meV), and the other with a high activation energy (112–127meV). The ramp-up process seemed to have little effect on the low-energy recombination center type, but the 600-second ramp showed an increased activation energy (127meV) and reduced coupling coefficient, suggesting reduced density, for the higher energy center. Increasing the activation energy also reduces its impact for a given temperature. The 100-second and 1000-second ramps resulted in activation energies for these centers at 112 meV and 116meV, respectively.

The SQW samples were used for atomic force microscopy (AFM) inspection. The 100-, 600- and 1000-second ramp samples were found to have root-mean-square (rms) surface roughness values of 0.43, 0.31 and 0.37nm, respectively. ■

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Author: Mike Cooke

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Reliable 0.25µm GaN HEMTs for X-band applications

A sunken source-connected field-plate boosts the reliability, voltage rating and output power of gallium nitride high-electron-mobility transistors, says Wolfspeed.

US-based Wolfspeed has reported improved reliability, voltage rating, and output power of 0.25µm-gate gallium nitride (GaN) high-electron-mobility transistors (HEMTs) from implementing a sunken source-connected field-plate (FP) [Kyle M. Bothe et al, IEEE Electron Device Letters, volume 43, issue 3 (March 2022), p354].

The estimated mean time to failure (MTTF) of Wolfspeed's new sunken FP design (Figure 1) was $6x10^7$ hours at 225°C junction temperature, beating the performance of previous reports, while maintaining a high output power density. The device is aimed at X-band 8.0–12.0GHz microwave applications such as high-power wide-band radar and communications.

Field plates are used to reduce the peak electric field for a given bias condition, enabling higher breakdown voltages to be achieved. Hence the drain bias (V_D) rating can be increased, allowing higher saturated output powers (Psat) to be reached. Further benefits were increased linear gain and power-added efficiency (PAE).

The researchers comment: "Positioning the sunken field plate closer to the channel enhances the Faraday shielding effect to block the parasitic fields connection between the gate and drain. Furthermore, the trapping of the device was improved by optimizing the trench etch chemistry and resulting trench profile."

Wolfspeed used its own 0.25µm HEMT foundry to fabricate the devices, including layers for passive devices aimed at monolithic microwave integrated circuit (MMIC) production. The metal-organic chemical vapor deposition (MOCVD) of GaN and aluminium gallium nitride (AlGaN) on silicon carbide (SiC) was optimized for 10GHz performance with a view to reliable and

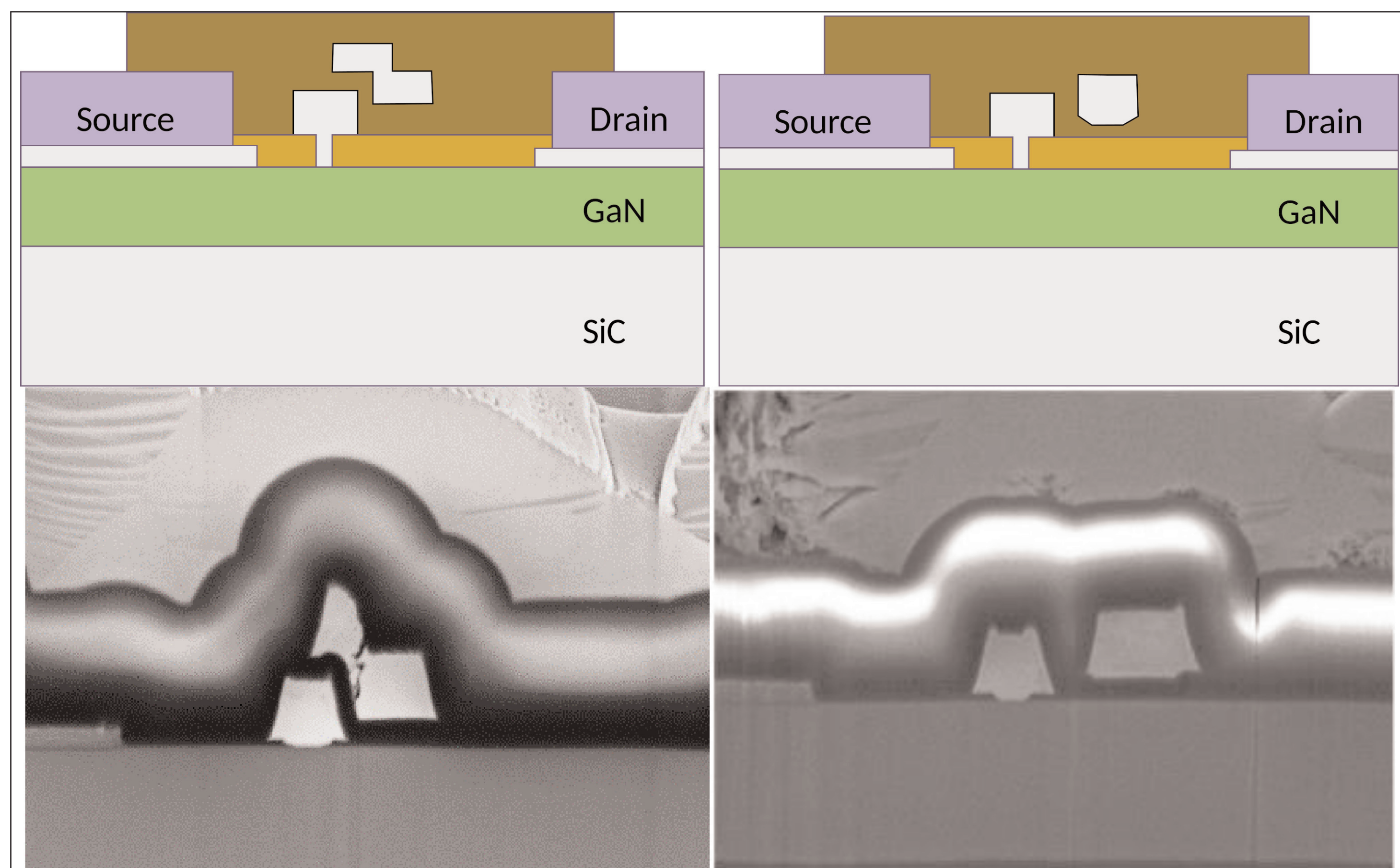

Figure 1. Schematic and fabricated cross sections of (a) standard field-plated GaN HEMT and (b) novel sunken source-connected field-plated HEMT.

robust high-volume manufacturing. The 1.4μm insulating iron-doped GaN buffer was grown on an AlN nucleation layer. The AlN barrier layer was less than 2nm. The material was capped off with 18nm AlGaN.

The researchers comment: "The thickness of the AlGaN cap was chosen to ensure that the gate-length to barrier ratio maintained the correct aspect ratio to minimize short-channel effects." The thick AlGaN cap also blocked gate leakage current, removing the need for a conventional GaN cap layer.

The material structure resulted in a two-dimensional electron gas (2DEG) under the barrier layer with a $1.2 \times 10^{13}/cm^2$ electron density and $2000cm^2/V\text{-}s$ mobility, resulting in a sheet resistance of ~270Ω/square.

The device fabrication used a gold-free alloy for the recessed source/drain electrodes. Recessing avoids the need for GaN regrowth and results in a low-profile height contact.

The gate fabrication process used silicon nitride passivation. A shrink method developed by Wolfspeed was implemented to enable the 365nm-wavelength i-line lithography to achieve the 0.25μm gate length. The gate was placed off-center in the 4.5μm gap between the source/drain electrodes.

The field plates were added after the gate, also using i-line lithography. The 0.95μm sunken field plate was offset by 0.15μm from the T-gate edge. The relatively large size of the field plate minimized the gate–drain capacitance (C_{gd}), fully covering the gate–drain trench, at the cost of a slight increase in drain–source capacitance (C_{ds}). Devices with a conventional 0.8μm field plate, overlapping the gate by more than 2μm, were fabricated on the same wafer, allowing fair comparison with respect to process variations.

The devices were thinned to 100μm and connections made through backside slot vias before testing (Table 1). Improved trapping and radio frequency performance was indicated in comparisons between DC and pulsed operation with the drain current reduction of 23% for the standard FP decreasing to 18% for the sunken FP. The new sunken FP structure also resulted in better, generally lower, parasitic capacitances and higher breakdown voltage (V_{BD}).

RF accelerated life tests at 3.5GHz were carried out on devices with 3.6mm periphery. The temperature was raised during testing to give three junction temperatures in the 360–425°C range. The quiescent drain current was 200mA. The input power was 29dBm. The lifetime was determined by catastrophic failure or a 1dB reduction in Psat. Using an Arrhenius temperature-accelerated lifetime model, the researchers estimate a more than 6×10^7 hour lifetime at 225°C junction temperature. "This is a more than two orders of magnitude increase over the conventional field-plate design," the team points out.

The sunken FP design enables Wolfspeed to both beat existing mean-time-to-failure estimates of previous reports on 0.25μm GaN HEMTs while maintaining power density (Figure 2).■

https://doi.org/10.1109/LED.2022.3146194

www.wolfspeed.com/

Author: Mike Cooke

Table 1. Comparison of HEMT performances.

Parameter	Units	Standard FP	Sunken FP
R_{on}	Ω-mm	2.3	2.3
g_m	mS/mm	370	370
V_p	V	−2.8	−2.8
V_{BD}	V	>120	>150
C_{gs}	pF	1.36	1.15
C_{gd}	fF	34	14
C_{ds}	fF	200	230
Gain	dB	17	19
PAE	%	57	64
P_{sat}	W/mm	7.8	10.6
V_D rating	V	40	50
Lifetime (225°C)	hours	< 1E6	> 6E7

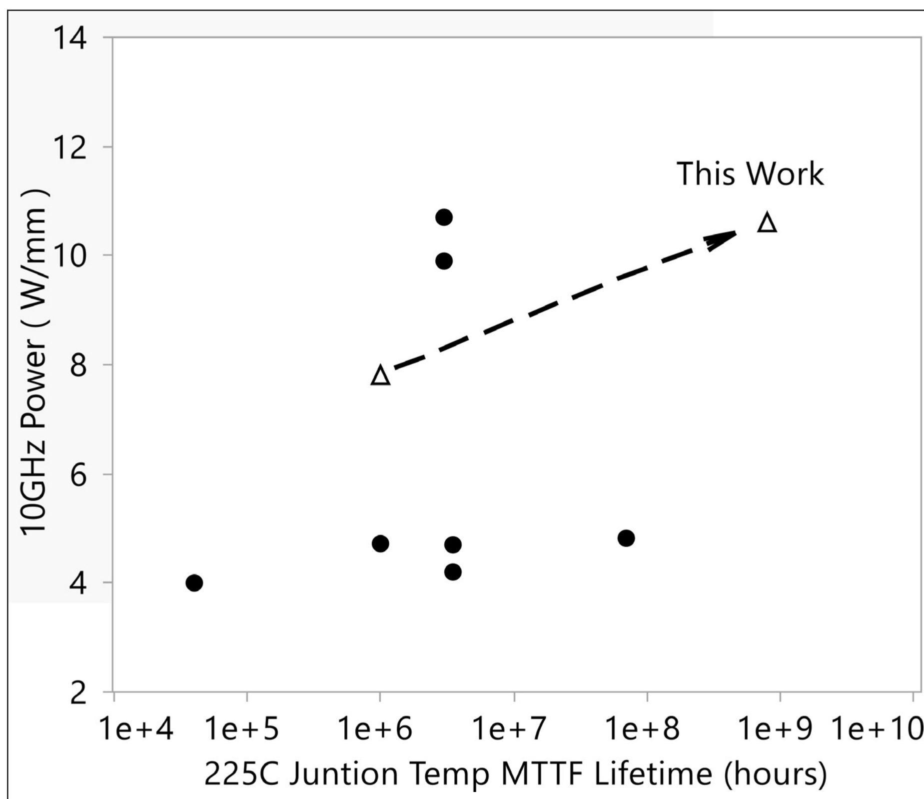

Figure 2. Comparison of leading 10GHz RF power 0.25μm GaN HEMTs with respect to MTTF device lifetime.

Sandia reports GaN diode with record 6.4kV breakdown

The target is 20kV, to protect the electric grid from electromagnetic pulses.

Sandia National Laboratories has fabricated and tested a gallium nitride (GaN)-based electronic device that can shunt excess electricity within a few billionths of a second while operating at a record 6400V — a step towards protecting the electric grid from an electromagnetic pulse (Yates et al, 'Demonstration of >6.0-kV Breakdown Voltage in Large Area Vertical GaN p-n Diodes With Step-Etched Junction Termination Extensions', IEEE Transactions on Electron Devices; DOI: 10.1109/TED.2022.3154665). The team's ultimate goal is to provide protection from voltage surges, which could lead to months-long power interruptions, with a device that operates at up to 20,000V.

An electromagnetic pulse (EMP) can be caused by natural phenomena (such as solar flares) or human activity (such as a nuclear detonation in the atmosphere). An EMP causes huge voltages in a few billionths of a second, potentially affecting and damaging electronic devices over a large area.

Close-up of Sandia's array of GaN diodes — a step on the path to protecting the electrical grid from EMPs. (Photo by Rebecca Gustaf).

EMPs are unlikely, but if one were to occur and damage the huge transformers that form the backbone of the USA's electric grid, it could take months to replace them and re-establish power to the affected portion of the nation, says Bob Kaplar, manager of a semiconductor device research group at Sandia.

"The reason why these devices are relevant to protecting the grid from an EMP is not just that they can get to high voltage — other devices can get to high voltage — but that they can respond in a couple billionths of a second. "While the device is protecting the grid from an EMP, it's at a very high voltage and thousands of amps are going through it, which is a huge amount of power. A material can only handle so much power for a certain amount of time, but we think the material in our diode has some advantages over other materials."

Regulator valve for the grid

The new diode can shunt a record 6400V of electricity within a few billionths of a second but the team, including Sandia electrical engineer Luke Yates (the paper's first author), is working towards fabricating a diode able to operate at about 20,000V, since most grid distribution electronics operate at around 13,000V.

The voltage surges caused by EMPs are a hundred times faster than those caused by lightning, so experts don't know if the devices designed to protect the grid against lightning strikes would be effective against an EMP, says Jack Flicker, a Sandia electric grid resiliency expert on the team.

"The electric grid has a number of different protections," Flicker adds. "They range in timeframe from very fast to very slow, and they're overlaid on the electric grid to ensure that an event cannot cause a catastrophic outage of the electric grid. The fastest protection that we typically have on the grid reacts against pulses at one millionth of a second, to protect against lightning. For EMPs, we're talking ten billionths of a second, a hundred times faster." The new Sandia device can react that quickly.

Growing perfect layers

"A major challenge of achieving these very high-voltage diodes is the need to have very thick gallium nitride layers. The drift regions of these devices have thicknesses of about 50μm," Crawford says. "The growth

process we use can have growth rates of only one or two microns per hour," he adds. "A second major challenge is maintaining very low densities of crystalline defects, specifically impurities or missing atoms in the semiconductor material, throughout the growth time in order to generate devices that work at these very high voltages."

For the team to reach their ultimate goal of a device that operates at 20,000V, they will need to grow the layer even thicker with even fewer defects, Crawford notes. There are several other technical challenges to constructing a device that can operate at such high voltages and currents, she added, including designs to manage the very high internal electric fields within the devices.

Testing ultrafast diodes

After Crawford's team fabricated the devices, Flicker and his team tested how the devices responded to fast voltage spikes, similar to what would occur during an EMP. His challenge has been modifying a tool to measure the very fast response time of the devices.

"Developing the tools that can accurately measure the very fast responses is very difficult," Flicker says. "If we're talking one or two billionths of a second, they need to be able to measure even faster than that, which is a challenge."

Flicker and his team used very specialized equipment to apply a high-voltage pulse, and measure the electric pulse that is reflected back from the diode to tell when the device turns on, very accurately and in less than a billionth of a second.

Useful for smart transformers, solar panel converters and more

Devices like Sandia's GaN diode can be used for other purposes, beyond protecting the grid from EMPs, Kaplar says. These include smart transformers for the grid, electronic devices to convert electricity from roof-top solar panels into power that can be used by household appliances, and even electric car charging infrastructure.

Commonly, solar panel converters and electric car charging infrastructure can handle 1200V or 1700V. But operating at higher voltage allows for higher efficiencies and lower electricity losses.

Another portion of the project is to develop diodes for these types of devices that operate at high but not record-breaking voltage, but are easier to manufacture, Kaplar says. The Naval Research Laboratory is leading this part of the project.

Some smart transformers and electronic devices can now operate at up to 3300V, Flicker says, but efficiencies would be even greater if they could operate at 10,000V or 15,000V with one semiconductor device.

"We have this primary goal of protection of the electrical grid, but these devices have other uses beyond that," Flicker notes. "It's interesting to have our application area but know that these devices can be used in power electronics, power converters, everything that's at very high voltages."

The research is funded by ARPA-E and the larger project is in partnership with the Naval Research Laboratory, Stanford University, National Institute of Standards and Technology, EDYNX and Sonrisa Research. ■

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NiO/Ga_2O_3 heterojunction power electronics devices

Researchers claim the highest Baliga figure of merit for high breakdown voltage balanced against on-resistance.

Hebei Semiconductor Research Institute and Nanjing University in China claim the highest Baliga figure of merit (FOM) achieved so far among all reported β-gallium oxide (Ga_2O_3) diodes [Yuangang Wang et al, IEEE Transactions on Power Electronics, v37, p3743, 2022].

The 5.18GW/cm^2 FOM comes in at about 15% of the theoretical limit for Ga_2O_3 of 34GW/cm^2, based on material properties. The device also surpassed reported silicon carbide (SiC) limits for diodes for the first time. The theoretical limit for SiC is 3.35GW/cm^2, calculated by the team, based on the references ([1] B. J. Baliga, Wide Bandgap Semiconductor Power Devices, Woodhead Publishing, 2019, p4; [2] Masataka Higashiwaki et al, Gallium Oxide Materials Properties, Crystal Growth, and Devices, Springer, 2020, p8).

The ultra-wide bandgap of Ga_2O_3 leads to expectations of a very high critical field for breakdown. Ga_2O_3 also has prospects arising from lower potential production costs, along with commercial availability of Ga_2O_3 in substrate form.

The devices (Figure 1) used a pn heterojunction structure of a thin p-type nickel oxide (p-NiO) layer on n-type Ga_2O_3. In addition, a junction termination extension (JTE) and a small-angle beveled field-plate (BFP) were used to control electric field crowding effects. Such structures reduce the peak field and allow higher breakdown voltages to be reached.

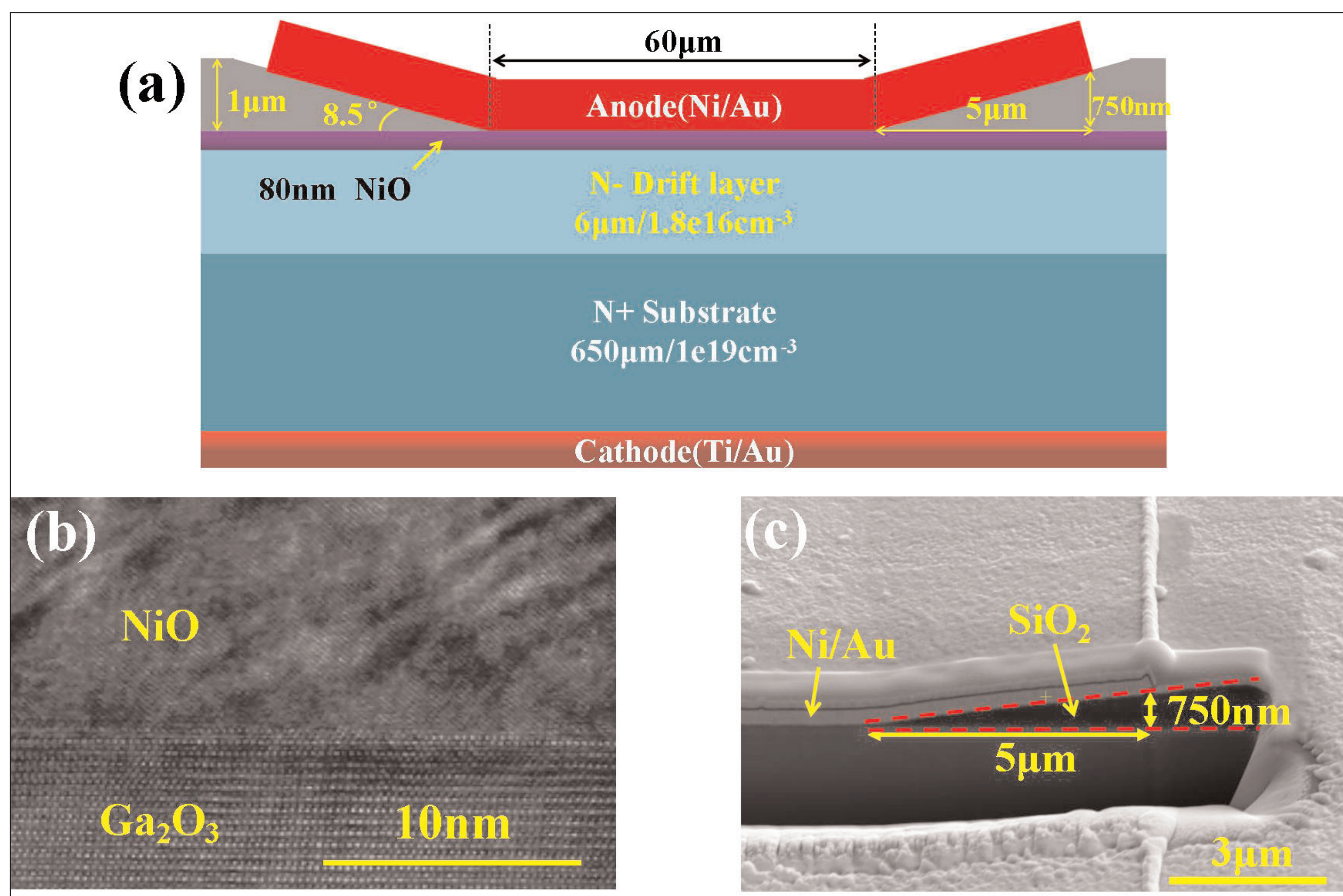

Figure 1. Schematic cross-section of (a) NiO/Ga_2O_3 HJD with JTE and small-angle BFP, (b) cross-sectional high-resolution transmission electron microscope images of NiO/Ga_2O_3 interface, and (c) cross-sectional scanning electron microscope images of BFP structure.

The Baliga FOM represents the leading trade-off between breakdown voltage and specific on resistance in the combination $V_{br}^2/R_{on,sp}$.

The drift layer of the device was grown on heavily n-type Ga_2O_3 substrate using halide vapor phase epitaxy (HVPE). The electron concentration from tin doping of the substrate was $1x10^{19}/cm^3$. The 6μm drift layer had a much lower electron concentration of $1.8x10^{16}/cm^3$.

The 80nm polycrystalline NiO layer was applied by 150W radio frequency (RF) magnetron sputtering in argon/oxygen atmosphere at room temperature. Hall measurements showed the layer to be p-type with a hole concentration of $2.5x10^{18}/cm^3$ with $0.53cm^2/V$-s mobility. The NiO layer was covered with silicon dioxide (SiO_2) from plasma-enhanced chemical vapor deposition (PECVD).

The beveled field-plate was formed from variable-temperature (90–145°C) photoresist reflow and inductively coupled plasma etch of the SiO_2 layer. The bevel angle was about 8.5°.

The back ohmic contact came from electron-beam evaporation and rapid thermal annealing (RTA) in nitrogen of titanium/gold (Ti/Au). The Ni/Au anode was formed in a lift-off process. The field-plate was around 5μm thick. The anode area was 60μmx60μm.

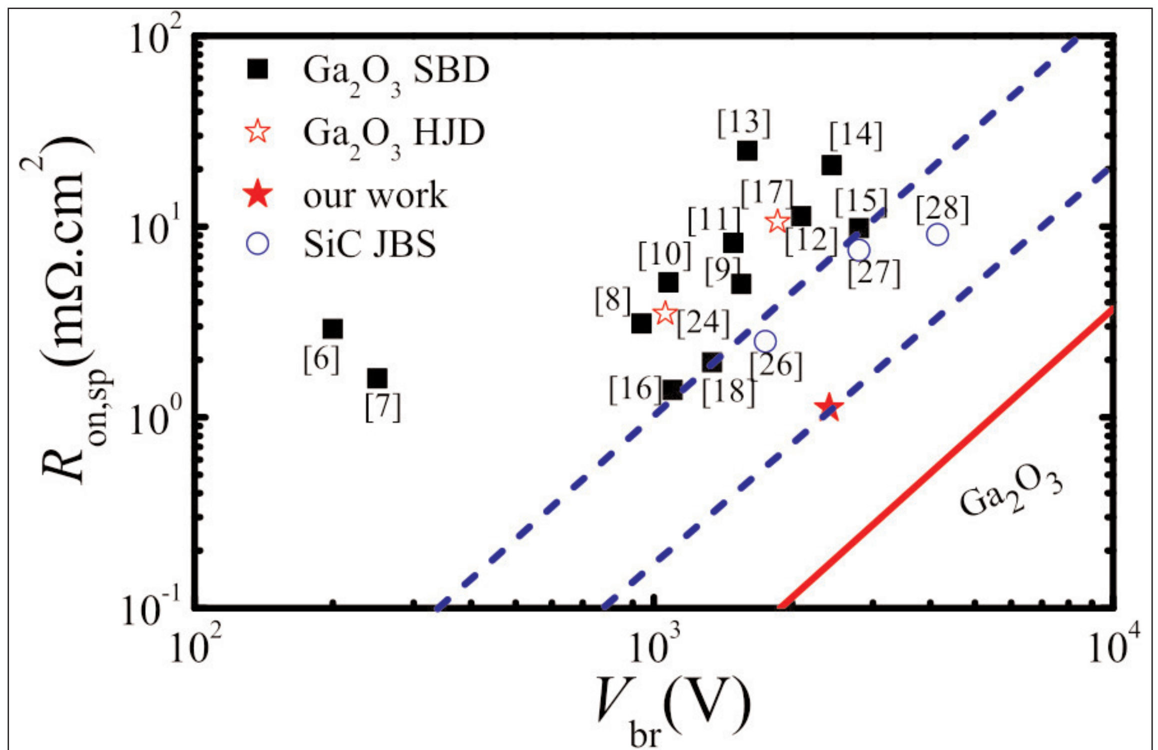

Figure 2. Plot of Ron,sp versus V_{br} for reported vertical β-Ga_2O_3 and SiC diodes. Red solid star represents Hebei/Nanjing record. Diagonal lines represent equal Baliga figures of merit, including the Ga_2O_3 theoretical limit.

The researchers are still working on challenges for the delivery of large-size devices with controllable performance and robust reliability. These challenges concern the uniformity of the Ga_2O_3 epitaxial wafer and sputtered NiO layer, especially in terms of thickness, concentration, and defect density.

Despite the challenges, the Baliga figure of merit of the JTE/BFP HJD reached a record $5.18GW/cm^2$

The researchers also produced Ga_2O_3Shottky barrier diodes (SBDs) and heterojunction diodes (HJDs) without JTE and/or beveled field-plate.

The SBD had the lowest $R_{on,sp}$ of $1.09mΩ\text{-}cm^2$, while it was $1.23mΩ\text{-}cm^2$ for an HJD without junction termination extension or beveled field-plate. The JTE and BFP reduced $R_{on,sp}$ for HJDs to $1.12mΩ\text{-}cm^2$. The turn-on voltage of the HJDs was around 1.6V (giving $1A/cm^2$ current density), higher than for the SBD. Also, the ideality of the HJDs was higher at 1.38/1.20 without/with JTE and BFP, compared with 1.08 for the Schottky barrier diode.

Although the SBD seems preferable so far, the HJD, with its higher barrier and deeper depletion junction depth, is likely to be more resilient under ultra-high voltage stress. Without JTE/BFP the reverse-bias breakdown for the HJD came in at 955V, relative to 460V for SBDs. Adding a JTE increases this to 1945V. The full JTE/BFP package gave a further boost to 2410V.

The researchers are still working on challenges for the delivery of large-size devices with controllable performance and robust reliability. These challenges concern the uniformity of the Ga_2O_3 epitaxial wafer and sputtered NiO layer, especially in terms of thickness, concentration, and defect density.

Despite the challenges, the Baliga figure of merit of the JTE/BFP HJD reached a record $5.18GW/cm^2$ (Figure 2). ■

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Author: Mike Cooke

Boosting transconductance and squeezing off-current

Taiwan's National Yang Ming Chiao Tung University claims transconductance among the highest for InGaAs FinFETs so far.

National Yang Ming Chiao Tung University in Taiwan has reported increased transconductance (g_m) and reduced OFF-current (I_{OFF}) for indium gallium arsenide (InGaAs) fin field-effect transistors (FinFETs) from remote nitrogen plasma passivation of the gate insulation layers [Hua-Lun Ko et al, IEEE Transactions on Electron Devices, volume 69, issue 2 (February 2022), p495].

The devices were fabricated from n^+-InGaAs on heavily p-type indium phosphide (p^+-InP). The source/drain regions were doped with silicon implantation and activation annealing. The fins were etched with plasma, followed by citric acid sidewall smoothing and fin-width shrinking. The fins were oriented in the (010) crystal direction to give the highest aspect ratio.

The gate insulators consisted of 0.8nm aluminium nitride and 2.9nm hafnium dioxide, both applied using atomic layer deposition (5 cycles and 30 cycles, respectively). The insulation was treated with nitrogen (N_2) remote plasma (RP) in-situ to fill oxygen vacancies in the high-k materials. This reduced the OFF-current density in all devices to less than $5x10^{-4}$μA/μm. Further, the team comments: "Additionally, trap-assisted tunneling (TAT) and Frenkel–Poole emission are greatly inhibited by N_2 RP passivation."

The researchers estimate that the equivalent oxide thickness of these high-k layers is 0.8nm.

The devices were completed by annealing at 450°C in forming gas (hydrogen/nitrogen mix), gate metal deposition, ohmic source/drain metalization, and post-metalization annealing.

The resulting devices demonstrated high ON-current and peak transconductance (Figure 2). "The devices

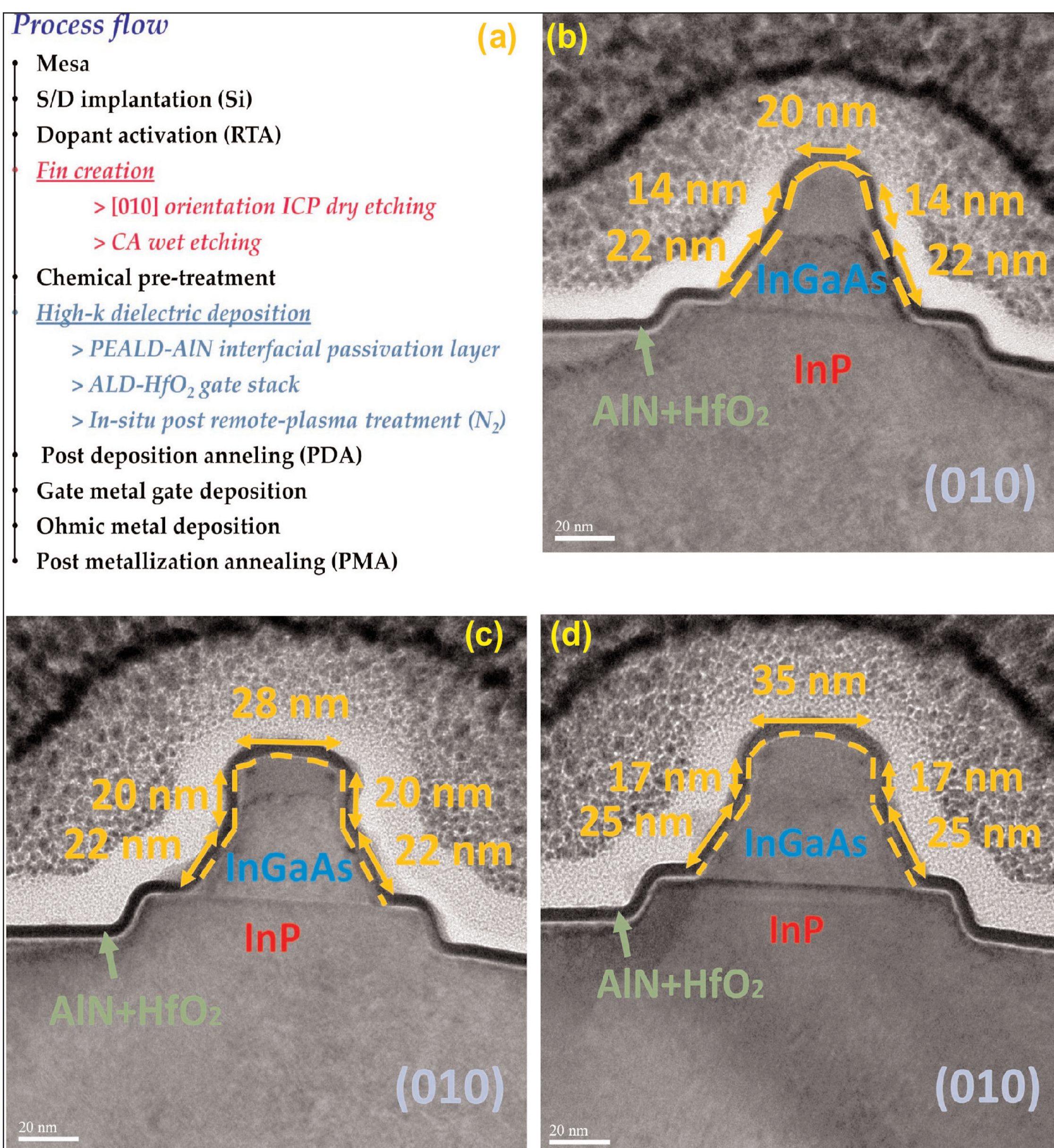

Figure 1. (a) FinFET fabrication. Cross-sectional high-resolution transmission electron microscope images of fins of width 20nm, (c) 28nm and (d) 35nm.

fabricated in this work showed highest g_m of 2727μS/μm, highest I_{ON} of 835μA/μm, high Q-factor (Q = g_m/SS_{sat}) of 22.3, high I_{ON}/I_{OFF} current ratio of $3x10^5$, and low OFF-current of $4.5x10^{-4}$μA/μm for Lch = 45nm and W_{fin} = 35nm N_2-passivated $In_{0.53}Ga_{0.47}As$ FinFETs," the team reports.

At 0.5V drain bias (V_{DS}), the sub-threshold swing (SS) was as low as 78mV/dec, and drain-induced barrier lowering (DIBL) was 55mV/V. Reducing the drain bias to 0.05V allowed even lower OFF-currents of $1.13x10^{-4}$μA/μm. ■

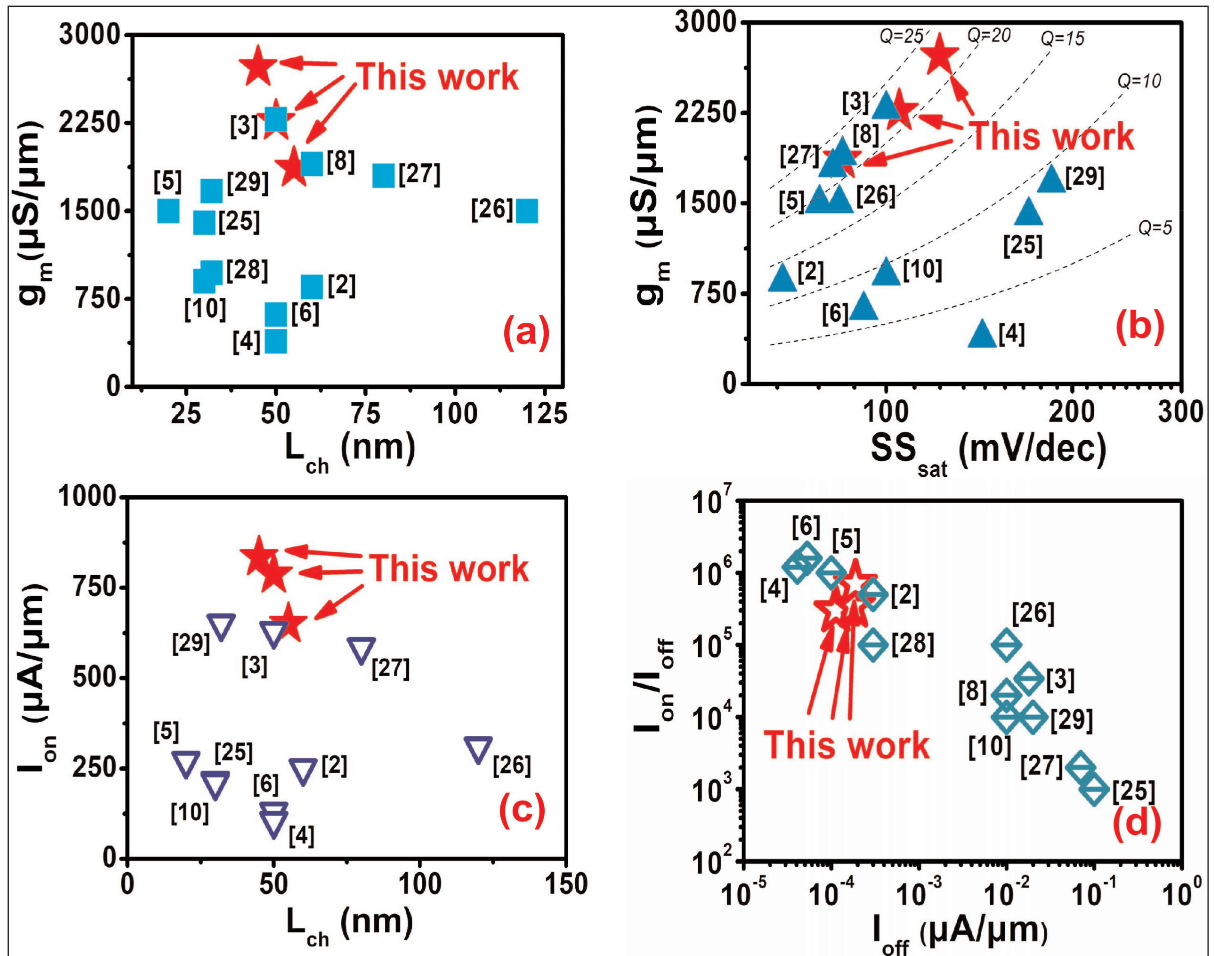

Figure 2. Benchmark plots of (a) peak gm versus channel length (L_{ch}), (b) peak g_m versus subthreshold swing (SS) in saturation regime, (c) I_{ON} at $V_{GS}-V_{th}$ = 0.5V and V_{DS} = 0.5V versus L_{ch}, and (d) I_{ON}/I_{OFF} ratio versus OFF-current. Data compared with other state-of-the-art $In_{0.53}Ga_{0.47}As$ FinFET devices.

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Pushing indium phosphide DHBT frequency to 1.2THz

Researchers claim a record maximum oscillation frequency x breakdown voltage product for any type of transistor.

Switzerland's ETH Zürich claims a record 1.2THz maximum oscillation frequency (f_{MAX}) for a 0.25μmx0.44μm double-heterojunction bipolar transistor (DHBT) [Akshay M. Arabhavi et al, IEEE Transactions on Electron Devices, vol69, issue 4 (April 2022), p2122] (see Figure 1). The materials used were a combination of indium phosphide (InP), gallium indium arsenide (GaInAs) and gallium arsenide antimonide (GaAsSb) with a staggered 'type-II' band alignment. This alleviates electron-blocking effects at the base–collector hetero-junction.

The product of f_{MAX} and open-base common-emitter breakdown voltage (BV_{CEO}) of 6.48THz-V is also claimed to be the highest reported for any type of transistor. Even making the geometric average (square root of product) of f_{MAX} with the 475GHz cut-off (f_T) gives a InP DHBT record product with BV_{CEO}) of over 4THz-V. Gallium nitride high-electron-mobility transistors offer 4.9THz-V with a relaxed definition for breakdown voltage.

According to the team, these achievements result from:

- a tunable base–emitter access distance down to 10nm;
- the use of thicker base contact metals;

(continued overleaf)

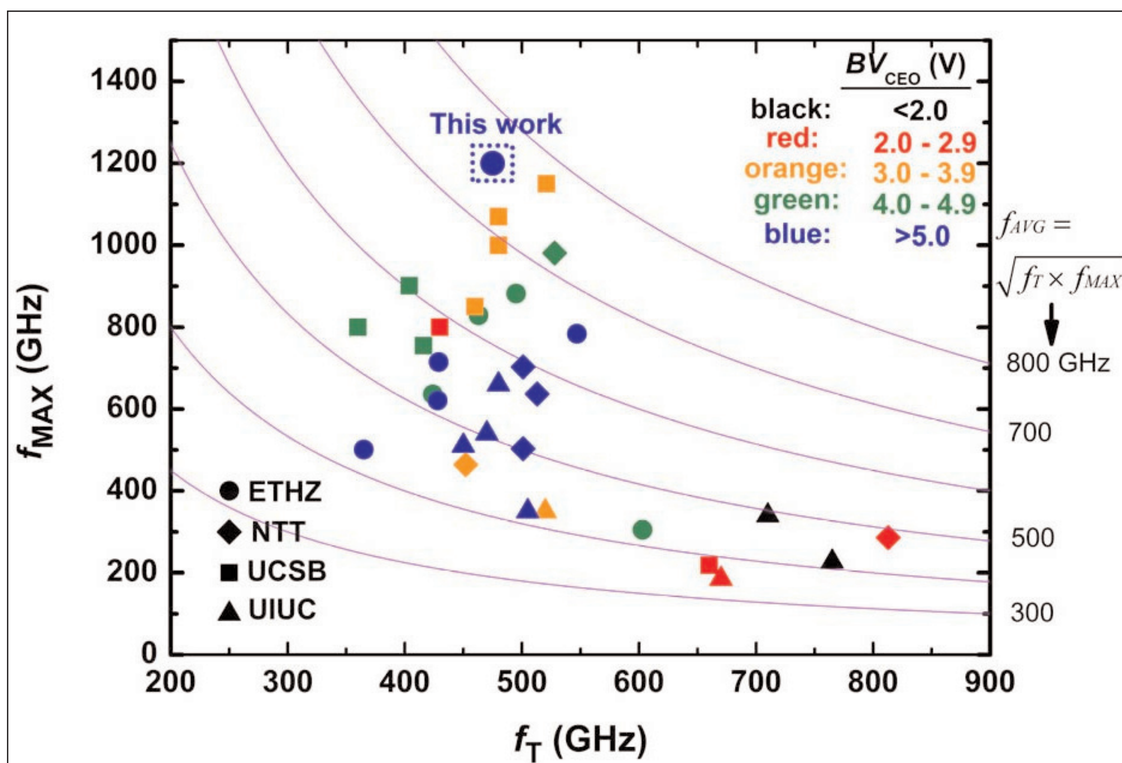

Figure 1. Survey of reported InP DHBT metrics. Breakdown voltages are color-coded.

Material	Doping (/cm^3)	Thickness
$Ga_{0.47}In_{0.53}As \rightarrow Ga_{0.25}In_{0.75}As$	Si: 3 9x10^{19}	10nm
InP	Si: 4x10^{19}	20nm
InP	Si: 2.2x10^{16}	5nm
$Ga_{0.22}In_{0.78}P \rightarrow InP$	Si: 2.2x10^{16}	10nm
$Ga_{0.22}In_{0.78}P$	Si: 2.2x10^{16}	5nm
$GaAs_{0.42}Sb_{0.58} \rightarrow GaAs_{0.61}Sb_{0.39}$	C: 8.5x10^{19}	20nm
InP	Si: 1.0x10^{17}	125nm
InP	S: 2 9x10 ^{19}	50nm
$Ga_{0.47}In_{0.53}As$	Si: 4.0x10^{19}	20nm
InP	2 9x10^{19}	300nm
InP semi-insulating substrate		350μm

Figure 2. Semiconductor material structure.

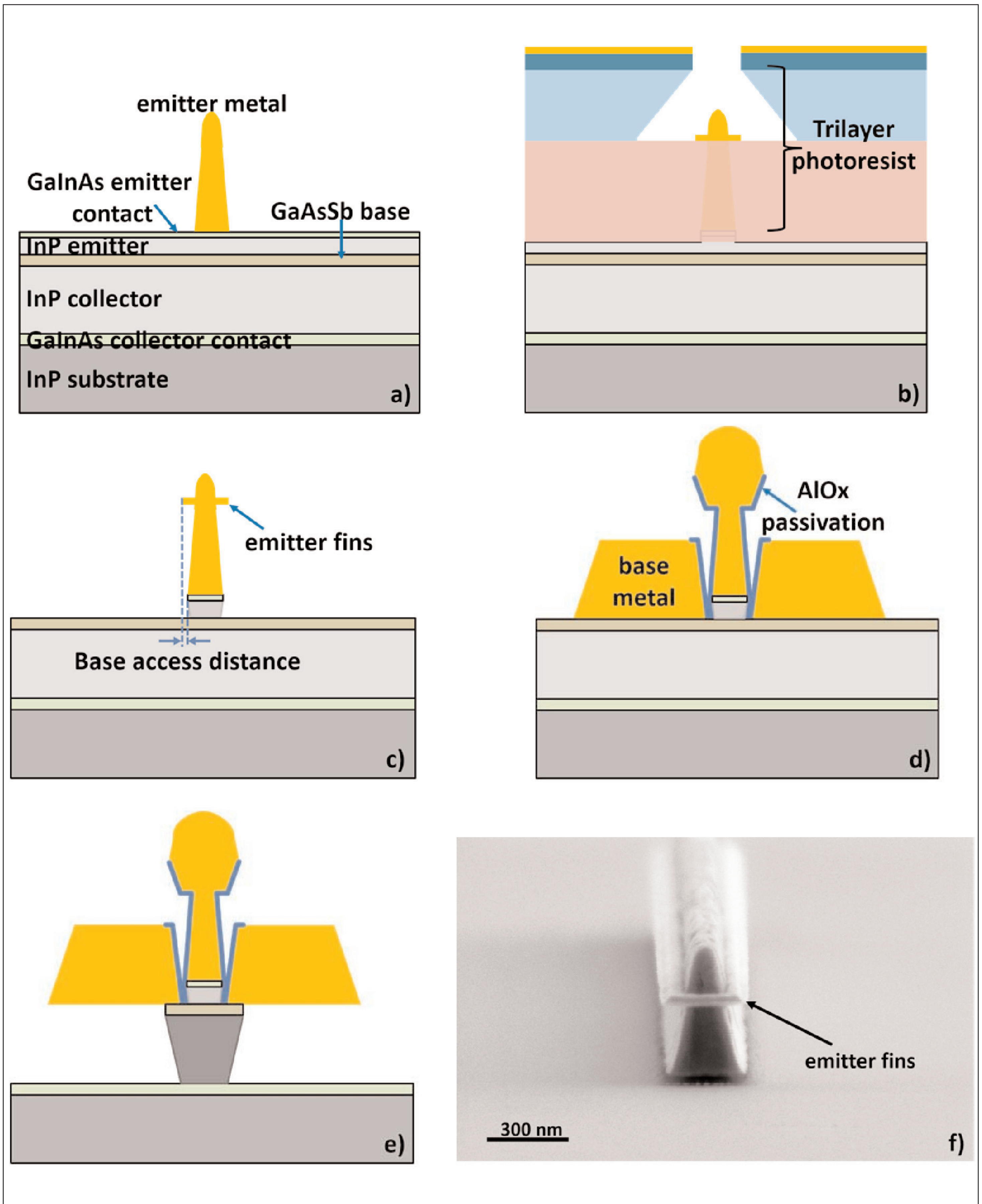

Figure 3. Simplified schematic view of key emitter fin fabrication steps: (a) emitter metal; (b) emitter fin formation using trilayer photoresist; (c) emitter mesa showing the base access distance; (d) self-aligned base contacts and AlO_x passivation; and (e) narrow base–collector mesa. Schematics not to scale. (f) Scanning electron micrograph of emitter after mesa formation.

- minimization of parasitic capacitances and resistances via precise lateral wet etching of the base–collector (B/C) mesa.

The researchers comment: "The present scaling breakthrough, with the availability of THz transistors with larger junction areas capable of operation under high input drive and higher collector voltages, opens opportunities for the generation of significant signal power at mm-wave and sub-mm wave frequencies."

The team sees oscillators and power amplifiers at these high frequencies as being more dependent on high f_{MAX} rather than f_T. The researchers also see the maintenance of high terahertz frequency performance to devices of 1.645μm^2 area, more than 6x larger than previously reported THz InP DHBTs, as being an important achievement.

The epitaxial semiconductor material (Figure 2) was prepared using metal-organic vapor-phase epitaxy (MOVPE) on 2-inch InP substrate. The gallium indium arsenide emitter layer was graded ($Ga_{0.47}In_{0.53}As \longrightarrow G_{a0.25}In_{0.75}As$) to eliminate the conduction-band offset at the emitter–base (E/B) interface. The gallium arsenide antimonide base layer was also ramped ($GaAs_{0.42}Sb_{0.58} \longrightarrow GaAs_{0.61}Sb_{0.39}$), along with the doping concentration.

Device fabrication began with forming the titanium/platinum/gold emitter electrode (Figure 3). Argon sputtering was used to etch the GaInAs emitter contact layer, while also smoothing the emitter electrode. Horizontal fins were added to the emitter electrode in processes involving a tri-layer photoresist, electron-beam lithography, and electron-beam evaporation and lift-off of the fin metal. The fins set the base access distance in a self-aligning manner.

The emitter mesa was formed by phosphoric acid etch. The base region was then defined with electron-beam lithography, followed by electron-beam evaporation of palladium/nickel/platinum/gold. The fins allow a reduced base access distance to be combined with a thicker base metal layer (~50%) without shorting between the emitter/base contacts, reducing contact resistance. The surfaces of the base and emitter structures were then passivated with atomic layer deposition (ALD) of aluminium oxide (AlO_x).

A sequence of dry and wet etches were used to give an undercut collector mesa with an effective base–collector contact width of 40nm. This distance ensures that "only a transfer length equivalent of base material remains under the base metal contact," the team comments.

The device was planarized using a Teflon-based process and completed with electron-beam evaporated coplanar probe pads.

The open-base common-emitter breakdown voltage BV_{CEO} was 5.4V at a collector current density of 1kA/cm^2. Single-pole extrapolations from Mason's unilateral power gain and common-emitter short-circuit current-gain small-signal radio frequency (RF) measurements up to 50GHz gave peak maximum oscillation (f_{MAX}) and cut-off (f_T) frequencies of 1.2THz and 475GHz, respectively, with 1V collector–emitter bias (V_{CE}).

A single-finger (0.175μmx9.4μm) DHBT biased for class-A operation was subjected to active-loop load-pull continuous wave (cw) large-signal measurements at 94GHz. The power-added efficiency (PAE) was 32.5% (40% collector efficiency) with 1.6V V_{CE} bias and 1mA base current (I_B). The saturated output power ($P_{out,sat}$) was 8.73dBm and the gain 7.8dB.

Increasing V_{CE} to 1.9V enabled a higher peak $P_{out,sat}$ at the expense of lower PAE: 10.4dBm (832mV V_{BE}) and 29.3%, respectively. The $P_{out,sat}$ density was 6.67mW/μm^2, or 1.7W/mm according to emitter length.

The device was found to operate stably at the large V_{CE} bias with no evidence of degradation. "Such device stability under aggressive large-signal operation suggests inherent reliability advantages in the InP–GaAsSb material system," the team comments.

The measurements were made without thermal management enhancements such as substrate thinning and/or transferring the devices to thermally conductive substrates, e.g. aluminium nitride or silicon carbide. ■

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China 510623
Tel: +86 020-83511906
Fax: +86 020-83511907
E-mail: Sales@vitalchem.com
www.vitalchem.com

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

United Mineral & Chemical Corp
1100 Valley Brook Avenue,
Lyndhurst, NJ 07071, USA
Tel: +1 201 507 3300
Fax: +1 201 507 1506
www.umccorp.com

2 Bulk crystal growth equipment

Cyberstar
109 Rue Hilaire de Chardonnet — Technisud,
38100 Grenoble,
France
Tel: +33 (0)4 76 49 65 60
E-mail: cyberstar@cyberstar.fr
www.cyberstar.fr

3 Substrates

AXT Inc
4281 Technology Drive,
Fremont,
CA 94538, USA
Tel: +1 510 438 4700
Fax: +1 510 683 5901
www.axt.com

Crystal IS Inc
70 Cohoes Avenue,
Green Island,
NY 12183,
USA
Tel: +1 518 271 7375
Fax: +1 518 271 7394
www.crystal-is.com

CS Microelectronics Co Ltd (Vital Materials subsidiary)
Gaofeng Park,
Wanzhou Economic-Technological Development Area,
Chongqing,
China 404040
Tel: +86 023-58879888
E-mail: csm_sales@vitalchem.com
www.cs-micro.com

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

Freiberger Compound Materials
Am Junger Loewe Schacht 5,
Freiberg, 09599,
Germany
Tel: +49 3731 280 0
Fax: +49 3731 280 106
www.fcm-germany.com

Kyma Technologies Inc
8829 Midway West Road,
Raleigh, NC, USA
Tel: +1 919 789 8880
Fax: +1 919 789 8881
www.kymatech.com

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

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

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

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

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

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

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

Wafer Technology Ltd is a UK based producer of III-V materials and epitaxy-ready substrates offering the widest product range in the business.

Wafer World Inc
1100 Technology Place, Suite 104,
West Palm Beach,
FL 33407,
USA
Tel: +1-561-842-4441
Fax: +1-561-842-2677
www.waferworld.com

4 Epiwafer foundry

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

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

IQE
Cypress Drive,
St Mellons,
Cardiff
CF3 0EG, UK
Tel: +44 29 2083 9400
Fax: +44 29 2083 9401
www.iqep.com

IQE is a leading global supplier of advanced epiwafers, with products covering a diverse range of applications within the wireless, optoelectronic, photovoltaic and electronic markets.

OMMIC
2, Chemin du Moulin B.P. 11,
Limeil-Brevannes, 94453,
France
Tel: +33 1 45 10 67 31
Fax: +33 1 45 10 69 53
www.ommic.fr

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

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

VIGO SYSTEM S.A.
ul. Poznanska 129 /133, 05-850
Ozarów Mazowiecki, Poland
Tel: +48 22 733 54 10
E-mail: ent@vigo.com.pl
ent-epitaxy.com

www.vigo.com.pl www.ent-epitaxy.com

VIGO System's Epitaxy Division produces high-grade III–V compound semiconductor epitaxial structures for photonic and microelectronic devices. With more than 35 years' experience, the division offers a broad range of epi-wafers, both in large volumes and small customised batches. It focuses on innovative products for wireless, TC, sensing or printing applications.

5 Deposition materials

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

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

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

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

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

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

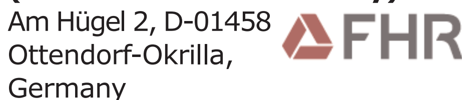
6 Deposition equipment

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

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

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

FHR Anlagenbau Gmbh (Vital Materials subsidiary)
Am Hügel 2, D-01458
Ottendorf-Okrilla,
Germany



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

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

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

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

Riber
31 rue Casimir Périer, BP 70083,
95873 Bezons Cedex,
France
Tel: +33 (0) 1 39 96 65 00
Fax: +33 (0) 1 39 47 45 62
www.riber.com

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

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

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

7 Wafer processing materials

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

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

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

EV Group
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com

EV Group is a technology and market leader for wafer processing equipment. Worldwide industry standards for aligned wafer bonding, resist processing forthe MEMS, nano and semiconductor industry.

Logitech Ltd
Erskine Ferry Road,
Old Kilpatrick, near Glasgow G60 5EU,
Scotland, UK
Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com

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

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

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

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

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

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

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

9 Materials & metals

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

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

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

10 Gas and liquid handling equipment

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

CS CLEAN SOLUTIONS AG
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'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
VACUUM BARRIER VBC
CORPORATION
Vacuum Barrier's vacuum-jacketed dynamic and sealed SEMIFLEX LN2 pipe delivers LN_2 at bulk tank pressure in two-phase condition for on-demand supply. Our liquid/vapor phase separators deliver low-pressure LN_2 to each use point for on-demand supply. Combine with SEMIFLEX Triax LN_2 pipe eliminates two-phase flow to all use points.

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

VACUUM BARRIER VBC CORPORATION

Vacuum Barrier's vacuum-jacketed dynamic and sealed SEMIFLEX LN2 pipe delivers LN_2 at bulk tank pressure in two-phase condition for on-demand supply. Our liquid/vapor phase separators deliver low-pressure LN_2 to each use point for on-demand supply. Combine with SEMIFLEX Triax LN_2 pipe eliminates two-phase flow to all use points.

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

As an ISO 9001 registered global leader in the remanufacturing of wafer inspection systems, Brumley South Inc specializes in designing, installing and supporting upgrades for ADE, Nanometrics, Dryden and KLA-Tencor Surfscan tools, polysterene latex sphere calibration standards, particle deposition systems, and semiconductor parts and service.

Class One Equipment Inc
5302 Snapfinger Woods Drive,
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

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, 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)
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, San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

22–26 May 2022
International Symposium on Power Semiconductor Devices and ICs (ISPSD 2022)
Marriott Pinnacle Downtown Hotel, Vancouver, Canada
E-mail: ngwt@vrg.utoronto.ca
www.ispsd2022.com

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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 July 2022
3rd International Congress on Advanced Materials Sciences and Engineering (AMSE-2022)
Hotel Ambasador, Opatija, Croatia
E-mail: eve4@amse-materials2021.com
www.istci.org/amse2022

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

7–9 September 2022
CIOE 2022 (24th China International Optoelectronic Exposition)
Shenzhen World Exhibition & Convention Center,
Shenzhen, China
E-mail: cioe@cioe.cn
www.cioe.cn/en

11–16 September 2022
19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2022)
Davos, Switzerland
E-mail: info@icscrm2022.org
www.icscrm2022.org

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

16–19 October 2022
2022 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Sheraton Phoenix Downtown,
Phoenix, AZ, USA
E-mail: cs@cshawevent.com
www.bcicts.org

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

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